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DEPARTMENT OF COMMERCE AND LABOR

REPORT OF THE SUPERINTENDENT

OF THE

COAST AND GEODETIC SURVEY

SHOWING

THE PROGRESS OF THE WORK

FROM

JULY 1, 1903, TO JUNE 30, 1904

55

WASHINGTON
GOVERNMENT PRINTING OFFICE
1904

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

DEPARTMENT OF COMMERCE AND LABOR

Document No. 21

COAST AND GEODETIC SURVEY

ERRATA.

Coast and Geodetic Survey Report for 1904.

Page 187, seventeenth line from bottom of page, for "1889" read "1899."

Page 191, fourth line from bottom of page, for "to" read "or."

Page 201, twentieth line from top of page, for "223" read "199."

Page 202, transpose names of vessels in lines 8 and 9 from top of page.

Page 266, ninth line from bottom of page, for "Feland" read "Phelan."

Page 266, sixth line from bottom of page, for "Feland" read "Phelan."

Page 280, eleventh line from bottom of page, for "– C′c" read "+ C′c."

Page 280, twelfth line from bottom of page, for "– Cc" read "+ Cc."

Page 287, fifth line from bottom of page, omit period between a and b.

Page 308, line Irkutsk-Kansk, for "33^{m}" read "34^{m}."

Page 308, thirty-second line from top of page, opposite value for Vladivostok-Greenwich, add "and German."

Page 335, seventeenth line from top of page, for "Of" read "Cf."

Page 350, twelfth line from bottom of page, for "80" read "90."

Page 351, thirteenth line from top of page, third column from right, for "5.87" read "11.87."

Page 351, twelfth line from bottom of page, eighth column from right, for "– 49" read "– 39."

Page 375, fourteenth line from bottom of page, delete "approach."

Page 386, sixth line from bottom of page, delete "scarcely."

Page 388, twentieth line from top of page, for "III" read "III½."

On fig. 20, Appendix No. 5, northern point of Scotland, for "X" read "IX."

On fig. 22, Appendix No. 5, near lower left-hand corner, for "2.9" read "12.9."

On fig. 25, Appendix No. 5, insert a light line extending from Cape Trost to end of light line tangent to west end of Nova Zembla, thence to Brady I., Franz Josef Land.

On fig. 26, Appendix No. 5, insert a light line extending across Smith Sound from Cape Ohlsen.

Page 465, twenty-sixth line from top of page, third column from right, for "9.076" read "0.076."

Page 481, twenty-ninth line from top of page, for "1891" read "1893."

Library slips, page (4), twenty-fifth line from top of page, for "Bauer, J. A.," read "Bauer, L. A."

LETTER OF TRANSMITTAL.

DEPARTMENT OF COMMERCE AND LABOR,
OFFICE OF THE SECRETARY,
Washington, September 1, 1904.

In compliance with the requirements of section 4690, Revised Statutes, I have the honor to transmit herewith, for the information of Congress, a report transmitted to this Department by Mr. O. H. Tittmann, Superintendent of the Coast and Geodetic Survey, showing the progress made in the work of the Survey during the fiscal year ended June 30, 1904. It is accompanied by maps illustrating the general advance in the operations of the Survey up to that date.

Respectfully,

V. H. METCALF,
Secretary.

The SENATE AND HOUSE OF REPRESENTATIVES.

LETTER OF SUBMITTAL.

DEPARTMENT OF COMMERCE AND LABOR,
COAST AND GEODETIC SURVEY,
Washington, September 1, 1904.

SIR: In conformity with law and with the regulations of the Department of Commerce and Labor, I have the honor to submit herewith, for transmission to Congress, the annual report of progress in the Coast and Geodetic Survey for the fiscal year ended June 30, 1904. It is accompanied by maps illustrating the general advance in the field work of the Survey up to that date.

Respectfully,

O. H. TITTMANN,
Superintendent.

The Honorable the SECRETARY OF COMMERCE AND LABOR.

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O. H. TITTMANN, *Superintendent.*
FRANK WALLEY PERKINS, *Assistant Superintendent.*

OFFICE OF THE SUPERINTENDENT.

W. B. Chilton, *Clerk.*
H. M. Fitch, *Clerk.*
Charles Over, *Messenger.*

THE WORK OF THE YEAR.

It is gratifying to announce the completion of the determination of the difference of longitude between San Francisco, Cal., and Manila, P. I., thus connecting the longitude circuit around the earth. This work was made practicable by the generous cooperation of the officers of the Commercial Pacific Cable Company, who placed their cables and operators at the service of the Survey, during the short periods needed for the transmission of time signals between the stations for comparison of chronometers. Incidentally, during the progress of this work, the longitude of Honolulu, Hawaii; of Midway Island; and Guam Island were determined. The details of this work are given in Appendix 4.

The triangulation along the ninety-eighth meridian was extended toward the north and toward the south from the portion already completed, the total extension amounting to 500 kilometers along the meridian, and the work was in progress at the close of the year.

The location on the ground and marking of the boundary between Alaska and the British possessions, as laid down by the Alaska Boundary Tribunal, was inaugurated under the direction of the Department of State by the Superintendent as Commissioner of the United States, in cooperation with the Commissioner of Great Britain.

The various operations of the magnetic survey of the country show a gratifying progress during the year. The determination of the magnetic declination, dip, and intensity was made in 327 localities, embracing 367 stations distributed over 24 States and Territories, and 2 foreign countries. An extensive investigation was made of the marked local disturbances in the vicinity of Juneau, Alaska, 45 stations being occupied for this purpose. In cooperation with the Louisiana geological survey, the magnetic survey of that State was completed. Effective cooperation was secured with an expedition sent to the Bahama Islands by the Baltimore Geographical Society, and valuable results were thus obtained without expense to the Survey.

Excellent progress was made in securing magnetic observations at sea during the voyages of the ships of the Survey to and from their fields of work. In the Atlantic and Pacific oceans 92 results of magnetic declination and 33 results of magnetic dip and intensity were thus obtained, nearly all of them derived from complete swings of the ships, forward and back.

Continuous records of the variations of the magnetic elements were secured throughout the year at five magnetic observatories situated at Cheltenham, Md.; Baldwin, Kans.; Sitka, Alaska; near Honolulu, Hawaii; and Vieques, P. R. During the year a large number of magnetic storms were recorded, the most remarkable one occurring October 31–November 1.

It is interesting to note that within this year a bureau of international research in terrestrial magnetism was created by the Carnegie Institution of Washington, with an officer of the Survey, the inspector of magnetic work, in charge as director.

A continuous record of tide observations with self-registering gauges was obtained during the year at 8 stations, including 1 station in Hawaii and 1 in the Philippine Islands, and for a portion of the year at an additional station which was established on the Gulf of Mexico, at Galveston, Tex.

The electric tide indicator installed in the Maritime Exchange at Philadelphia continued to give satisfaction. A similar apparatus was installed during the year in the Maritime Exchange at New York.

The tide indicators, established for the use of mariners in New York Harbor, in the Delaware River at Reedy Island, and in San Francisco Bay continued in operation during the year.

Compass deviation ranges were established by marks placed on the inner Delaware Breakwater, which will prove of great value to shipping, as any vessel can now determine the corrections to her compass while swinging at anchor in the National Harbor of Refuge.

The field work necessary for the revision of two volumes of the United States Coast Pilot, covering the coast from Point Judith, Rhode Island, to Chesapeake Bay entrance, Virginia, was completed.

Hydrographic surveys were made in 16 States and Territories; topographic surveys in 9; triangulation in 14; and leveling in 6.

The primary triangulation along the Pacific coast north of San Francisco was continued.

In Alaska, a survey was made of Davidson Inlet, work was continued in Prince William Sound, and two vessels were dispatched to make a survey of Kiska Harbor, Aleutian Islands.

In Porto Rico, hydrographic work was continued in the harbors and bays and offshore.

The director of coast surveys in the Philippine Islands, an officer of the Coast and Goedetic Survey (with a detail of assistants), in cooperation with the insular government, has continued the important work of charting the imperfectly known waters of the archipelago. The largest vessel belonging to the Survey was engaged on this duty during the entire year.

Detached surveys based on astronomic determinations and including base measurement, triangulation, topography, hydrography, and tide observations were made at various points, and a connected triangulation already extends over the greater portion of the west coast of Luzon Island north of Manila Bay. Two additional telegraphic longitudes were determined; magnetic and tide observations were continued. Fifteen new charts were prepared and published at the Manila suboffice, and four volumes of sailing directions (including new editions of Parts I and II) were published.

In the Office the current work was kept up to date and satisfactory progress was made in the various branches of its work, including computation, reduction, plotting, and discussion of results of field work, and the preparation of the results for publication by chart or otherwise. A considerable amount of work was done for the Department of State in connection with the preparation of maps of the Alaska boundary for publication.

Satisfactory results were obtained during the year at the latitude observatories maintained under the direction of the Superintendent at the expense of the International Geodetic Association, at Gaithersburg, Md., and at Ukiah, Cal., for the purpose of measuring the variations of latitude.

I attended the Fourteenth General Conference of the International Geodetic Association at Copenhagen, Denmark, as the delegate of the United States, and continued the work of re-marking the boundary line between the United States and Canada from the Rocky Mountains westward, as Commissioner of the United States, two officers of the Survey being detailed for work in the field. I was detailed to report to the United States agent at London, England, for duty in connection with the presentation of the case of the United States to the Alaska Boundary Tribunal, and performed that duty. Another officer of the Survey was also detailed on this duty. As Commissioner of the United States on the International Delimination Commission, I inaugurated the work of marking the boundary between Alaska and Canada as laid down by the Alaska Boundary Tribunal, and one officer was detailed for work in the field.

One officer continued on duty as a member of the Mississippi River Commission. The survey of Mason and Dixon's Line, the boundary between the States of Maryland and Pennsylvania, was completed and progress was made in the preparation of the report and maps showing the results of the work. The survey of the natural oyster beds and reefs in the State of Louisiana was continued in cooperation with the Louisiana Oyster Commission by an officer of the Survey detailed for this purpose. One officer remained in charge of the triangulation of the city of New York, which is in progress by the city authorities. Officers of the Survey with their vessels were called upon to patrol racing regattas upon three occasions and performed this duty to the satisfaction of the parties concerned. An exhibit was prepared and installed at the Louisiana Purchase Exposition at St. Louis, and an officer was assigned to duty in charge of the exhibit.

The amount appropriated for the Coast and Geodetic Survey for the fiscal year 1904 was $968 025,* of which $210 245 was for manning and equipping the vessels of the Survey, $120 000 for building a new vessel, $38 100 for repairs and maintenance of vessels, and $50 000 for office expenses. The remainder of the appropriation was about equally divided between expenses of parties in the field and salaries of the field and office forces.

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* Exclusive of appropriation for printing.

In addition to the above sums the appropriations of $100 000 for marking the boundary between the United States and Canada, west of the Rocky Mountains, and of $100 000 for locating and marking the Alaska boundary are disbursed by the disbursing agent of the Coast and Geodetic Survey, under the direction of the Superintendent as Commissioner.

Details in regard to the field work of the year are given in Appendix 1.

I. OFFICE OF ASSISTANT IN CHARGE.

ANDREW BRAID, *Assistant in Charge.*

The Assistant in Charge has direct supervision of the work of the divisions of the Office, as follows:

Computing Division.
Division of Terrestrial Magnetism.
Tidal Division.
Drawing and Engraving Division.
Chart Division.
Instrument Division.
Library and Archives Division.

He also has charge of the purchase of supplies and of all other expenditures for office expenses, the care of the public property at the Office, the distribution of the publications of the Survey distributed free, and of the sale of the Charts, Coast Pilots, and Tide Tables published by the Survey. All the routine work connected with the above duties was done under his direction by the employees in the Office. Details in regard to all of this work are given in Appendix 2 to this Report by extracts from the report of the Assistant in Charge and by a compilation from the reports of the Chiefs of Divisions.

II. OFFICE OF INSPECTOR OF HYDROGRAPHY AND TOPOGRAPHY.

H. G. OGDEN, *Inspector.*

A.—Inspection.

Personnel.

Name.	Occupation.
D. B. Wainwright	Assistant; July 1 to Apr. 8.
P. A. Welker	Assistant; Aug. 17 to Sept. 24.
J. M. Griffin	Clerk.
R. D. Chase	Do.

The routine duties of the Office were kept up to date. The work of the parties in the field was inspected whenever necessary, and numerous trips were made in connection with the repair and maintenance of the surveying vessels. In the latter part of April the Inspector went to San Francisco to direct the repairs to the steamer *Patterson*, and remained there until June 10. During the absence of the Inspector, Assistant Wainwright acted as Inspector while he was on duty in the Office, and from April 10 to June 20 Assistant Gershom Bradford was Acting Inspector.

During the year plans and specifications for a new wooden steamer were prepared by Mr. L. B. Friendt, a naval architect, under the supervision of the Inspector. The contract for the construction of the vessel was approved by the Secretary of Commerce and Labor on March 26, 1904, and the work was in progress on June 30.

The office work of the Coast Pilot party is under the direction of the Inspector, and the details of this work are given under the heading "B.—Coast Pilot party."

In his report, Assistant Ogden states that the officers and clerks under his direction have rendered most cordial and efficient assistance throughout the year.

THE VESSELS AND THEIR HYDROGRAPHIC WORK.

THE STEAMER BACHE.

Assistant P. A. Welker, Commanding.
Assistant J. B. Boutelle, Commanding.

At the beginning of the year this vessel was at Baltimore, Md., fitting out for a cruise on the coast of Maine, for which she sailed on August 13. En route an examination was made for a reported shoal in the vicinity of the Winter Quarter Shoal, and magnetic observations were made during the trip and at Delaware Breakwater. The work of the season included examinations for a number of reported changes and dangers and their determination, on the coast of Maine, Massachusetts, and off Sandy Hook, and the season finally closed at the latter place, the vessel sailing for Baltimore from New York on November 25. On her arrival at Baltimore she was fitted out for a season's work in Porto Rico, and sailed for San Juan on January 27. Her work for the season included the continuation of the hydrography of Porto Rico on the west coast and extended from Point Guanajibo southward to Cape Rojo. A shore party in charge of Mr. J. C. Landers, Aid, worked under the directions of the commanding officer of the *Bache*, using the launch *Rudy*, and made the survey of Boqueron Bay and also the inshore hydrographic survey off Cape Rojo. On the completion of this work on the west coast, the *Bache* sailed for San Juan and made a hydrographic reconnaissance of the entrance to San Juan Harbor, at the request of the War Department, and, on finishing that work, sailed on May 28 for Baltimore, Md., via Hampton Roads. At the close of the year she was at Baltimore, Md., fitting out for her season's work on the coast of Maine.

THE STEAMER BLAKE.

Assistant R. L. Faris, Commanding.
Assistant E. B. Latham, Commanding.

At the beginning of the year this ship was at Norfolk, Va., fitting out for her season's work on the New England coast. She sailed on August 6 for her working grounds in Buzzards Bay, Massachusetts, where she continued the development of shoal spots in the bay which was left incomplete last season. En route from Baltimore an examination for a reported shoal off Winter Quarter Shoal and the usual magnetic observations were made. In the latter part of August the work in Buzzards Bay was suspended and the party took up an examination of the waters eastward and southward of Nantucket Shoals. On the completion of this work, the party was engaged in examinations for reported dangers and shoals until the close of the season. She sailed for Baltimore on October 22, where she was fitted out for her winter's work in Porto Rico. Owing to unforeseen delays and especially to an accident in the yard where she was being repaired in which she was seriously damaged, she did not sail for Porto Rico until March 5. During the season she made a number of special examinations, a development of the passages off the north and east coast of Porto Rico and in Vieques Sound, and verified a portion of the work done by the schooner *Eagre* in that locality. Work was closed and she sailed for Baltimore, via Hampton Roads, on June 2, and at the close of the year was in the hands of the contractors undergoing repairs and fitting for her summer's work on the New England coast.

THE SCHOONER EAGRE.

Assistant J. B. Boutelle, Commanding.

At the beginning of the year this vessel was laid up at Baltimore, and on July 31 she was sold to the Navy Department.

THE STEAMER ENDEAVOR.

Assistant F. A. Young, Commanding.

At the beginning of the year this vessel was at work making a survey of the Kettle Bottom Shoals in the Potomac River. This work was interrupted from July 6 to 12, when she went to Norfolk for some minor repairs, and also when assigned to patrol duty for the regatta on the Potomac at Washington on September 12, and was suspended for the season on November 8, when she sailed for Baltimore, Md., to fit out for a season at Key West, Fla. She sailed on February 2, via Fort Monroe, and during the season made a close survey, using the harbor sweep, of an area about 2 miles square, southwest of the Key West Light. Work in this locality was closed and the vessel sailed for Port Royal, S. C., on June 5, where the position of the new Hilton Head Front Range was determined and a line of soundings run to determine the deepest water over the range. On completing this work, the vessel sailed for Baltimore, on June 17, and at the close of the year was still at Baltimore making arrangements to fit out for a season's work on Nantucket Shoals.

THE STEAMER GEDNEY.

Assistant E. F. Dickins, Commanding.

At the beginning of the year this vessel was fitting out for her summer's work in Alaska, sailing for her working grounds on July 12. En route, she made a determination of the new Mary Island Light-house, and examined and located a rock at the southern entrance to Tongass Narrows. During the season she took up the survey, including the triangulation, topography, and hydrography, of the approaches to Davidson Inlet, Iphigenia Bay. Work was closed and the vessel started for San Francisco, Cal., October 10. The launch *Cosmos* and launch No. 117 were assigned for the use of the party on the *Gedney* during the season, and at the close of the season were left in the Survey storehouse on Japonski Island. After the return of the vessel to San Francisco, on November 17, she was put out of commission and laid up in Oakland Creek in charge of shipkeepers. On April 16 she was again put in commission and fitted for her summer's work, sailing on May 8. En route, she completed the survey in San Juan Channel, Washington, which had been started by a shore party under Assistant Dickins, and made an examination for a reported shoal spot on Hein Bank. She sailed on June 6 from Seattle and continued the work of the previous season in Iphigenia Bay, and was so engaged at the close of the year.

THE STEAMER HYDROGRAPHER.

Assistant W. I. Vinal, Commanding.
Nautical Expert John Ross, Commanding.
Aid W. E. Parker, Commanding.

At the beginning of the year this vessel was at Baltimore, Md., and sailed for Port Jefferson, L. I., for repairs on July 18. On the completion of the repairs, August 18, she sailed for Jersey City, and on August 24 the party on board took up the field revision of Parts IV and V of the Atlantic Coast Pilot. By direction of the Secretary of Commerce and Labor, this work was suspended and the vessel and party were assigned to patrol duty during the regatta of the New York Bay Regatta Association on the Kill von Kull on August 29 and again on September 2, after which she resumed her regular field work. On November 4 she sailed for Washington, and on November 21 sailed for Hampton Roads, where she was fitted out for a season at Key West, Fla., and sailed on December 1. During the season she was engaged in a close development of the Sand Key and Southwest channels with the harbor sweep, and special examinations for reported dangers in Key West Harbor. On the completion of this assignment she proceeded, on June 10, to St. Catherines Sound, Georgia, and made a development of the channel at the entrance to the sound, which was completed by the close of the year.

THE SCHOONER MATCHLESS.

Assistant G. L. Flower, Commanding.
Assistant W. I. Vinal, Commanding.

At the beginning of the year this vessel was engaged in the survey of the Severn River, Maryland, and on July 27 sailed to take up work on the West River and Eastern Bay, including a reconnaissance of a portion of Chesapeake Bay in that vicinity. This work was finished and the vessel sailed for Baltimore on October 15, and, after some minor repairs, proceeded to her working grounds in the Little Choptank River, on October 31. Work in this locality was suspended in April and she sailed for Alexandria, Va., to make a hydrographic survey of the Potomac River, beginning at Washington and working down the river. She was engaged on this work at the close of the year.

THE STEAMER MCARTHUR.

Assistant H. P. Ritter, Commanding.

At the beginning of the year this vessel was laid up in Oakland Creek, California, and was not put in commission until April 25, when she was fitted out for a season's work at Kiska, Alaska. She sailed from San Francisco on May 19 and reached Kiska on June 30.

THE STEAMER PATHFINDER.

Assistant J. J. Gilbert, Commanding.
Assistant F. Westdahl, Commanding.

At the beginning of the year this vessel was at Hongkong undergoing repairs, and sailed for Manila on July 3. On July 15 she started a line of deep-sea soundings from a point off Lingayen Gulf to a point northeast of the island of Formosa, and returned to Manila on the 30th, after completing this work. She sailed for Lagonoy Gulf on August 11, completed the survey of the gulf, and returned to Manila on October 30.

After making surveys in Manila Bay she sailed on March 8 for Salomague for hydrographic work on the northwest coast of Luzon, and on the completion of the season sailed for Hongkong on May 28 for repairs and remained there until the close of the year.

THE STEAMER PATTERSON.

Assistant J. F. Pratt, Commanding.

At the beginning of the year this vessel was engaged in running a line of deep-sea soundings from Juan de Fuca Strait to Sitka Sound, arriving at Sitka on July 3. This work was undertaken at the request of the Chief Signal Officer, United States Army. She left Sitka on the 7th and continued the deep-sea soundings to the entrance to Chatham Strait. She sailed for Juneau on the 17th to deliver the results of the soundings to the chief signal officer on the U. S. S. *Burnside* (cable ship) and started on her return to Sitka on the 19th, via Icy Strait and Cross Sound. She left Sitka on the 27th and continued the deep-sea soundings as far as Cape St. Elias. She then took up the survey of Controller Bay, which was continued until September 19, when this work was stopped and the vessel sailed for Orca, continuing the deep-sea soundings from Cape St. Elias into Prince William Sound. She left Orca for Dutch Harbor on September 23, en route for Kiska Island, Alaska. After her arrival at Dutch Harbor on the 29th it developed that one of the furnaces to the boiler was so seriously damaged that it was necessary to return to Seattle, Wash., for repairs, and she sailed on October 10, arriving on the 20th. New furnaces were installed and the vessel sailed for Honolulu, Hawaii, on March 30. About 800 miles out the furnaces again became disabled and she returned to San Francisco, Cal., arriving there on the 17th of April. Two new furnaces were again installed and the vessel sailed for Kiska, via Dutch Harbor, on June 10.

The schooners *Quick*, *Spy*, and *Transit* were laid up during the entire year at Madisonville, La., in the charge of a ship keeper. Some slight repairs were made to the *Transit* during the year.

THE STEAMER TAKU.

Assistant H. P. Ritter, Commanding.

At the beginning of the year this vessel was on her working grounds in Prince William Sound, and on September 30 was laid up in charge of a ship keeper at Orca, where she was at the close of the year.

The steamer *Yukon*, together with the launches *Alpha* and *Delta*, have been laid up during the entire year at Dutch Harbor, Alaska.

The launch *Cosmos* was assigned as a tender to the *Gedney* during both seasons in Alaska, as was also Launch No. 117, and during the interval between seasons was laid up in the Coast Survey storehouse on Japonski Island.

The launch *Fuca* was sold on January 12, 1904.

The launch *Inspector* was assigned to the party of Mr. C. G. Quillian, Aid, on the Hudson River and afterwards on the coast of New Jersey. At the close of the year she was laid up at Atlantic City, N. J.

The launch *Rudy* at the beginning of the year was laid up at Mayaguez, P. R., and during the year was used by the party of Mr. J. C. Landers, Aid, already referred to under the steamer *Bache*. At the close of the year she was stored at Mayaguez, P. R.

B.—Coast Pilot party.

Personnel.

Name.	Occupation.
John Ross	Nautical Expert.
H. C. Graves	Do.
H. L. Ford	Do.
R. L. Libby	Aid; Oct. 21 to Nov. 11.
T. O. Pulizzi	Writer.

The preparation of the following publications was completed and the volumes were published during the fiscal year.

United States Coast Pilot, Pacific Coast, California, Oregon, and Washington.

United States Coast Pilot, Atlantic Coast, Part III (second edition), Part IV (fourth edition), and Part V (third edition).

Supplements to United States Coast Pilots, Part VI (second edition), Part VII (second edition), and Part VIII (second edition).

Supplement to United States Coast Pilot, Pacific Coast, Alaska, Part I.

Coast Pilot Notes on Warren Channel and Davidson Inlet, Alaska.

Bulletin No. 40, Coast Pilot Notes on the Fox Island Passes, etc. (fifth edition).

Information for use in the field in revising Parts IV and V, named above, was prepared.

Lists of geographic names for charts covering the coast of Alaska were compiled, and also a list of the harbors in the Philippine Islands. Information was collected and arranged for use in compiling Coast Pilots for Alaska and for Porto Rico. The usual routine office work of keeping a record of all changes, reported dangers, hydrographic examinations, new information, and other data necessary for the correction, revision, and compilation of the Coast Pilots, was kept up to date.

The correction of all Coast Pilot volumes by hand to date of issue from the office required a considerable portion of the time of the party.

The following members of the party were absent on duty in the field for the periods covered by the dates given, and the account of their work in the field is given under the proper heading in Appendix 1.

John Ross, Nautical Expert, August 21 to November 16.
H. C. Graves, Nautical Expert, August 31 to November 12.
T. O. Pulizzi, Writer, October 1 to November 12.

During the absence of Mr. Ross on field duty Mr. Ford had immediate charge of the work in the office. The demand for Coast Pilots showed a marked increase during the fiscal year.

III. OFFICE OF INSPECTOR OF GEODETIC WORK.

J. F. HAYFORD, *Inspector.*

The duties of the Inspector of Geodetic Work were performed at the Office in Washington, except for the period between July 16 and August 12. The Inspector left Washington on July 16 and proceeded to Green River, Wyo. He spent one day with each of the leveling parties at work in this vicinity under charge of Aids H. D. King and R. L. Libby. He then inspected the primary triangulation party, under charge of Assistant O. W. Ferguson, at work on the triangulation along the ninety-eighth meridian in the vicinity of Lake Preston, S. Dak. Several days were spent watching the observations. Six days were spent with Assistant W. H. Burger, who was engaged in extending the reconnaissance for triangulation in Minnesota. While with the triangulation party a 60-foot wooden observing tripod was tested by observations made on distant objects to ascertain how much twist should be expected in such tripod from the action of the sun. The Inspector also visited the work on the Lake Survey in the vicinity of Mackinac Island, Mich., to obtain information in regard to the iron signals (observing tripods and scaffolds) erected there as a substitute for wooden signals. These iron signals were designed by Asst. Engineer H. F. Johnson with a view to their use at other stations after having served their purpose where first erected, and they are constructed of sections of gas pipe with iron rods to sustain all tension strains. The examination was made for the purpose of determining whether it was desirable or practicable to use such signals at the triangulation stations of the Coast and Geodetic Survey. As at present advised the cost of using these iron signals would about equal the present cost of the wooden signals now being used on the ninety-eighth meridian where new lumber is purchased as near as practicable to the stations where it is to be used and the signals are abandoned after they have served their purpose. As a result of the inspection of fieldwork, as above, the Inspector keeps in closer touch with the work and observers, and the value of his recommendations to the Superintendent is correspondingly increased.

During the remainder of the year the necessary supervision was exercised by a careful examination of the correspondences with field parties and of the records of observations sent to the Office from time to time, and by an inspection of the computations and results.

IV. OFFICE OF INSPECTOR OF MAGNETIC WORK.

L. A. BAUER, *Inspector.*

The duties performed by this Office during the past year consisted, as heretofore, in the following: Inspection of field and observatory work in terrestrial magnetism; the preparation of the necessary directions and information required by the various parties and ships engaged in magnetic work; examination of the observation records received; the controlling of the constants of the various instruments employed, and the testing and derivation of constants of newly acquired instruments.

The Inspector personally inspected the work of the field parties operating in New Jersey, Louisiana, and South Carolina, and at various times the observatory work at Cheltenham, Md.

The entire activity of the Survey in magnetic work during the fiscal year may be summarized as follows:

Magnetic work on land.—The determination of the magnetic declination, dip, and intensity in 328 localities, embracing 368 stations distributed over 24 States and Territories and 2 foreign countries, as exhibited in the table.

Special mention should be made of the extensive examination of the marked local disturbances in the vicinity of Juneau and Douglas Island, Alaska, about 45 stations having been occupied for this purpose during July and August, 1903.

Successful cooperative work with the Louisiana geological survey was carried on, so that with the valuable assistance rendered by the State geologist, Dr. G. D. Harris, the magnetic survey of the State was completed.

Effective cooperation was secured with the expedition to the Bahama Islands sent by the Baltimore Geographical Society under the leadership of Dr. G. B. Shattuck. A complete instrumental outfit was loaned by the Coast and Geodetic Survey, but all expenses incurred in securing the observations were defrayed by the expedition. Important results were obtained by the observer, Dr. O. L. Fassig, at six stations. At two of the stations results had been previously obtained, so that the secular change can be deduced.

Summary of magnetic work done between July 1, 1903, and June 30, 1904.

State.	Number of localities.	Number of stations.	Old localities reoccupied.	Declination observed.	Dip observed.	Intensity observed.
Alabama	8	8	1	8	8	8
Alaska	40	66	5	65	50	39
California	6	6	3	6	6	6
Delaware	1	1	0	1	0	0
District of Columbia	2	2	1	6	8	7
Georgia	2	2	0	2	2	2
Guam	6	6	0	9	1	0
Hawaii	6	7	4	7	1	1
Kansas	5	5	2	10	10	8
Kentucky	37	38	2	38	37	37
Louisiana	50	51	5	56	51	51
Maine	2	2	1	2	2	2
Maryland	4	8	3	4	7	3
Massachusetts	1	1	0	1	1	1
Missouri	13	13	1	13	12	13
Montana	7	7	2	6	7	7
New Jersey	28	31	11	32	29	29
North Carolina	1	1	1	1	1	1
Ohio	40	41	1	44	43	43
Philippine Islands	6	6	0	6	2	2
Porto Rico	7	8	5	12	12	12
South Carolina	14	16	4	18	18	18
Tennessee	32	32	2	33	33	33
Washington	3	3	2	4	4	4
Bahamas	4	6	2	5	4	3
British Columbia	1	1	1	1	1	1
Total	328	368	59	390	349	330

Magnetic work at sea.—Observations were secured by the various ships as follows:

The *Bache* on her cruise from Baltimore to the coast of Maine last summer obtained declination observations by swinging completely through 16 equidistant points of the compass forward and back, at Delaware Breakwater (twice), off Gayhead, Mass., Johns Bay, Me., Bar Harbor, Me., and New York Harbor. Also some intermediate compass observations were made on and near the ship's course.

During the winter she was provided with a gimbal stand and a Lloyd-Creak dip circle for ship and shore work. On her cruise from Baltimore to Porto Rico and return she was swung completely, securing the three magnetic elements (declination, dip, and intensity) going and returning, at Norfolk, Va., at Mayaguez, P. R., and also at six intermediate places at sea.

The *Blake* on the cruise last summer from Baltimore to Buzzards Bay, Mass., swung ship completely for compass deviations and declination, twice at Hampton Roads, three times in Buzzards Bay, and once in Chesapeake Bay. During the last swing in Buzzards Bay and the one in the Chesapeake observations of dip and intensity were also made with the Lloyd-Creak dip circle. Some observations were also made at sea on the return trip from the New England coast to Baltimore. On the trip to Porto Rico and return she was swung completely, securing declination, dip, and intensity observations in the Chesapeake (at the mouth of the Patuxent River), at Norfolk (going and returning), at Fajardo Roads (twice), and at seven intermediate places at sea.

The *Endeavor* swung ship completely at Fort Monroe for compass deviations and declination, and made some compass observations between Norfolk and Key West.

The *Gedney* made some compass observations on a range course in Gastineau Channel, Alaska, to assist in the further development of the local disturbances existing in that locality. She also swung ship completely at San Francisco for compass deviations and declination.

The *Hydrographer* swung ship completely for compass deviations and declination in the Chesapeake, at the mouth of the Potomac River, and at Key West, Fla.

The *McArthur* swung ship completely for compass deviations and declination at San Francisco, Sitka, and Dutch Harbor.

The *Patterson* swung ship in Sitka Bay, Alaska, for compass deviations and declination. During the winter she was provided with a gimbal stand and Lloyd-Creak dip circle. She was swung completely at Port Angeles, Wash., and twice at sea, and at San Francisco, securing compass deviations, declination, dip, and intensity observations.

Summary of magnetic work done at sea between July 1, 1903, and June 30, 1904.

Vessel.	General region.	Number of swings.	Observations from swings.			Observations on and near course.		
			Declination.	Dip.	Intensity.	Declination.	Dip.	Intensity.
Bache	Atlantic Ocean	17	17	11	11	0	0	0
Blake	do	18	18	14	14	40	3	3
Endeavor	do	1	1			5		
Gedney	Pacific Ocean	1	1			11		
Hydrographer	Atlantic Ocean	2	2					
McArthur	Pacific Ocean	3	3					
Patterson	do	5	5	4	4	2	1	1
Total		47	47	29	29	58	4	4

There were thus secured, incidentally to the regular surveying duties of the various vessels, 105 results of magnetic declination (variations of the compass), nearly half of which are dependent upon complete swings of the vessels, forward and back, and, hence, possess an accuracy of about 10′ to 15′; also 33 results of magnetic dip and intensity of magnetic force, nearly all of them derived from complete swings, forward and back.

Magnetic observatory work.—Continuous records of the variations of the magnetic elements were secured throughout the year at five magnetic observatories, situated at Cheltenham, Md.; Baldwin, Kans.; Sitka, Alaska; near Honolulu, Hawaii; and Vieques, P. R. At the Sitka, Honolulu, and Vieques observatories some records of earthquakes were obtained, and at the Cheltenham observatory some incidental observations in atmospheric electricity were secured. Registrations of the magnetic variations on the rapid (two-hour) rate were made simultaneously at all the observatories on the 1st and 15th of each month. During the past year a large number of very notable magnetic storms were recorded, the most remarkable one being that of October 31–November 1, which disturbed the telegraph and cable lines for several hours and disturbed the compass by a degree and a half and more, according to locality.

V. OFFICE OF DISBURSING AGENT.

SCOTT NESBIT, *Disbursing Agent.*

Personnel.

Name.	Occupation.
N. G. Henry	Confidential clerk and cashier.
Miss Ida M. Peck	Clerk.
Mrs. Jennie H. Fitch	Clerk.
L. C. Ritchie*	Captain's clerk, July 1 to June 25.
M. B. Sturgus*	Captain's clerk, June 11 to June 30.

The disbursement of the funds of the Coast and Geodetic Survey is made not only by payments directly from the Disbursing Agent, but also largely through the medium of its Assistants and other officers when acting as chiefs of parties. These officers, on approval of the Superintendent, receive advances of public funds from the Disbursing Agent in lump sums, under authority of an Executive order dated March 26, 1886.

In conformity to this order there are now 64 officers of this Service bonded in the sum of $2 000 to $5 000 each. When acting as chiefs of parties, these officers receive from time to time such advances of public funds from the Disbursing Agent as are required to meet the necessary current expenses of the work in hand.

A ledger account is kept in the office of the Disbursing Agent with each chief of party receiving an advance, each one being charged with all advances made to him, and, on the other hand, receiving credit for all proper expenditures made by him when presented on regularly supported vouchers after such accounts have been audited in the office of the Disbursing Agent and found to be correct. All of these accounts, with their supporting vouchers, are then sent to the Auditor for the State and other Departments for examination and audit by him.

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*Temporarily detailed in connection with the accounts of vessels.

This system has met the needs of this service, and results, in the main, in economy and good order in its expenditures.

In addition to the regular appropriations of the Coast and Geodetic Survey, Mr. Nesbit also disburses the appropriations for the survey and marking of the boundary between the United States and Canada, and the boundary between Alaska and Canada. These appropriations are for the sum of $100 000 each per annum.

VI. OFFICE OF THE EDITOR OF PUBLICATIONS.

ISAAC WINSTON, *Editor.*

E. C. Hall, *Stenographer and Typewriter.*

The compilation of the Annual Report (pp. 1–1032), covering the progress of the work of the Survey, July 1, 1902, to June 30, 1903, was completed, made ready for printing, and transmitted to the Senate under date of September 2, 1903. This report was available for issue on April 1, 1904. Thirteen leaflets, describing the work of the Survey, used at former expositions, were revised and published for use at the Louisiana Purchase Exposition at St. Louis.

Considerable progress was made in collecting, compiling, and copying material relating to the history of the Survey.

Numerous assignments to temporary duty were completed, and all possible aid was extended to officers engaged in preparing material to form a portion of the Annual Report.

The publications of the Coast and Geodetic Survey during the fiscal year are given in the following list:

Report of the Superintendent showing the progress of the work July 1, 1902, to June 30, 1903, 1,032 pages, with following appendices, published also as separates.
No. 3. Precise Leveling in the United States, 1900–1903, with a readjustment of the level net and resulting elevations. 623 pages.
No. 4. Triangulation southward along the ninety-eighth meridian in 1902. 120 pages.
No. 5. Results of magnetic observations made by the Coast and Geodetic Survey between July 2, 1902, and June 30, 1903. 74 pages.
No. 6. Channel and Harber Sweep. 6 pages.
United States magnetic declination tables and isogonic charts for 1902, and principal facts relating to the earth's magnetism. (2d edition) 405 pages.
United States Coast Pilot, Atlantic Coast, Parts I and II, from the St. Croix River to Cape Ann. (2d edition) 243 pages.
United States Coast Pilot, Atlantic Coast, Part III, from Cape Ann to Point Judith. (2d edition) 199 pages.
United States Coast Pilot, Pacific Coast, California, Oregon, and Washington. 215 pages.
Supplement, United States Coast Pilot, Atlantic Coast, Part VI. (2d edition) 10 pages.
Supplement, United States Coast Pilot, Atlantic Coast, Part VII. (2d edition) 18 pages.
Supplement, United States Coast Pilot, Atlantic Coast, Part VIII. (2d edition) 26 pages.
Supplement, United States Coast Pilot, Pacific Coast, Alaska, Part I. 14 pages.
Coast Pilot Notes on Warren Channel and Davidson Inlet, Alaska. 4 pages.
Tide Tables for the year 1904. 508 pages.
Tide Tables, Atlantic Coast (reprint), 1904. 177 pages.
Tide Tables, Pacific Coast (reprint), 1904. 161 pages.
Notices to Mariners, Nos. 299 to 312.

Catalogue of Charts, 1903. 174 pages.

Report of Geodetic Operations in the United States to the Fourteenth General Conference of the International Geodetic Association. 28 pages.

Leaflets for distribution at the Louisiana Purchase Exposition at St. Louis, Mo.

No. 1. The Coast and Geodetic Survey. 5 pages.
No. 2. Triangulation and Reconnaissance. 4 pages.
No. 3. Base Apparatus. 10 pages.
No. 4. Time, Latitude, Longitude, and Azimuth. 4 pages.
No. 5. Terrestrial Magnetism. 4 pages.
No. 6. Hydrography. 4 pages.
No. 7. Topography. 4 pages.
No. 8. Tides and Tidal Currents. 4 pages.
No. 9. Leveling.
No. 10. Coast Pilots. 4 pages.
No. 11. Chart Publications. 4 pages.
No. 12. Gravity. 4 pages.
No. 13. Geodesy, or Measurement of the Earth. 5 pages.

Notices to Mariners and volumes of sailing directions were prepared and published in Manila, P. I., and issued from the suboffice at that place, as follows, viz:

Philippine Island Notices to Mariners Nos. 6 to 12 of 1903 and Nos. 1 to 5 of 1904.
Sailing Directions, Philippine Islands, Part I. (2d edition) 61 pages.
Sailing Directions, Philippine Islands, Part II. (2d edition) 59 pages.
Sailing Directions, Philippine Islands, Part VI. 87 pages.
Sailing Directions, Philippine Islands, Part VII. 114 pages.

NECROLOGY.

George A. Fairfield, for many years an Assistant in the Coast and Geodetic Survey and at the time of his death the Assistant to the Officer in Charge of the Office, died at the home of his son, in Saco, Me., on Friday, July 17, 1903.

Mr. Fairfield was born at Saco, Me., March 1, 1829. He was a graduate of Bowdoin College, Maine, and entered upon his life's work on June 23, 1849, in his twenty-first year, when he was appointed an aid in the field force of the Coast Survey. He remained in office until death ended his long career of fifty-four years of faithful public service. His first service was under the late Assistant C. O. Boutelle on triangulation on the coast of Maine and Massachusetts, and four years later he was made chief of an independent party. In 1853–54 he inaugurated and was in charge of a comprehensive series of tidal observations along the Atlantic and Gulf coasts. In the spring of 1855 he was assigned to duty on the Pacific coast, relieving the late Gen. Richard D. Cutts of the charge of the triangulation north of San Francisco. He returned to duty on the eastern coast in 1858, and during the civil war served under Gen. J. G. Foster and Admiral S. P. Lee, 1863–64, on the coast of North Carolina, where he made surveys required by the United States Army and Navy to facilitate their operations. His work extended over a large portion of the Atlantic seaboard, and during the years 1880–1890 he was in charge of that portion of the transcontinental triangulation lying in the States of Illinois and Indiana, a most difficult country for such work, where it was necessary to use the highest observing tripods and scaffolds ever used in geodetic work up to that date. On August 16, 1893, he was assigned to the charge of the work of furnishing points for State surveys, and continued on this duty until May 17, 1895. During this time he also had charge of the Tidal Division for a short period in 1894 and of the Engraving Division June 11, 1894, to June 30, 1895. He returned to field duty in July, 1895, and remained so employed until May 5, 1898, when he was assigned permanently to the Office, and served in the Computing Division and in the Office of the Assistant in Charge until the date of his death. Mr. Fairfield was more fortunate than most men in having served his country faithfully for more than half a century, and the record of his work in the archives of the Survey forms an enviable monument to his memory. At a meeting of the members of the Coast and Geodetic Survey held at the Office on July 20, 1903, the following resolution was one of those unanimously adopted:

> That in the death of our late associate, George Albert Fairfield, the public service, and especially the Bureau of which he was a member, has been deprived of the services of a man whose honesty of purpose and faithful performance of duty have always been beyond question. All duties intrusted to him were conscientiously performed, and he has left an enduring monument in the archives of the Bureau in the record of his large share in the "Survey of the Coast" during his fifty-four years of continuous service. His methodical nature and painstaking habits render the records of his work standards well worthy of emulation, and his uniform good nature endeared him to all who knew him.

Mary A. Grant, Writer, died on December 29, 1903. She was born in England, November 6, 1836, and was appointed in the Survey from Wisconsin on May 26, 1898.

Edwin Horatio Fowler, Chief Draftsman, died on March 11, 1904. Mr. Fowler was born in South Newberry, N. H., October 20, 1856. He graduated from the Chandler Scientific Department of Dartmouth College in 1878, and on July 9, 1879, entered the Coast and Geodetic Survey as Draftsman. He served in that capacity until 1897, when he was made Chief Draftsman, and held this position when he died. During the period 1897–1904 the work of the Drawing Section was admirably systematized under his immediate direction, all chart corrections being arranged on "History sheets," under the card-catalogue system. The process of transferring to original sheets the notes, titles, and general lettering which are common to all was adopted so that the work of preparing these sheets for approval and registration is reduced to a minimum; and sheets of standard letters with a self-spacing device were prepared and resulted in a method of building up titles which will eventually insure uniformity in the titles of all the field sheets and all the charts published by photolithography. Mr. Fowler was an accomplished draftsman, and the work executed by him and under his direction forms an enduring record of his energy and ability during his many years of faithful service to the Government.

Henri Louis François Marindin, for many years an Assistant in the Coast and Geodetic Survey, and a distinguished member of the field force, died on March 25, 1904.

Mr. Marindin was born at Lausanne, Switzerland, July 2, 1843, and received his early education in the Swiss schools. He came to the United States before attaining manhood, and finished his scholastic education in the Owego Academy at Owego, N. Y., 1860–1863.

He entered the Coast Survey as aid on November 26, 1863, and was soon assigned to duty in a party engaged in the survey of Roanoke River, North Carolina, made at the special request of Admiral S. P. Lee, flag officer of the North Atlantic blockading squadron, the party being quartered on the gunboat *Seymour* for that purpose. In 1864 he served in a topographic party at work in the vicinity of Bermuda Hundred, Va., under the orders of Major-General Butler, with Brigadier-General Weitzel in immediate charge of the work; and later in the same year, and in January, 1865, he served in a topographic party engaged in work along the Potomac River under the direction of Maj. C. S. Stewart. He thus began his service to the nation of his adoption by aiding in the perpetuation of the Union, and continued to serve his country faithfully until death ended his long and honorable career. In 1865 he was engaged in special surveys for a canal route through Nicaragua, and in 1870 he was engaged in a similar work on the Isthmus of Darien. His special work in the Coast Survey was in the field of physical hydrography, and many important features in the currents and in the development of harbors and bars along the Atlantic and Gulf coasts of the United States have been made known to commerce as the result of his systematic and careful investigation of the complex problems presented as the result of the action of winds and tides on the waters of the sea. He spent more than eighteen years in command of vessels of the Survey while engaged in this work. On March 24, 1897, he was appointed by President McKinley to represent the Coast and Geodetic Survey on the Mississippi River Commission, and after that date devoted much time and attention to the duties thus imposed upon him, but continued his regular work on the Survey whenever it was possible to do so. His particular ability was recognized by numerous special assignments to duty in connection with harbor boards to establish harbor lines, and in the establishment of speed-trial courses for vessels of the Navy, and is shown in several scientific discussions of various physical problems relating to hydrography which have appeared from time to time as appendices to the Annual Report of the Superintendent. At a meeting of the members of the Coast and Geodetic Survey, held at the Office on March 25, 1904, the following resolution was one of those unanimously adopted:

> *Be it resolved*, That the members of this service desire to express their sense of the irreparable loss suffered by the Survey in the death of so able and efficient an officer, who, in the course of his service of more than forty years, had distinguished himself in many branches of their common labors, and their own sorrow in thus parting from a friend endeared to them by many charming traits of character and respected by all for his steadfast devotion to duty.

Adolph Lindenkohl, the Senior Draftsman in the Coast and Geodetic Survey, died on June 22, 1904, after a faithful and distinguished service covering the past fifty years.

Mr. Lindenkohl was the son of George C. F. and A. E. Lindenkohl, and was born at Niederkaufungen, Hesse-Cassel, Germany, on March 6, 1833. He was educated at the Realschule (Cassel, 1844–1849) and the Polytechnische Schule (Cassel, 1849–1852), graduating at the latter institution in 1852. Soon after graduating he came to the United States and engaged in teaching for two years. In 1854 he became a citizen of his adopted country and was appointed draftsman in the Coast Survey, and held this position with distinguished ability until the day of his death.

He spent much of his leisure time in studying the vast physical problems relating to the earth, devoting himself especially to physical geography, oceanography, and deep-sea temperatures, densities, and currents. Numerous articles upon these subjects were written by him and have been published as appendices to the Coast and Geodetic Survey Reports, in Petermanns Mitteilungen, and in the American Journal of Science. He was always much interested in geographical exploration and spent a good deal of time in compiling maps from original sources, unofficially. His ability was rewarded in the Coast Survey by rapid promotion through all the grades of his profession until be became a recognized authority on chart publication. Being endowed with a remarkable memory for facts and dates, his intimate acquaintance with the chart work of the Survey during the fifty years of his service was of very great value in all matters concerning the compilation of charts from the older records, and the numerous drawings compiled and made by him during the last half century bear witness to the skill and fidelity which distinguished his career. His work was always rapidly executed and characterized by accuracy. During the civil war, in 1862–1864, he was detailed to serve with the Army as topographer, thus aiding in the preservation of the Union. His first service was in aiding Assistant A. M. Harrison in the topographic survey of the northern bank of the Potomac River in the vicinity of Rosiers Bluff in December, 1862, under the direction of the Engineer Department of the Army. In the following summer he was assigned as topographer under the direction of Col. J. H. Alexander, acting chief engineer of the defenses of Baltimore. At the request of the chief engineer of the Military Department of West Virginia, Lieutenant Meigs, Mr. Lindenkohl was detailed in October, 1863, to assist in compiling the data which had been collected at Clarksburg from army surveys and by expeditions of the cavalry forces. Other material, procured from the records of surveys at Annapolis and Baltimore, Md., and from the Engineer Bureau, was made auxiliary to the preparation of a military map of the department. Mr. Lindenkohl also assisted in the construction of a large map of the environs of Cumberland and computed the longitude of a number of places in the State, from sextant observations by Lieutenant Meigs. He was employed in West Virginia until the 16th of February, and then returned to duty in the Drawing Division of the Coast Survey Office. Mr. Lindenkohl was a member of the following Societies: The American Association for the Advancement of Science, the Washington Academy of Sciences, the Philosophical Society of Washington, and the National Geographic Society.

APPENDIX 1

REPORT 1904

DETAILS OF FIELD OPERATIONS

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Indiana.
Kentucky.
Maine.
Maryland.
Massachusetts.
Michigan.
Mississippi.
New Hampshire.
New Jersey.
New York.
North Carolina.
Ohio.
Pennsylvania.
Rhode Island.
South Carolina.
Tennessee.
Vermont.
Virginia.
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Wisconsin.

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3	Hydrography.	Maine.	Boutelle.	Bache.	44
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6	Hydrography. Magnetic observations.	Massachusetts. Virginia.	Faris.	Blake.	47
7	Hydrography. Topography.	Maryland.	Flower.	Matchless.	49
8	Topography.	Maryland. Virginia.	Forney.		51

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19	Hydrography. Topography.	New Jersey. New York.	Quillian.		66
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21	Magnetic observations.	Alabama. Georgia. Louisiana. Ohio.	Smith, L. B.		69

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29	Reconnaissance.	Minnesota.	Burger.		77
30	Astronomic observations. Triangulation.	Minnesota. North Dakota. South Dakota.	Burger.		80
31	Triangulation.	Texas. Minnesota. South Dakota.	Ferguson.		81
32	Tide observations.	Texas.	Marindin.		84
33	Magnetic observations.	Kansas.	Smith, L. B.		84
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39	Astronomic observations. Magnetic observations.	Montana.	Eimbeck. Preston.		89
40	Astronomic observations. Reconnaissance. Triangulation.	California. Oregon. Washington.	French.		90
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53	Hydrography. Magnetic observations. Topography.	Hawaii.	King.		112
54	Astronomic observations.	Pacific Islands.	Smith, E. Morse.		114
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58	Astronomic observations. Base measurement. Hydrography. Magnetic observations. Topography. Triangulation.	Philippine Islands.	Derickson.	Research.	125
59	Topography. Triangulation.	Philippine Islands.	Fairfield.		127
60	Astronomic observations. Base measurement. Topography. Triangulation.	Philippine Islands.	Flynn.		127
61	Base measurement. Hydrography. Physical hydrography. Topography. Triangulation.	China Sea. Philippine Islands.	Gilbert.	Pathfinder.	128
62	Astronomic observations. Magnetic observations.	Philippine Islands.	McGrath. Fairfield.		133
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DETAILS OF FIELD OPERATIONS.

EASTERN DIVISION.

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L. G. SCHULTZ, *Magnetic Observer.*	Aug. 1 to 10.
W. F. WALLIS, *Magnetic Observer.*	Aug. 2 to June 30.
S. G. TOWNSHEND, *Magnetic Observer.*	Aug. 1 to June 30.
W. M. HILL, *Magnetic Observer.*	Mar. 10 to Apr. 10.

The direction of the work at the Magnetic Observatory* at Cheltenham, Md., August 1 to June 30, was assigned to Assistant Bauer. Magnetic Observer W. F. Wallis was placed in immediate charge of the work on August 1 and continued in charge during the fiscal year. Mr. L. G. Schultz was on duty at the observatory August 1 to 10, Mr. S. G. Townshend from August 1 to June 30, and Mr. W. M. Hill March 10 to April 10.

Two sets of self-registering magnetographs were in continuous operation. Absolute observations for the determination of the base lines were made at least once a week, and some check determinations were made with another set of instruments. The scale values for the self-registering instruments were determined once a month. Observations of atmospheric electricity were made once a week. Special records on the magnetographs were obtained on the first and fifteenth of each month.

Various visits of inspection were made to the field parties in the eastern division, and during these, magnetic observations were made by Assistant Bauer at the following places: In September at Elizabeth and Salem, N. J.; in February at Lafayette and St. Bernard, La., and at Aikin, S. C.; and in June at Linden, Md.

MAGNETIC OBSERVATIONS. TRIANGULATION.	MAINE.	J. B. BAYLOR.

B. C. LILLIS, *Aid.*

SUMMARY OF RESULTS.

Magnetic observations:
  2 stations occupied.
Triangulation:
  187 square miles area covered.
  5 stations occupied.
  14 geographic positions determined.

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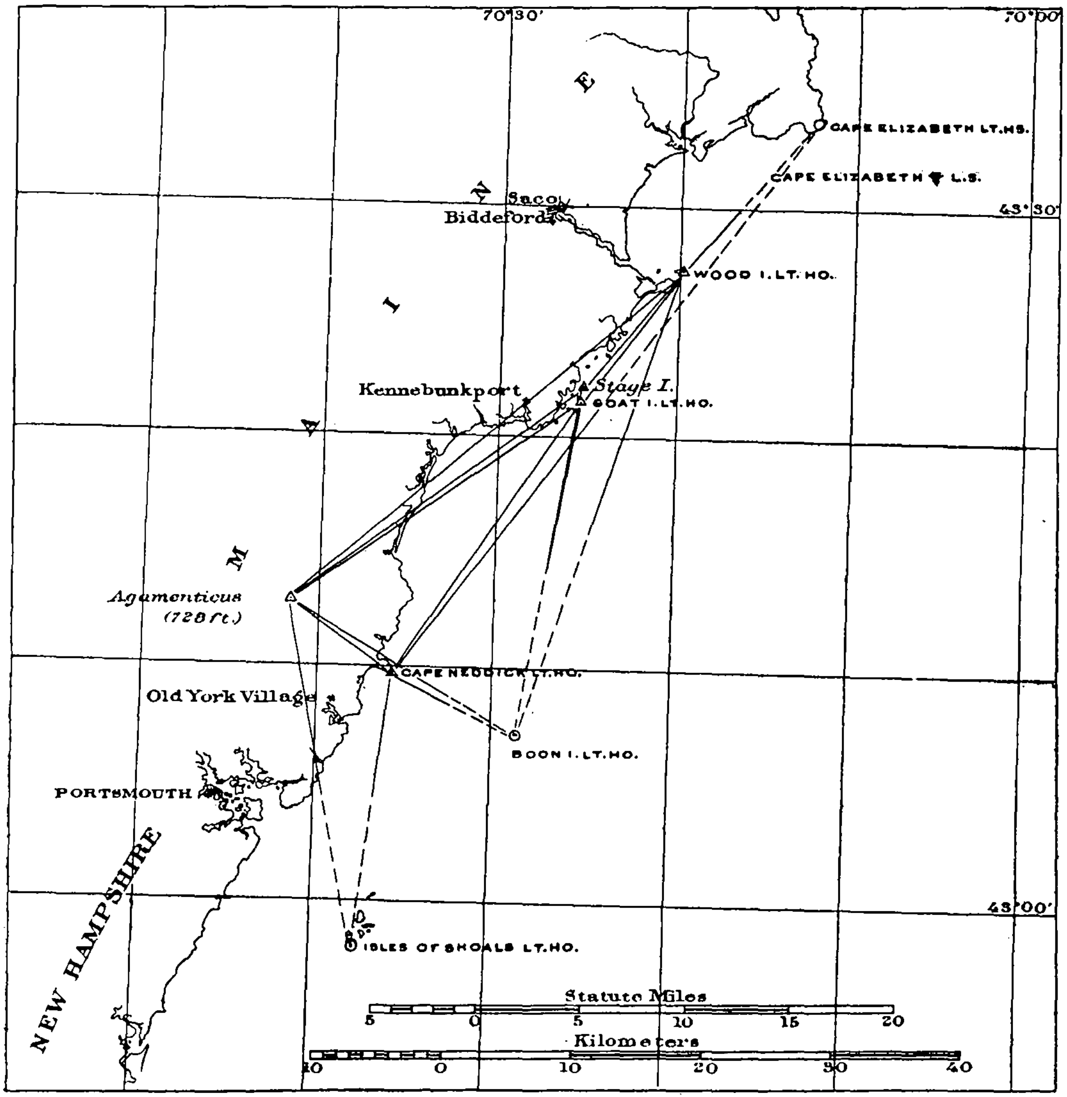
*The work at this observatory was under the direction of L. G. Schultz, Magnetic Observer, July 1 to July 31.

The determination of the geographic position of certain light-houses on the coast of Maine was assigned to Assistant Baylor, and he began the necessary field work in the vicinity of Kennebunkport on September 30, 1903.

He recovered the old triangulation stations Agamenticus and Stage Island, and used the line between them as a base in determining by triangulation the position of the following light-houses, viz: Wood Island, Goat Island, Boon Island, and Cape Neddick.

No. 1.



Triangulation, coast of Maine.

The two triangulation stations named and three of the light-houses were occupied for observations of horizontal angles. Several days were spent at Boon Island Light-house, but unfavorable weather prevented observations, and the attempt to secure observations at this point was finally abandoned because of the difficulty of leaving the island so late in the season.

Observations were made to determine the three elements of terrestrial magnetism at two stations, Kennebunkport and Portland.

The work for the season closed on November 21 on account of unfavorable weather.

HYDROGRAPHY. MAINE. J. B. BOUTELLE, Commanding,
Steamer *Bache*.

WM. M. ATKINSON, *First Watch Officer*.
G. E. MARCHAND, *Surgeon*.
M. F. FLANNERY, *Chief Engineer*.
J. A. MCGREGOR, *Second Watch Officer*.
WM. SANGER, *Captain's Clerk*.
E. C. SASNETT, *Aid*.
J. W. YATES, Jr., *Deck Officer, Second Class*.
E. V. MILLER, *Junior Captain's Clerk*.

SUMMARY OF RESULTS

Hydrography:
152 miles lines sounded.
10 700 soundings made.
12 tide stations established.
15 hydrographic sheets completed.

Hydrographic examinations on the coast of Maine were assigned to Assistant Boutelle, commanding the steamer *Bache*. The vessel left Delaware Breakwater on August 17 and proceeded to Bar Harbor, Me. Field work began in that vicinity on August 20 and was continued until August 26, when the vessel left for New York under instructions for special duty in connection with the patrol of the first annual regatta of the New York Bay Regatta Association. (See Special Duty.)

Field work was resumed on September 4 and continued without further interruption until November 4. During this time hydrographic examinations were made in the following localities, viz: Eastern Bay, White Ledge, Winter Harbor, Mouth of Blue Hill Bay, vicinity of Green Islands, Harrimans Ledge, Blue Hill Bay, York Narrows, Penobscot Bay, vicinity of the Sloop and Barred islands, Muscle Ridge Channel, Hurricane Sound, Muscongus Sound, Johns River, mouth of Kennebec River in vicinity of Bath and Richmond, Casco Bay in vicinity of Stave Island, and two ledges in Saco Bay off Old Orchard Beach. The field work of the party under Mr. Boutelle closed on November 4, when he transferred the command of the ship to Assistant P. A. Welker. Further details of the work are given under Mr. Welker's name.

Mr. Boutelle states that all the officers, except the Chief Engineer, took part in the surveying operations and in the navigation of the vessel, and testifies to the willingness and efficiency with which they performed the duties assigned them, and Mr. Atkinson receives special mention as a very able and efficient navigator and seaman.

COMPASS RANGE MARKS. DELAWARE. J. B. BOUTELLE.

The erection of marks on Delaware Breakwater, entrance to Delaware Bay, to serve as ranges in the determination of the deviation of ships' compasses, was assigned to Assistant Boutelle.

The exact location of all the marks had already been determined by Assistant H. L. Marindin, who had also ordered the marks, and Mr. Boutelle found them at Lewes, Del., when he arrived on May 13.

These marks are galvanized iron tubes 14 feet long and 5 inches in diameter, set about 3 feet in the stone forming the breakwater, in the proper positions to indicate, when used in connection with a single back range, angular changes of 1° in the lines joining the ranges.

The zero mark, or range indicating the true north and south line, has an iron triangle bolted to the top of the iron post, and the posts indicating the line of 5° west of the zero mark and the lines of 5°, 10°, 15°, and 20° east of the zero mark have circular targets bolted to their tops. These targets are formed of iron rings filled with wire netting with large white figures at their centers indicating the proper number of degrees from the zero mark which the line joining them and the back range makes with the north and south line. The other posts marking the degrees up to 5° west and up to 20° east of the zero mark are without targets. A house on the breakwater prevented the use of posts to mark the line of 7° and 8° east of the zero mark.

The back mark to be used in connection with all the marks on the breakwater is the east one of two tall chimneys to a fish-oil factory at Lewes, and on this chimney a white band, 12 feet wide, was painted near the top.

Ships anchored off the breakwater can determine the compass corrections by noting the bearings of the ranges as the ship swings with the tide.

The work was completed and Mr. Boutelle reported at the Office on June 1.

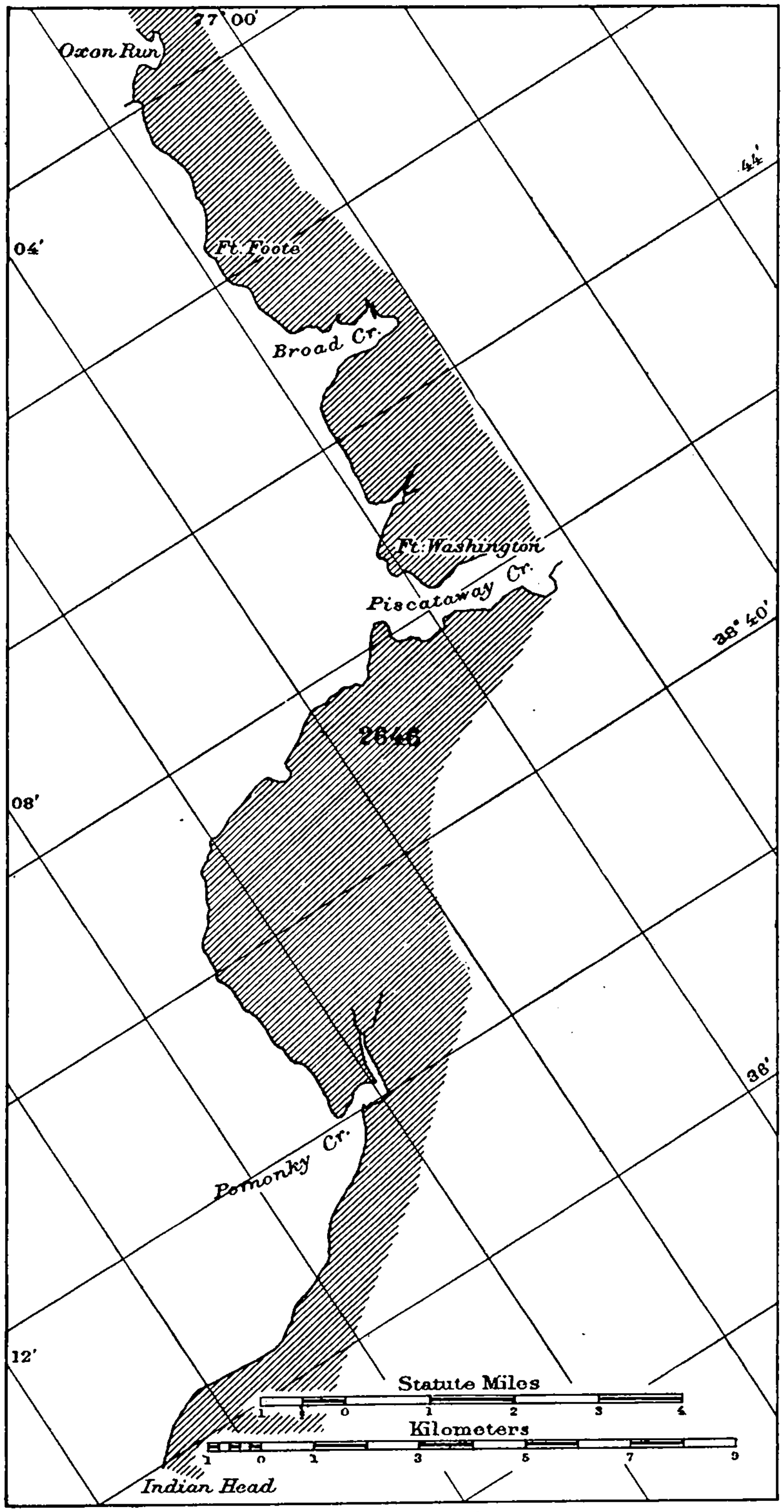
TOPOGRAPHY. MARYLAND. J. W. DONN.

SUMMARY OF RESULTS.

15 square miles area covered.
16 miles shore line of rivers surveyed.
27 miles shore line of creeks surveyed.
53 miles of roads surveyed.
2 topographic sheets completed.

On July 1 the topographic resurvey along the Maryland shore of the Potomac River north of Indian Head was in progress under the direction of Extra Observer J. W. Donn. His party was quartered at Alexandria as the only available boarding place for the members of the party. The War Department granted authority for the teamster and horses to occupy quarters at Fort Foote, and a launch was used to transport the party from Alexandria to and from Fort Foote and in making the survey of the shore line of the river and creeks. The horses and wagon were used in

No. 2.



Topography, Potomac River.

making the topographic survey away from the river, and the poor condition of the roads caused considerable delay in the progress of the work.

At the request of the commanding officer at Fort Washington, the distances to certain points, referred to certain other points on the ranges used in gun practice, were determined.

The survey was completed to the boundary line of the District of Columbia on October 31, and the field work closed for the season.

HYDROGRAPHY. MAGNETIC OBSERVATIONS.	MASSACHUSETTS. VIRGINIA.	R. L. FARIS, Commanding, Steamer *Blake*.

L. M. FURMAN, *First Watch Officer*.	
L. M. HOPKINS, *Chief Engineer*.	Aug. 7 to Aug. 17.
D. C. YOUNG, *Acting Chief Engineer*.	Aug. 28 to Oct. 26.
WM. B. PROCTOR, *Second Watch Officer*.	
J. H. EGBERT, *Assistant Surgeon*.	
W. F. GLOVER, *Third Watch Officer*.	
GEO. OLSEN, *Fourth Watch Officer*.	
E. W. KRAMER, *Aid*.	Oct. 6 to Oct. 26.
H. M. TRUEBLOOD, *Aid*.	

SUMMARY OF RESULTS.

Hydrography:
  600 square miles area covered.
  1 145 miles line sounded.
  9 441 soundings made.
  3 tide stations established.
  1 current station occupied.
  5 hydrographic sheets completed.
Magnetic observations:
  4 stations occupied.

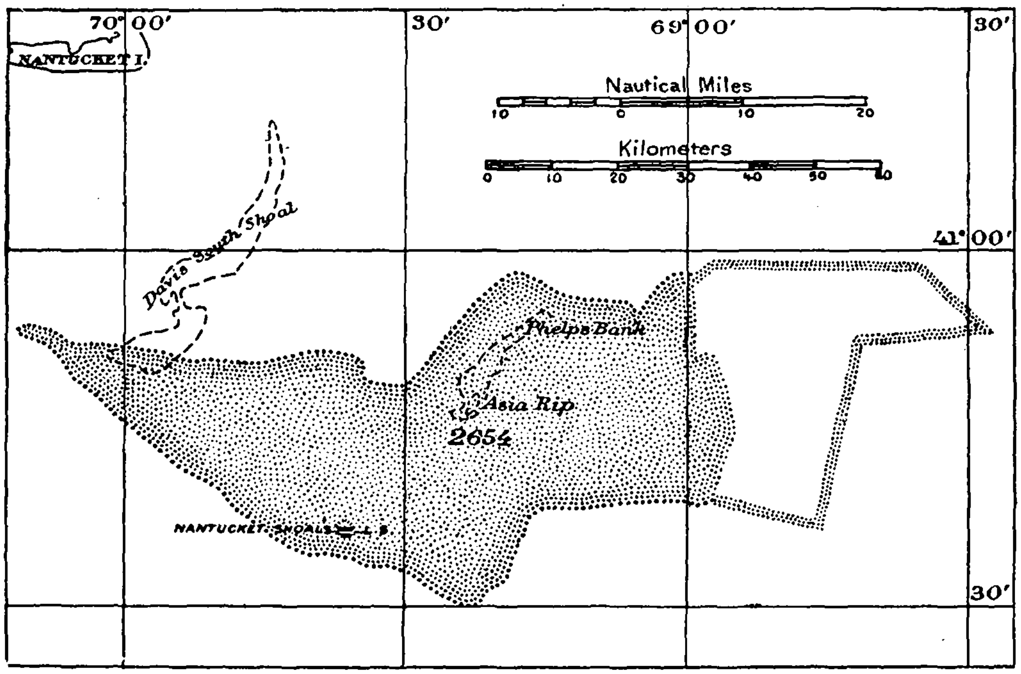
Hydrographic examinations on the coasts of Virginia and Maine were assigned to Assistant Faris, commanding the steamer *Blake*. On August 7 the vessel, with Assistant E. B. Latham temporarily in command, proceeded to make magnetic observations afloat in the vicinity of Old Point Comfort by swinging the ship, and in the afternoon sailed for Winter Quarter Shoal. Several hours were spent in sounding in this vicinity without developing any indications of the reported shoal.

The vessel reached New Bedford on the 10th, and magnetic observations were made the same day by swinging the ship. A tide gauge was established, signals were erected, and hydrographic work began on the 12th and was continued until the 20th, when Assistant Faris came on board and relieved Mr. Latham of the command of the ship.

Work in Buzzards Bay was then suspended and preparations were made to take up the examination of Nantucket South Shoals in the vicinity of Nantucket light-vessel. Soundings began on August 27 and were continued, whenever the weather permitted, until October 10. In the development of Phelps Bank a notable change in the depth of the water was found. Most of the shoal spots reported by passing ships were found to exist. The execution of this work was difficult and unsatisfactory on account of the fog, haze, and windy weather that prevailed and the irregularity of the tidal currents in this locality. Continued bad weather made it desirable to close work on Nantucket Shoals at this time. On October 12 the development of certain critical spots in Buzzards Bay was resumed, and was completed on the 15th.

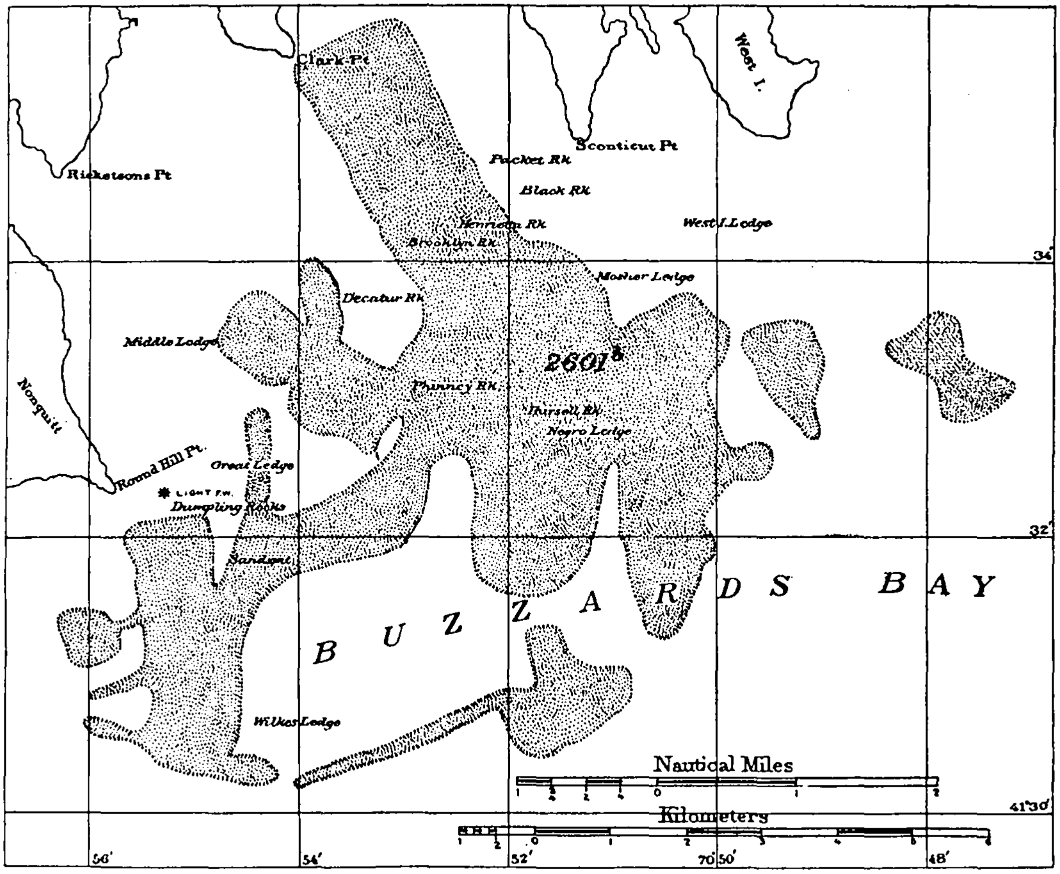
On the 19th Rhode Island Rock, near Cottage City, Mass., was located, and magnetic observations were made at a station on shore near New Bedford. On the 20th magnetic observations were made afloat by swinging the ship, and on the same day Almys Rock, in Sakonnet River, Rhode Island, was found and located and lines of soundings were run to develop the region in the vicinity of the rock. This closed the hydrographic work for the season, and on October 22 the ship sailed for Baltimore and reached there on the 26th. During the voyage such magnetic observations as the weather permitted were made daily, but a complete set could not be made until the 25th, in Chesapeake Bay. Assistant Faris states that all the officers on board, except the Chief Engineer, assisted in the general survey duties assigned to the ship, and expresses his hearty appreciation of the way in which they cooperated with him in carrying out his instructions.

No. 3.



Hydrography, Nantucket Shoals, Massachusetts.

No. 4.



Hydrography, Massachusetts.

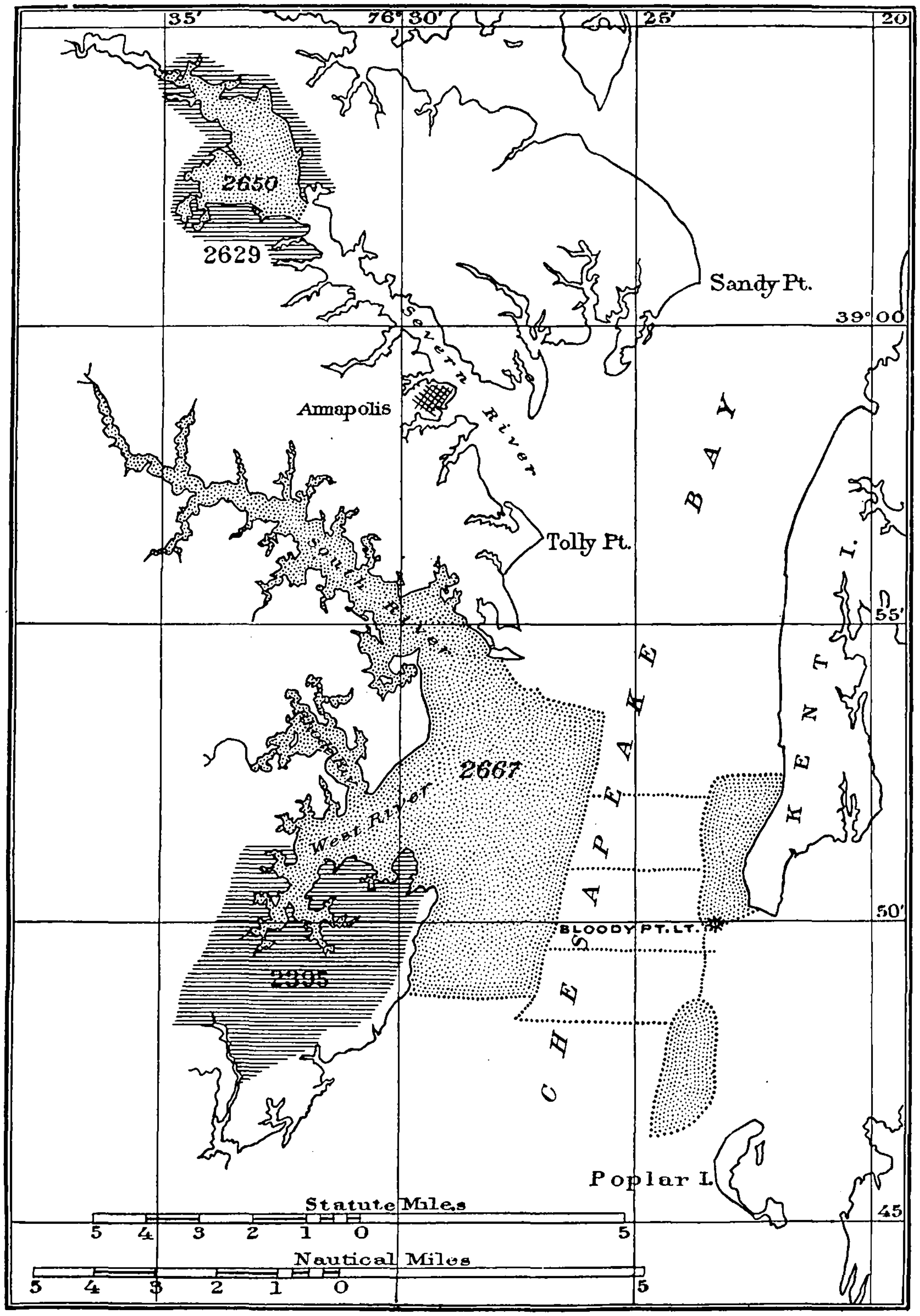
HYDROGRAPHY. MARYLAND. G. L. FLOWER, Commanding,
TOPOGRAPHY. Schooner *Matchless.*

J. C. LANDERS, *Aid.*	July 1 to July 27.
G. C. BALDWIN, *Aid.*	July 1 to Oct. 10.
J. W. MAUPIN, *Aid.*	
G. T. RUDE, *Deck Officer, Third Class.*	

SUMMARY OF RESULTS.

Hydrography:
55 square miles area covered.
520 miles lines sounded.
Topography:
20 square miles area covered.
1 mile shore line surveyed.
40 miles roads surveyed.

No. 5.



Hydrography and topography, Maryland.

On July 1 the continuation of the resurvey of the Severn River was in progress under the direction of Assistant Flower, commanding the schooner *Matchless*.

The topographic work was done by Mr. Landers and Mr. Maupin and was completed within the limits assigned on July 22. The hydrographic work was completed on the 25th and the vessel sailed for West River, via Annapolis, for supplies, and resumed work in that locality on July 29.

Nearly all the hydrographic signals built during the previous season were down. These were rebuilt and others were constructed for the work in hand. Mr. Maupin was placed on shore at West River with a plane-table party to continue the interior topographic work while the vessel completed hydrographic work on the eastern shore. On August 8 the vessel returned to West River and completed the hydrographic work on the west shore from Franklin Point to Thomas Point, including West River, Rhode River, South River, and the shoal water offshore to a depth of 5 fathoms on October 14.

This completed work of the party under Assistant Flower, and on October 15 the vessel proceeded to Baltimore. Mr. Flower states his pleasure in commending the officers of the vessel for their valuable and efficient services and for the zeal and cheerfulness with which they performed the duties assigned to them.

TOPOGRAPHY. MARYLAND. S. FORNEY.

VIRGINIA.

SUMMARY OF RESULTS.

July 1 to December 21.

43 square miles area covered.
16 miles shore line rivers surveyed.
20 miles shore line creeks surveyed.
95 miles roads surveyed.
2 topographic sheets completed.

April 30 to June 30.

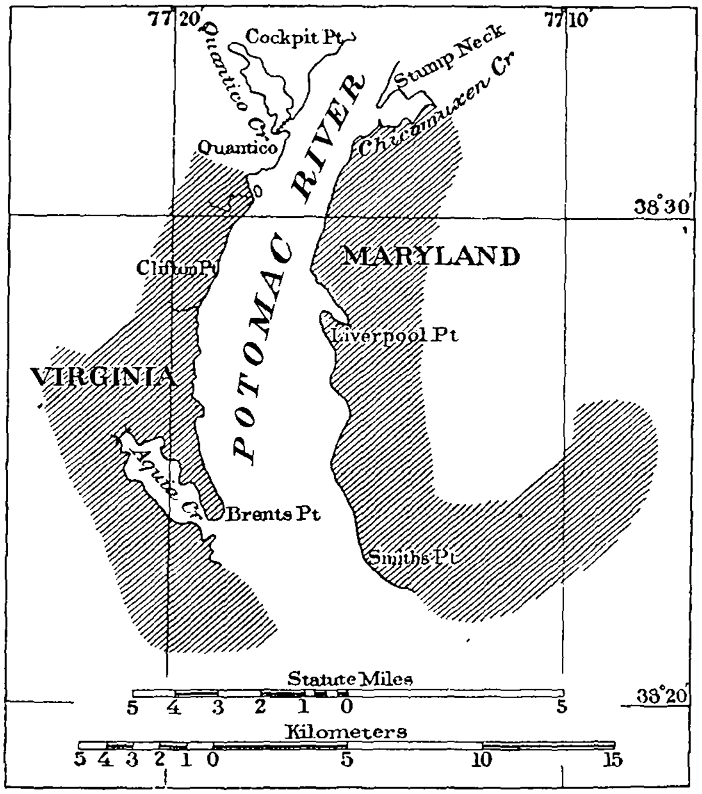
60 square miles area covered.
31 miles shore line rivers surveyed.
63 miles shore line creeks surveyed.
12 miles railroads surveyed.
105 miles roads surveyed.
2 topographic sheets completed.

On July 1 the topographic resurvey along the Potomac River in the vicinity of Maryland Point was in progress by a party under the direction of Assistant Forney, and the work was continued until December 21. During this period the resurvey was completed on the Maryland shore from Nanjemoy Creek to Budds Ferry and on the Virginia shore from Matomkin Point to Aquia Creek.

The work was extended inland from the river from 2 to 3 miles and includes the principal country roads and the prominent hills and ridges which overlook the river. The survey of the shore line of the creeks entering the river was based on a plane-table triangulation and transverse lines. Taken as a whole, the changes that have taken place since the previous survey are slight and unimportant. On December 21 the work was suspended for the winter and the party was disbanded.

Work on the resurvey of the banks of the Potomac River was resumed by Assistant Forney on April 30 and was in progress on June 30. The shore line of the river was completed to Stump Neck, and also the shore line of Mallows and Chicomuxen creeks in Maryland. In Virginia the shore line of the river was completed to Cockpit Point, and also the shore line of Aquia, Chopawamsic, and Quantico creeks. The interior work (contouring and roads) was completed to Chopawamsic Creek, in Virginia, and to Chicomuxen Creek, in Maryland.

No. 6.



Topography, Potomac River.

HYDROGRAPHY.
TOPOGRAPHY.

GEORGIA.

S. FORNEY.

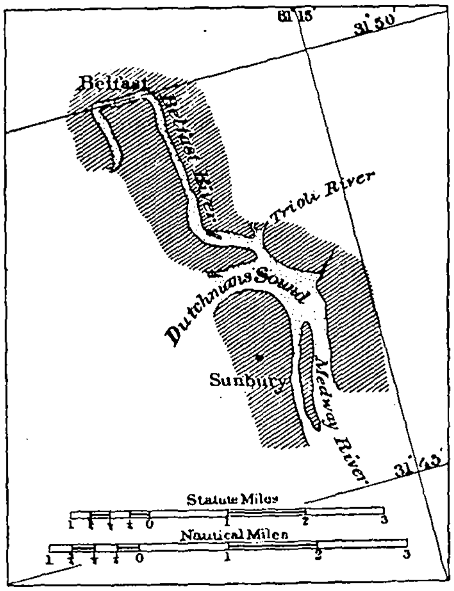
SUMMARY OF RESULTS.

Hydrography:
- 2 square miles area covered.
- 71 miles lines sounded.
- 8 718 soundings made.
- 2 tide stations established.
- 2 hydrographic sheets completed.

Topography:
- 14 miles shore line of rivers surveyed.
- 1 topographic sheet completed.

The extension of the survey of Medway and Belfast rivers, Georgia, to the head of navigation was assigned to Assistant Forney. He reached Savannah on January 28 and Belfast on the 31st. After considerable delay a suitable launch was hired for the work. Several of the old triangulation stations were soon recovered and signals were erected by using poles cut by the party, as it was impracticable to obtain sawed lumber. A plane-table triangulation was extended from the old work up the Medway and Belfast rivers to a point 1 mile above Belfast. The shores of the river are formed of marsh, which is covered at high water, and consequently it was necessary to build platforms as supports for the plane table. The shore line was surveyed between Sunbury and a point 1 mile above Belfast, and the hydrography covered the same region.

No. 7.



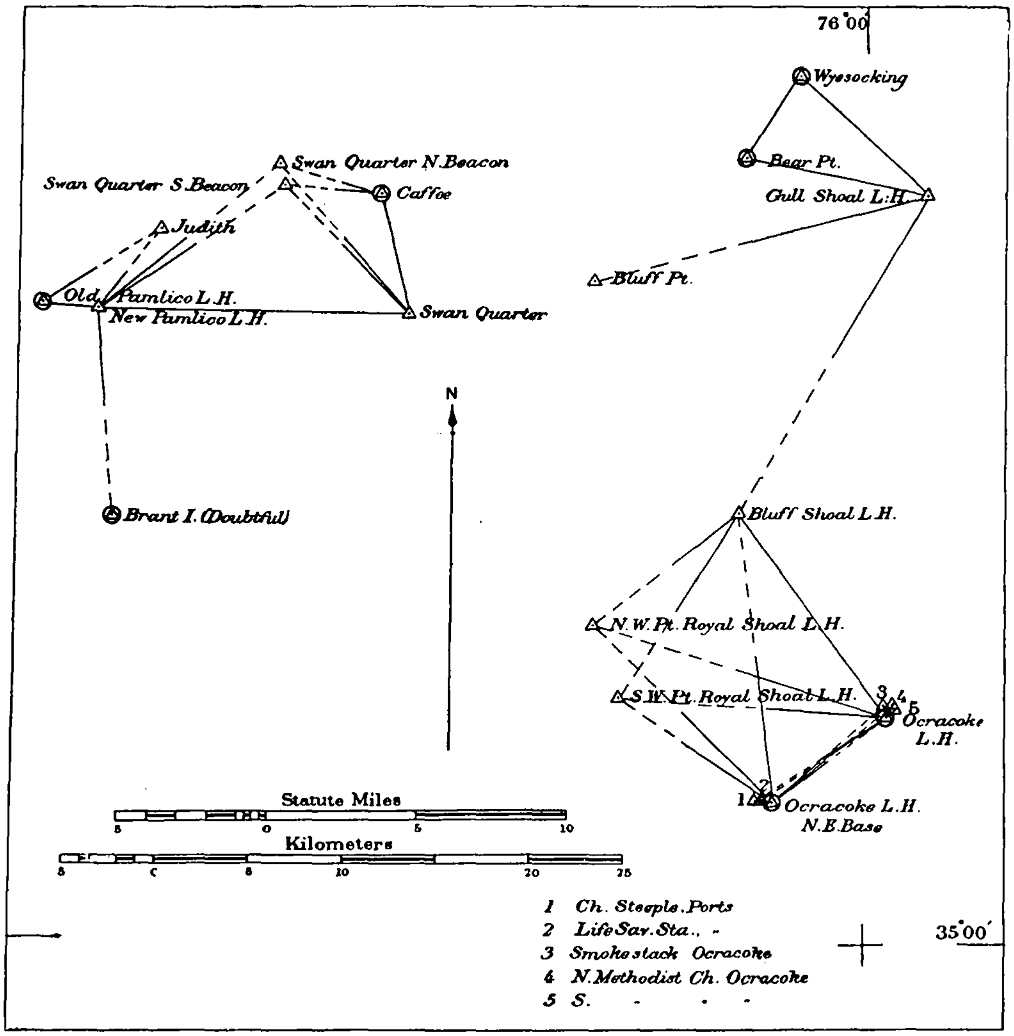
Hydrography and topography, Georgia.

The work was completed, and on April 18 Mr. Forney started to the Office. He expresses his appreciation of the many courtesies extended to the party by the officers and employees of the Hilton & Dodge Lumber Company, who did everything in their power to advance the progress of the work.

SUMMARY OF RESULTS.

108 square miles area covered.
16 stations occupied.
12 geographic positions determined.

No. 8.

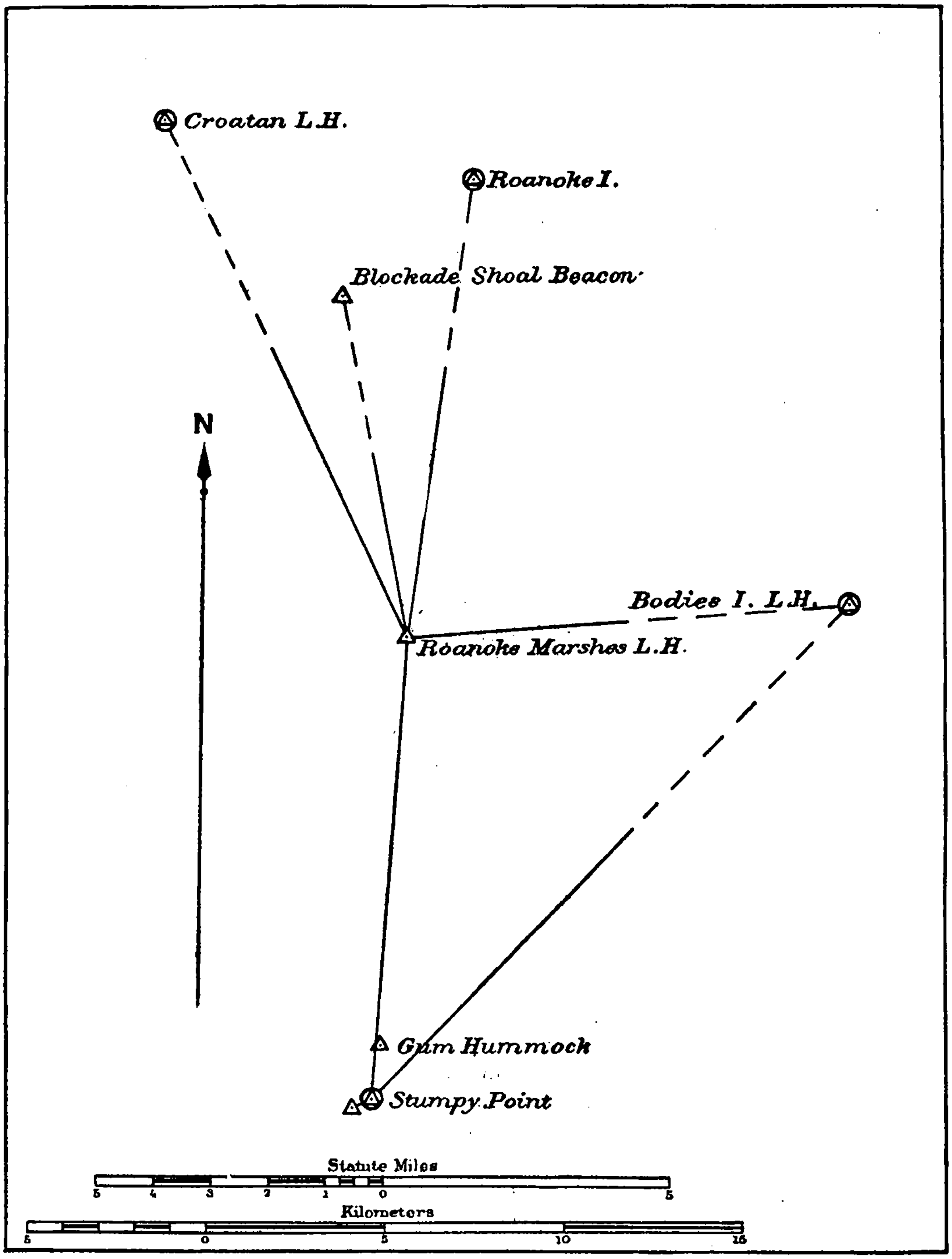


Triangulation, North Carolina.

The recovery of old triangulation stations in the vicinity of Albemarle, Croatan, Pamlico, and Core sounds, North Carolina, and the determination of the position of certain light-houses in the same locality was assigned to J. S. Hill, Aid.

He reached Elizabeth City on October 10, and made the necessary arrangements for beginning the work. After several days delay, waiting for the arrival of the

No. 9.



Triangulation, North Carolina.

instruments and other outfit, the field work began on the 19th by a general examination of the region in a small schooner chartered for that purpose. The shores are generally low and covered by marshes, and a considerable change in the shore line was noted, many of the stations having been destroyed as the result of erosion. An attempt was made to recover 50 of the old stations, and 20 of these were found and re-marked when necessary. Several triangulation stations were occupied in the vicinity of the following light-houses, and observations were made to determine their geographic positions, viz: Gull Shoal, Bluff Shoal, Northwest Point Royal Shoal, Southwest Point Royal Shoal. Observations were also made at stations in the vicinity of Swan Quarter and Pamlico light-houses, but the necessary work was not completed.

The winter was unusally severe and the work was delayed by unfavorable weather to a serious extent. Field operations closed for the season on the 29th of March.

MAGNETIC OBSERVATIONS. NEW JERSEY. OHIO. C. J. HOUSTON.

J. M. KUEHNE, *Magnetic Observer.*
L. B. SMITH, *Magnetic Observer.*
G. B. PEGRAM, *Magnetic Observer.*

The supervision of the extension of the magnetic survey in New Jersey and Ohio was assigned to Mr. C. J. Houston, Computer, Coast and Geodetic Survey.

Mr. Kuehne reported to Mr. Houston at Greenfield, Ohio, on July 3 and began magnetic observations at that place. On July 7 the work was turned over to Mr. Kuehne, who continued it until September 18. During this period the elements of terrestrial magnetism were determined at the following places in Ohio:

Berea.
Bowling Green.
Bryan.
Bucyrus.
Celina.
Defiance.
Delaware.
Elyria.
Findlay.
Forest.
Fremont.
Greenfield.
Kelleys Island.
Kenton.
Lima.
Mansfield.
Marysville.
Maumee.
Mount Gilead.
Napoleon.
Norwalk.
Oberlin.
Ottawa.
Paulding.
Port Clinton.
Put in Bay.
Sandusky.
Tiffin.
Toledo.
Upper Sandusky.
Wapakoneta.
Wauseon.

Messrs. L. B. Smith and G. B. Pegram began work in New Jersey on July 3. Mr. Smith remained in the field until July 11 and Mr. Pegram made magnetic observations at three stations under his direction and instruction. After that date he continued the work until September 22. During this period observations were made to determine the elements of terrestrial magnetism at the following stations:

Atlantic City.
Barnegat Light-house.
Bridgeton.
Camden.
Cape May Point.
Chatsworth.
Egg Island Light-house.
Freehold.
Longbranch.
Mays Landing.
Mount Holly.
Mount Rose.
Mount Royal.
New Brunswick.
Perth Amboy.
Port Norris.
Salem.
Sandy Hook.
Sea Isle City.
Toms River.
Trenton.

TOPOGRAPHY.
TRIANGULATION.

VIRGINIA.

E. B. LATHAM.

SUMMARY OF RESULTS.

July 2 to September 22.

Topography:
- 4 square miles area covered.
- 3 miles shore line surveyed.
- 2 miles shore line ponds surveyed.
- 1 mile road surveyed.
- 1 topographic sheet completed.

Triangulation:
- 56 square miles area covered.
- 8 stations occupied.
- 19 geographic positions determined.

November 4 to June 30.

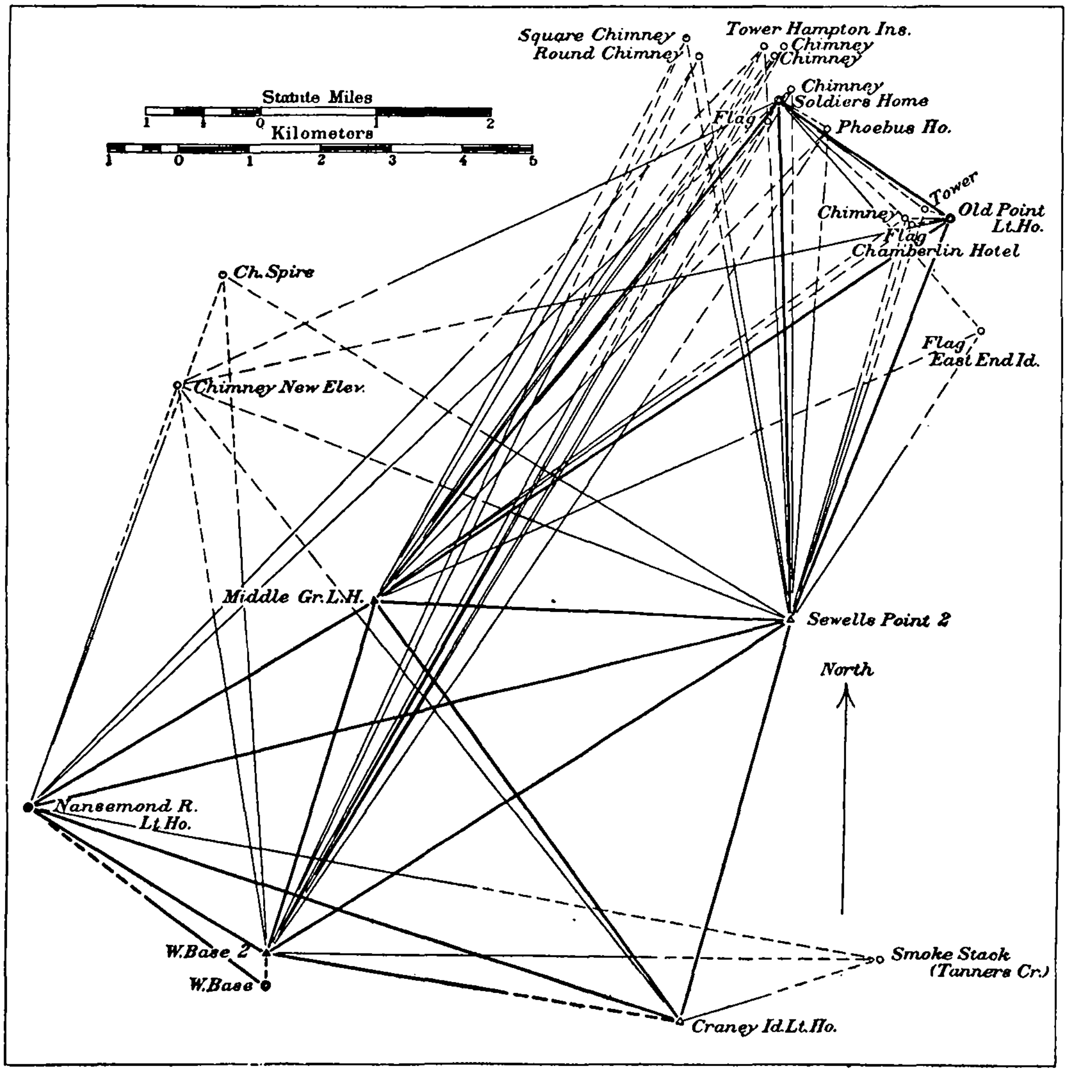
Topography:
- 135 square miles area covered.
- 170 miles shore line surveyed.
- 76 miles shore line creeks surveyed.
- 124 miles roads surveyed.
- 2 topographic sheets completed.

Triangulation:
- 110 square miles area covered.
- 15 stations occupied.
- 23 geographic positions determined.

The determination of the geographic position of certain objects in the vicinity of Hampton Roads, Virginia, was assigned to Assistant Latham. He began field operations on July 2 and completed the work on the 20th, and was then engaged on other duty (in command of the steamer *Blake*), until September 16, when he returned to Hampton Roads to locate the position of the wharf at Sewells Point and to make an examination for a reported shoal spot in the vicinity of Willoughby Spit. This work was completed on September 22, and the party was disbanded.

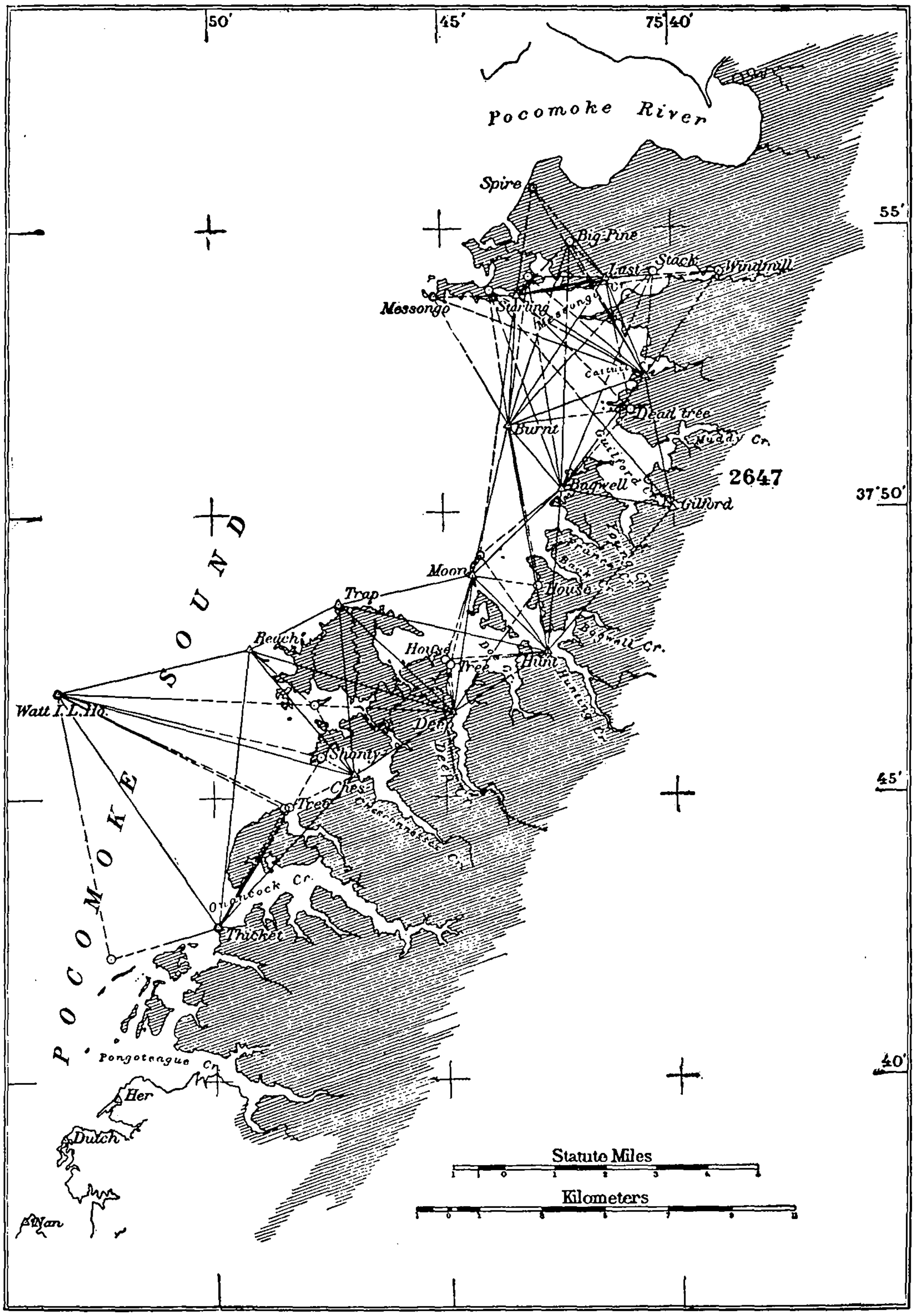
The extension of the survey along the shore of Chesapeake Bay, south of Pocomoke River, was also assigned to Assistant Latham. He made the necessary preparations, and on November 4 organized a party at Onancock, Va. The triangulation was extended from Pocomoke River to Onancock Creek and the topography was extended a short distance beyond this point, to Pongoteague Creek. Unfavorable weather considerably delayed the work during the winter months. The work was in progress at the close of the fiscal year.

No. 10.



Triangulation, Hampton Roads, Virginia.

No. 11.



Triangulation and topography, Maryland.

MAGNETIC OBSERVATIONS.

GEORGIA.
KENTUCKY.
NORTH CAROLINA.
SOUTH CAROLINA.
TENNESSEE.

F. M. LITTLE.

Stations occupied.

GEORGIA.

Statesboro.

KENTUCKY.

Barboursville.
Beattyville.
Booneville.
Brookville.
Campton.
Falmouth.
Frenchburg.
Georgetown.
Harlan.
Harrodsburg.
Hazard.
Hindmand.
Hyden.
Irvine.
Inez.
Jackson.
Lancaster.
Lawrenceburg.
London.
Louisa.
Manchester.
McKee.
Monticello.
Owenton.
Paintsville.
Pikeville.
Pineville.
Prestonsburg.
Salversville.
Sandy Hook.
Somerset.
Staunton.
Versailles.
West Liberty.
Whitesburg.
Williamsburg.
Williamstown.

NORTH CAROLINA.

Wadesboro.

SOUTH CAROLINA.

Aiken.
Aiken (Eustis Park).
Bamberg.
Barnwell.
Beaufort.
Bennettsville.
Conway.
Darlington.
Georgetown.
Kingstree.
Manning
Marion.
Moncks Corner.
St. George.
Walterboro.

TENNESSEE.

Athens.
Clinton.
Crossville.
Dayton.
Decatur.
Dunlap.
Huntsville.
Jamestown.
Jasper.
Kingston.
Loudon.
Pikeville.
Wartburg.

The extension of the magnetic survey in various localities in the eastern division was assigned to Assistant Little, and observations were made at the stations named above to determine the elements of the earth's magnetism. He reached Williamsburg, Ky., on July 3, and continued the work in this State until October 10. The work in Tennessee began on October 22 and extended to November 27. The work in North Carolina was done in January, beginning on January 6, and in February the stations in South Carolina and Georgia were occupied. The field work for the fiscal year closed at Statesboro, Ga., on February 27.

HYDROGRAPHY.
TOPOGRAPHY.
TRIANGULATION.

DELAWARE.

H. L. MARINDIN.

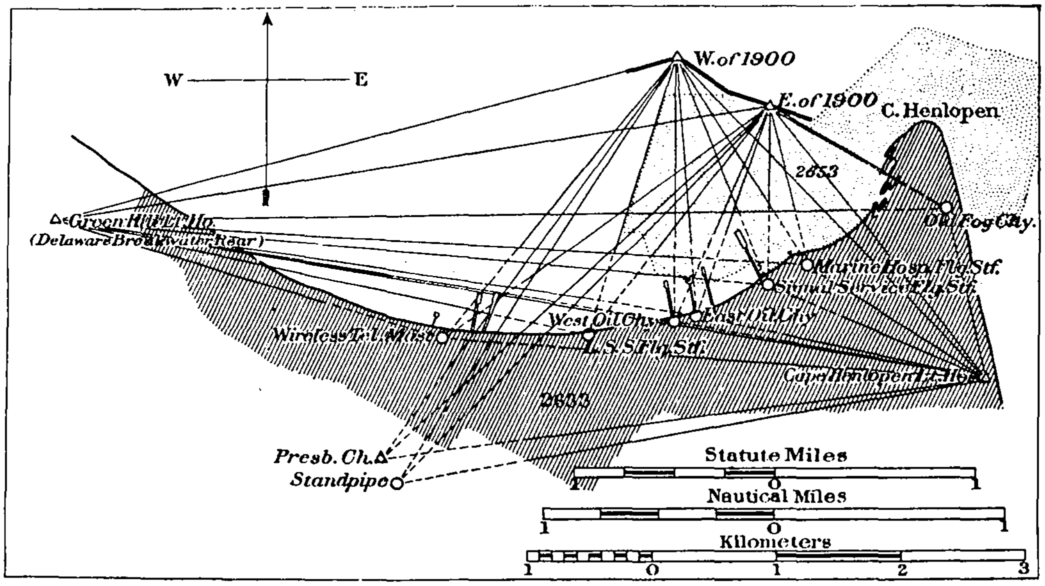
SUMMARY OF RESULTS.

Hydrography:
- 1 square mile area covered.
- 29 miles lines sounded.
- 1 988 soundings made.
- 1 tide station established.
- 1 hydrographic sheet completed.

Topography:
- 3 square miles area covered.
- 8 miles coast line surveyed.
- 4 miles shore line of creeks surveyed.
- 23 miles roads surveyed.
- 1 topographic sheet completed.

Triangulation:
- 5 square miles area covered.
- 4 stations occupied.
- 10 geographic positions determined.

No. 12.



Hydrography and topography, Delaware.

The establishment of compass deviation range lines at Delaware Breakwater and a resurvey of the harbor of Lewes, Del., and the neighboring shores were assigned to Assistant Marindin. He reached Lewes on July 18 and began work immediately. Some of the old triangulation stations were occupied and a number of new geographic positions were determined. The position of the points on the breakwater where the range marks should be erected were determined and targets of an appropriate form were ordered.

The topographic work began on August 7 and was continued whenever the weather and other duties permitted until September 21.

Assistant W. I. Vinal joined the party on September 15 and assisted in the hydrographic work, remaining with the party until the 30th. A small naphtha launch was hired for use in the hydrographic work.

The construction of the targets to mark the magnetic deviation ranges was delayed much longer than was expected, and on October 8 Mr. Marindin returned to Washington.

In December, while returning to Washington from special duty with the Mississippi River Commission, Mr. Marindin stopped at Fernandina, Fla., from the 3d to the 7th, and connected the tide staff with the numerous bench marks at that place by leveling between them.

HYDROGRAPHY. FLORIDA. W. E. PARKER, Commanding,
TOPOGRAPHY. GEORGIA. Steamer *Hydrographer*.
TRIANGULATION.

GEORGE OLSEN, *Watch Officer.*	Dec. 1 to Dec. 14.
W. F. GLOVER, *Watch Officer.*	Dec. 1 to Dec. 29.
W. H. STANFORD, *Watch Officer.*	Jan. 1 to Mar. 24.
WM. B. PROCTOR, *Watch Officer.*	June 9 to June 30.
H. W. PEERCE, *Chief Engineer.*	Dec. 1 to June 30.
C. G. QUILLIAN, *Aid.*	Jan. 11 to June 30.
G. C. BALDWIN, *Aid.*	Mar. 24 to Apr. 16.
T. T. FITCH, *Aid.*	Nov. 9 to June 30.

SUMMARY OF RESULTS.

Florida—December 13 to June 4.

Hydrography:
- 16 square miles area covered.
- 781 miles lines sounded.
- 37 465 soundings made.
- 2 tide stations established.
- 3 hydrographic sheets completed.

Topography:
- 2 miles shore line surveyed.
- 1 topographic sheet completed.

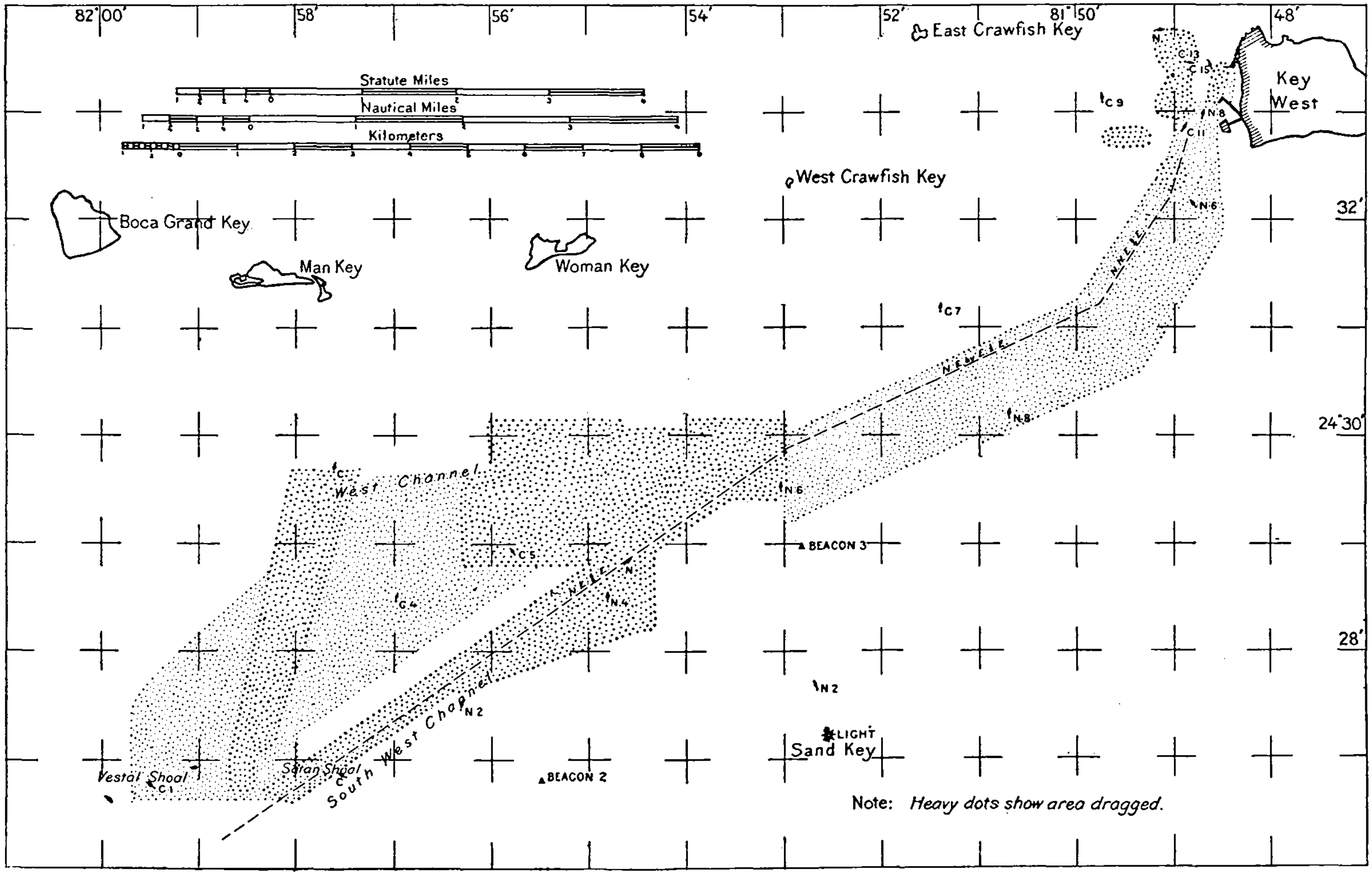
Georgia—June 16 to June 30.

Hydrography:
- 11 square miles area covered.
- 189 miles lines sounded.
- 6 692 soundings made.
- 2 tide stations established.
- 1 hydrographic sheet completed.

Topography:
- 3 miles shore line surveyed.

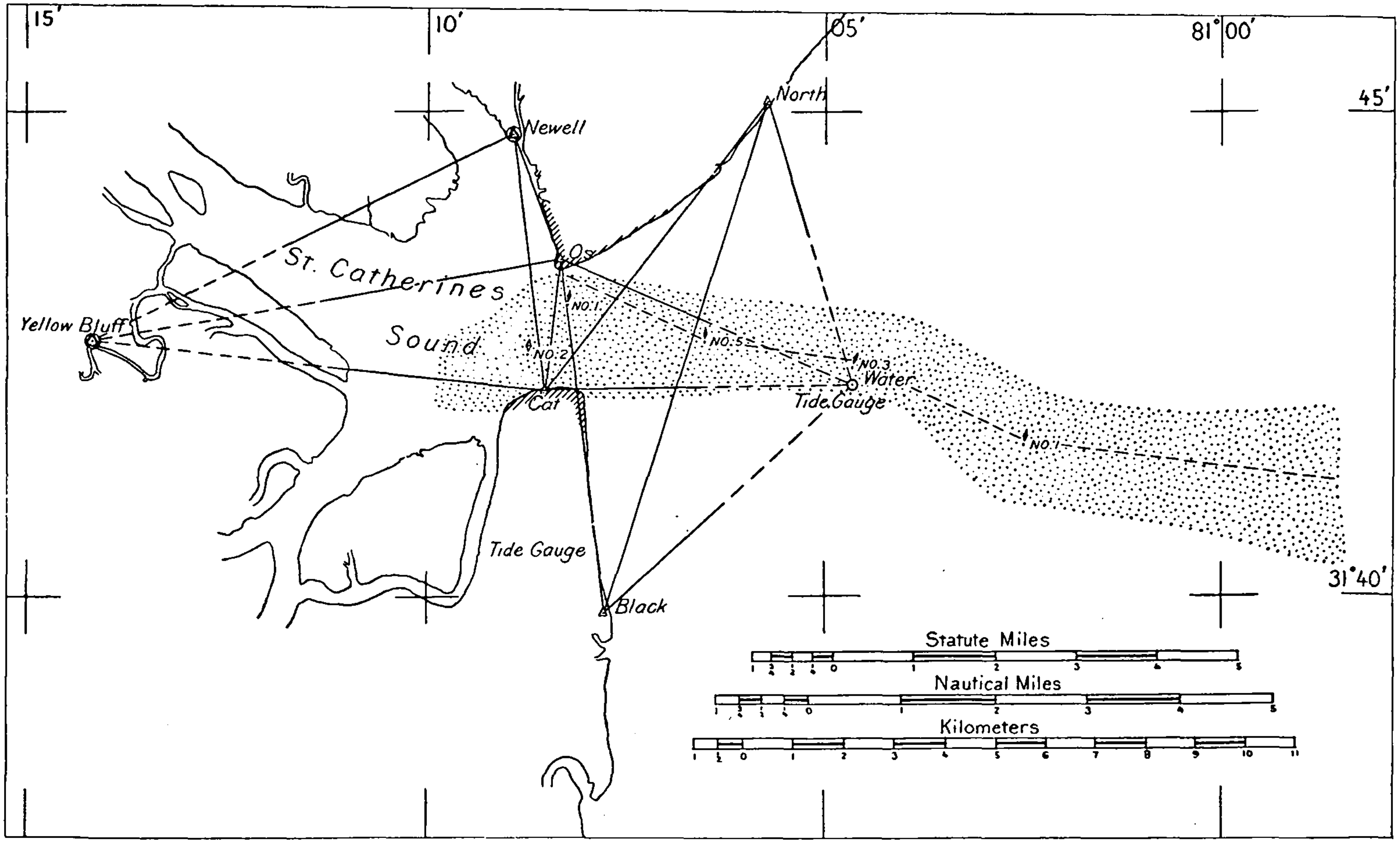
Triangulation:
- 21 square miles area covered.
- 5 stations occupied.
- 5 geographic positions determined.

No. 13.



Hydrography, Florida.

No. 14.



Hydrography, topography, and triangulation, Georgia.

Hydrographic examinations and surveys in the vicinity of Key West, Fla., were assigned to Aid W. E. Parker, commanding the *Hydrographer*, and he reached Key West on December 13. The signals in use during the previous season were found in position and only needed slight repairs. The tide-gauge station on Sand Key was recovered and a gauge was installed. From December to March unfavorable weather prevailed and slow progress was made.

Lines of soundings were made at intervals of 50 meters in two directions, normal to each other, and these distances were subdivided whenever the soundings indicated that this was desirable. A considerable portion of the area was covered with the channel sweep in use. The Southwest Channel was sounded for a width of one-fourth of a mile, from the Middle Ground to and across Satan Shoal, by lines along the channel, and wherever the width of the channel made it practicable to maneuver the vessel these lines were crossed by others. Dangerous localities were covered with the channel sweep in use, to determine the greatest depth which could be carried over them with safety. In addition to the work mentioned above, an examination was made of several shoal spots in this vicinity.

A channel was developed between Satan and Vestal shoals, and its limits and depths were determined by using the channel sweep. The hydrographic work was completed on June 3, and a topographic survey was then made of the water front at Key West.

On June 10 the vessel sailed for St. Catherine Sound, Georgia, and reached there on the 16th. Two tide gauges were established and the positions of signals were determined for use in the hydrographic survey of the entrance to St. Catherine Sound. This work was completed on June 30.

HYDROGRAPHY. NEW HAMPSHIRE. W. E. PARKER.
TRIANGULATION.

F. T. LAWTON, *Aid.*

SUMMARY OF RESULTS.

Hydrography:
- 3 square miles area covered.
- 138 miles lines sounded.
- 9 315 soundings made.
- 3 tide stations established.
- 3 current stations occupied.
- 1 hydrographic sheet completed.

Triangulation:
- 2 square miles area covered.
- 14 stations occupied.
- 16 geographic positions determined.

The hydrographic resurvey of the Piscataqua River in the vicinity of Portsmouth, N. H., was assigned to Aid W. E. Parker. He reached Portsmouth on July 28 and made preparations to take up the work. Mr. Lawton reported on August 10, and the field work began on August 15. Several old triangulation stations were recovered and a number of new positions were determined for use in the hydrographic work. The hydrographic survey of the river between Clarks Island and Birch Point began on August 27 and was completed on September 28. Simultaneous tide observations were made on a tide staff at Portsmouth and on one connected with the bench mark at Fort Constitution. Hydrographic work was then taken up in Little Harbor and in the passages south of the Piscataqua River. All the work was completed by October 15 and the party was then disbanded. The ledge off Goat Island and the ledge above Three Tree Island were developed by special soundings.

MAGNETIC OBSERVATIONS. TENNESSEE. E. D. PRESTON.

The extension of the magnetic survey in Tennessee was assigned to Assistant Preston, and the following stations were occupied between July 3 and September 5, when he was assigned to other duty and the field work closed:

Athens.
Benton.
Blountville.
Cleveland.
Dandridge.
Elizabethton.
Erwin.
Greeneville.
Jonesboro.
Knoxville.
Madisonville.
Maynardsville.
Maryville.
Morristown.
Mountain City.
Newport.
Rogerville.
Rutledge.
Sevierville.
Tazewell.

Observations to determine the elements of the earth's magnetism were made at all the stations named above.

HYDROGRAPHY. NEW JERSEY. C. G. QUILLIAN.
TOPOGRAPHY. NEW YORK.

J. C. LANDERS, *Aid.*

SUMMARY OF RESULTS.

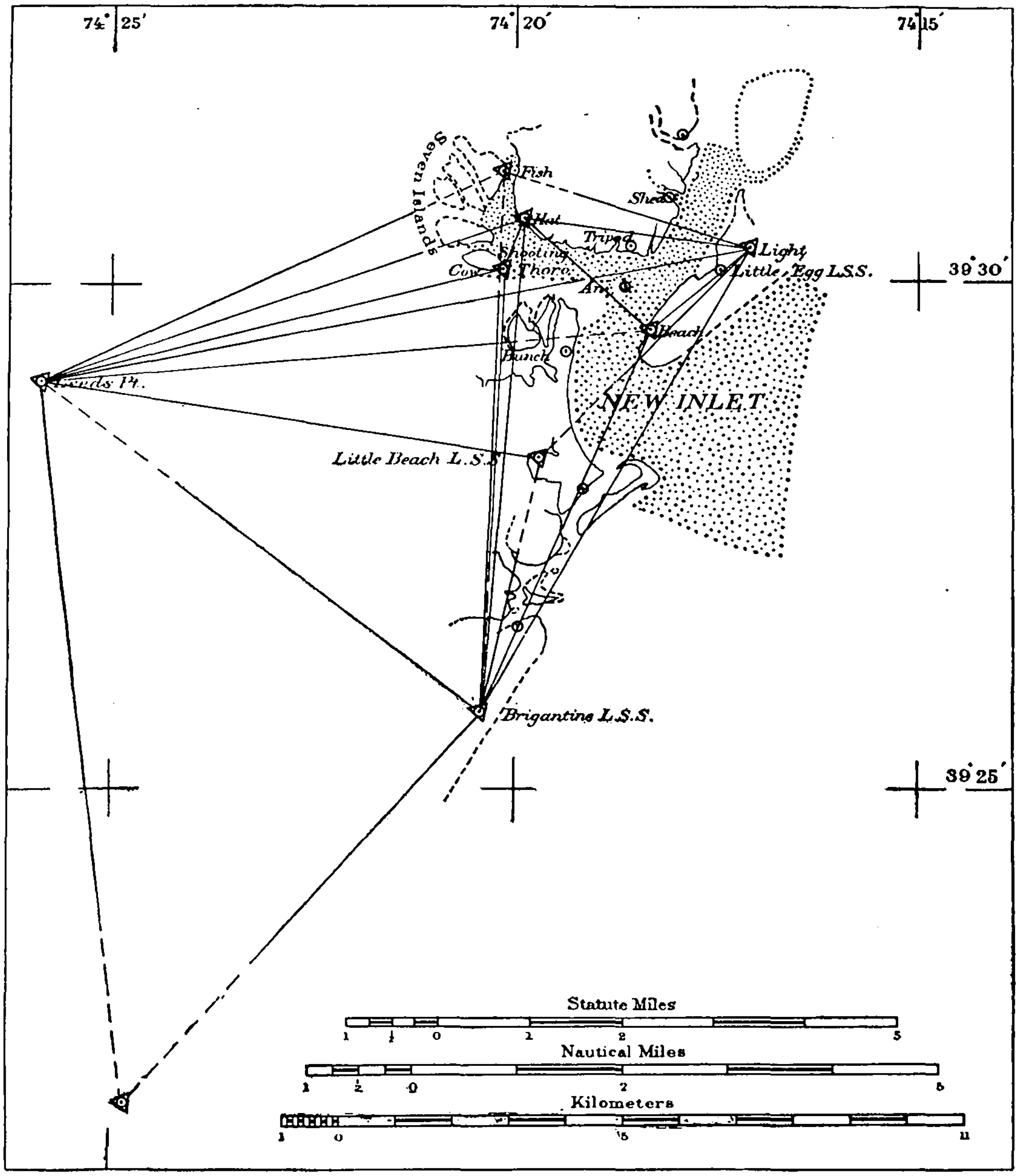
New York—August 5 to September 11.

Hydrography:
60 miles lines sounded.
3 081 soundings made.
1 tide station established.

New Jersey —September 23 to December 5.

Hydrography:
142 miles lines sounded.
12 401 soundings made.
2 tide stations established.
Topography:
31 miles of shore line surveyed.
10 miles of low water shoals surveyed.
3 miles of creeks surveyed.

No. 15.



Hydrography, topography, and triangulation, New Jersey.

The hydrographic examination of the Hudson River in the vicinity of Peekskill, N. Y., was assigned to Aid Quillian. He arrived at Peekskill in the launch *Inspector* on August 5 and made all necessary preparations for the work, under the direction of Assistant J. B. Boutelle, who had accompanied the party for the purpose of starting the work. In the vicinity of Stony Point lines of sounding were made along the river bed and crossed by a system of lines normal to the direction of the river, all lines being 200 meters apart. Off Jones Point similar lines were sounded at intervals of 140 meters, and these were crossed by other lines oblique to the direction of the river. Off triangulation station Gravel the distance between the lines of soundings was decreased to 120 meters.

From August 28 to 31 the work was temporarily suspended while the party assisted in patrolling a regatta held by the New York Bay Regatta Association in the Kill von Kull.

The work was completed on September 11. On September 17 the launch, with the party on board, left New York via the Delaware and Raritan Canal and Cape May, and reached Beachhaven, N. J., on the 23d. Signals were erected at old triangulation stations and the positions of other points were determined.

Necessary repairs to the launch and unfavorable weather delayed the beginning of the work until October 19. The hydrographic work consisted of the survey of New Inlet, outside from a point opposite Tucker Beach Light to a point a short distance south of Little Beach Life-Saving Station, and offshore to the 3-fathom curve; and inside, the main channel to the northward was surveyed to the head of Tuckers Island, and the Shooting Thoro up to Seven Islands. Two systems of sounding lines were run normal to each other with intervals of from 150 to 200 meters. A survey was made of the shore line of Little Beach and the islands inside, and also of the changes at Tuckers Beach since the previous survey. The work was completed in the latter part of November and the launch was taken to Atlantic City and stored. The party disbanded on December 5.

COAST PILOT.

CONNECTICUT.
DELAWARE.
MARYLAND.
NEW JERSEY.
NEW YORK.
VIRGINIA.

JOHN ROSS, Commanding,
Steamer *Hydrographer*.

C. L. GREEN, *First Watch Officer.*	
H. C. GRAVES, *Nautical Expert.*	Sept. 1 to Nov. 11.
H. W. PEERCE, *Chief Engineer.*	
T. O. PULIZZI, *Writer.*	Oct. 1 to Nov. 11.
J. W. OGDEN, *Recorder.*	Aug. 25 to Sept. 19.

The work of making the investigations along the coast between Point Judith, Rhode Island, and the entrance to Chesapeake Bay, necessary for a revision of Parts IV and V of the United States Coast Pilot, Atlantic Coast, was assigned to Nautical Expert Ross, commanding the *Hydrographer*. He took command on August 24, but he was delayed by an assignment to special duty and in making repairs until September 2, when the Coast Pilot work began in the Hudson River. The work was continued until September 11, when the ship was again on special duty for two days. The work was then continued without interruption until October 14, when it closed at Washington, D. C.

During the season the vessel steamed through Long Island Sound; New York Bay; Raritan Bay; Staten Island Sound; the Raritan River to New Brunswick; along the coast of New Jersey to Lewes, Del.; through Delaware Bay and Raritan River to Gloucester; and then passed through the Delaware and Chesapeake Canal en route to Washington. Various places were visited and coast pilot information was collected from all available sources.

The work was seriously delayed by unfavorable weather, but the locality covered by the volumes mentioned was examined as thoroughly as the conditions permitted.

In his report Mr. Ross expresses his appreciation of the faithful and able manner in which the members of his party performed the duties assigned to them.

MAGNETIC OBSERVATIONS.

ALABAMA.
GEORGIA.
LOUISIANA.
OHIO.

L. B. SMITH.

Stations occupied.

ALABAMA.

Ashville.
Birmingham.
Center.
Fort Payne.
Gadsden.
Guntersville.
Oneonta.
Scottsboro.

GEORGIA.

Trenton.

LOUISIANA.

Alexandria.*
Arcadia.*
Bastrop.*
Benton.
Colfax.
Coushatta.
Farmerville.*
Floyd.
Franklin.
Franklinton.
Gretna.
Harrisonburg.*
Homer.
Lake Charles.*
Lake Providence.
Leesville.
Mansfield.*
Many.*
Meriden.
Monroe.
Natchitoches.*
Plaquemine.
Pointe a la Hache.
Royville.*
Ruston.*
St. Bernard.
St. Joseph.
Shreveport.
Springville.
Vidalia.
Winnfield.
Winnsboro.*

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* Meridian lines already established at these places.

OHIO.

Chardon.
Eaton.
Lancaster.
Mansfield.
Mount Vernon.
Meridian.
Ravenna.

The extension of the magnetic survey in various localities in the eastern division was assigned to Mr. L. B. Smith, Magnetic Observer. He left Baldwin, Kans., on October 19 and proceeded to Ohio, where he began work immediately after his arrival. After completing the observations at the stations in Ohio, named above, he continued his work in Alabama by making observations at the stations given in the above list, and completed it on December 26. Magnetic work in Louisiana was then taken up, and the places named in above list were occupied.

The meridian lines already established at the Louisiana stations were verified, and similar lines were established at all stations where such lines were not in existence, except at Leesville, where it was impracticable to mark such a line, and an azimuth line was substituted for it. The work for the season closed on March 31.

W. S. Earhart, Magnetic Observer, was a member of the party October 21 to 22, and C. J. Metlicka, Magnetic Observer, from October 25 to December 4.

TIDE OBSERVATIONS.

FLORIDA.
MARYLAND.
NEW YORK.
PENNSYLVANIA.

Self-registering tide gauges were kept in operation throughout the year at the following places:

Fort Hamilton, N. Y., J. G. Spaulding, Observer; Philadelphia, Pa., H. E. Olsen, Observer; Baltimore, Md., F. A. Kummel, Observer, and Fernandina, Fla., B. W. Weeks, Observer.

HYDROGRAPHY.

MARYLAND.
VIRGINIA.

W. I. VINAL, Commanding,
Schooner *Matchless.*

J. W. MAUPIN, *Aid.*	Oct. 24 to Mar. 30.
R. L. LIBBY, *Aid.*	Nov. 14 to June 20.
F. H. SEWALL, *Aid.*	Mar. 28 to Apr. 15.
C. V. HODGSON, *Aid.*	Apr. 13 to June 30.
C. V. HODGSON, *Deck Officer.*	Mar. 31 to Apr. 12.
G. T. RUDE, *Deck Officer.*	Oct. 24 to June 30.

SUMMARY OF RESULTS.

Little Choptank River—November 4 to March 23.

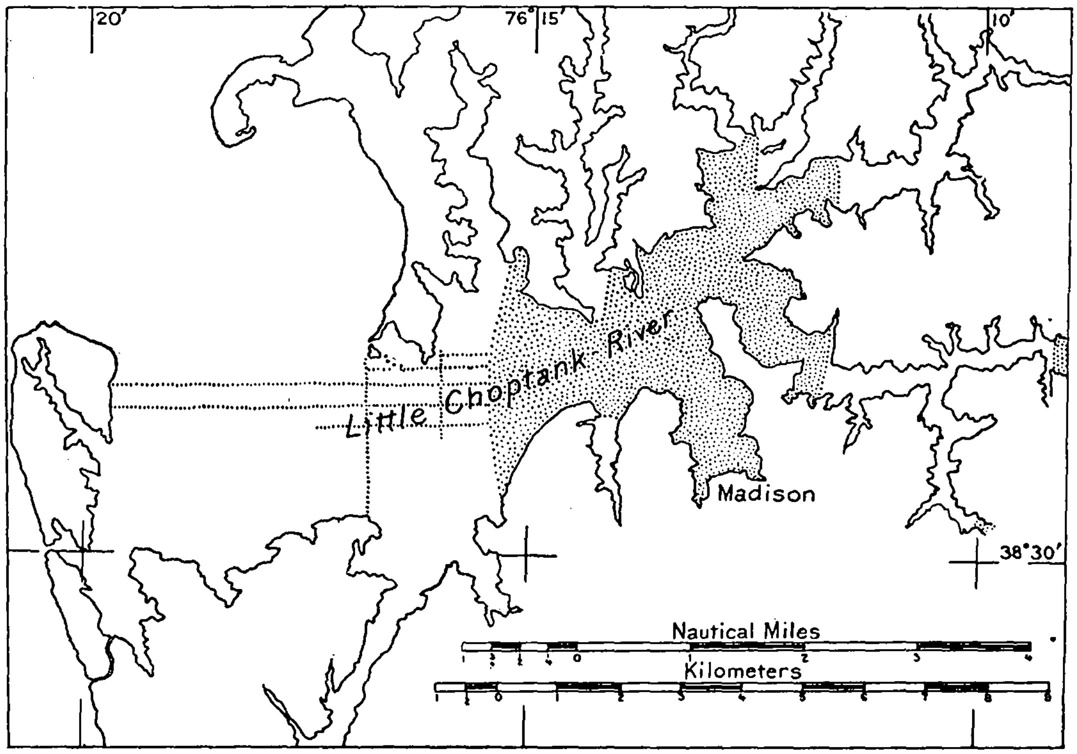
62 miles lines sounded.
3 086 soundings made.

Potomac River—March 25 to June 30.

265 miles lines sounded.
15 413 soundings made.

The continuation of the hydrographic survey of Little Choptank River, Maryland, was assigned to Assistant Vinal, commanding the schooner *Matchless*. He sailed from Baltimore on October 31, and on November 4 the work in the river began. It was continued whenever the weather conditions permitted until December 24, after which date the unusually cold weather and resulting ice prevented soundings until March 23, when the vessel sailed for Alexandria, to begin the hydrographic resurvey of the upper Potomac River.

No. 16.

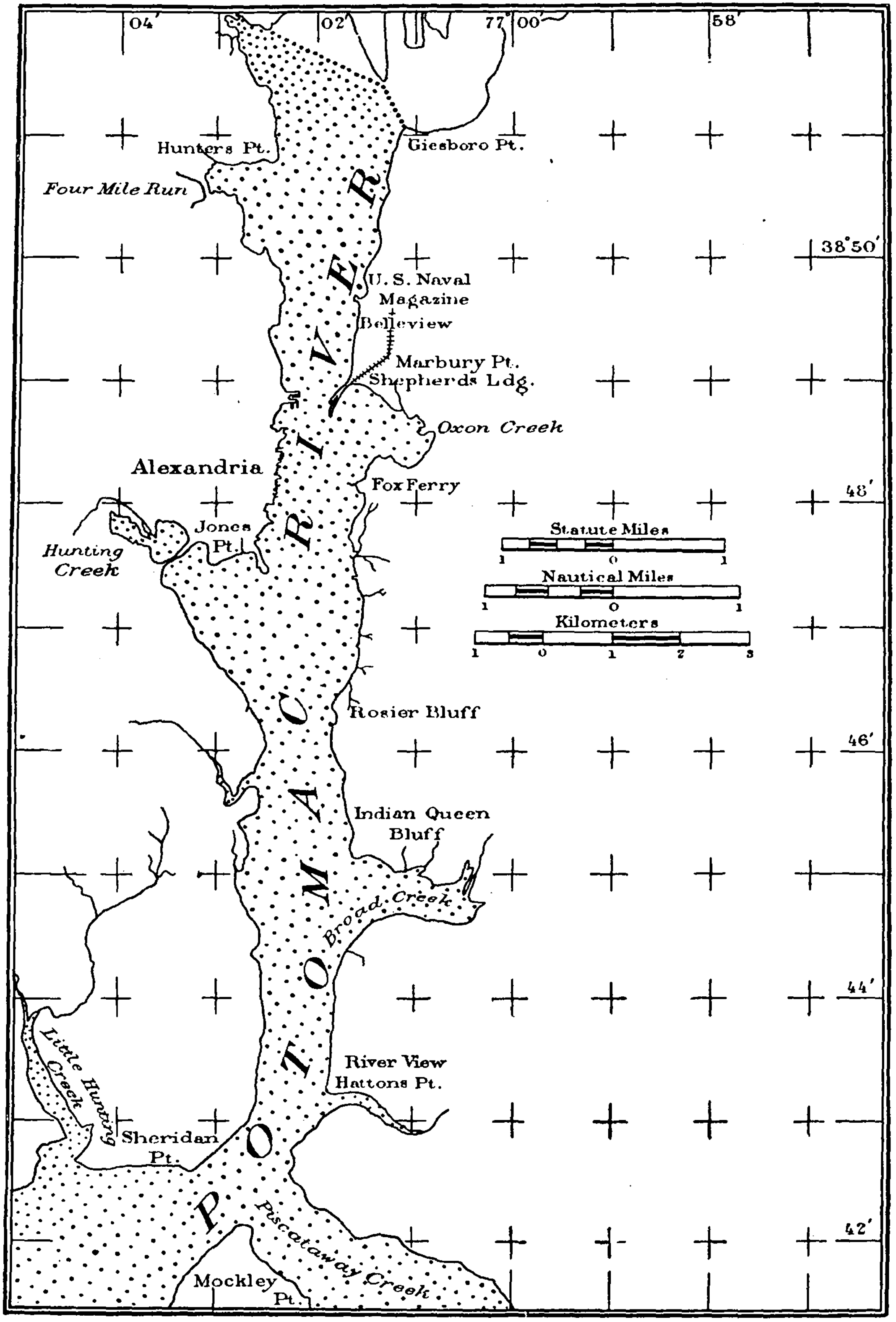


Hydrography, Maryland.

The old triangulation stations were recovered, signals were built, and tides were observed. The sounding work began on April 12 and was continued until June 30, and was in progress on that date. The area surveyed extends southward from the line between Gravelly Point and Giesboro Point to Little Hunting Creek.

In his report Assistant Vinal commends the efficient service rendered by the officers of the vessel.

No. 17.



Hydrography, Potomac River.

MAGNETIC OBSERVATIONS. NEW JERSEY. WM. F. WALLIS.

W. M. HILL, *Magnetic Observer*.

Stations occupied.

Elizabeth.	Hackensack.	Paterson.
Flemington.	Newark.	Somerville.

The direction of magnetic observations in New Jersey was assigned to Magnetic Observer Wallis, and Mr. Hill was detailed to make the observations.

Mr. Wallis accompanied Mr. Hill and assisted in the work at Elizabeth, Flemington, and Somerville, and Mr. Hill occupied the remaining stations without assistance. Observations began on June 7, and were in progress at the close of the year. Observations to determine the elements of the earth's magnetism were made at each station.

HYDROGRAPHY. MAINE. P. A. WELKER, Commanding,
MAGNETIC OBSERVATIONS. NEW JERSEY. Steamer *Bache*.
VIRGINIA.

WM. M. ATKINSON, *First Watch Officer*.
G. E. MARCHAND, *Surgeon*.
M. F. FLANNERY, *Chief Engineer*.
J. A. MCGREGOR, *Second Watch Officer*.
WM. SANGER, *Captain's Clerk*.
E. C. SASNETT, *Aid*.
J. W. YATES, *Deck Officer, Second Class*.
E. V. MILLER, *Junior Captain's Clerk*.

Hydrographic examinations, off the coast of Maine, off the coast of Virginia, and off the coast of New Jersey, and magnetic observations at sea were assigned to Assistant Welker, commanding the steamer *Bache*.

The vessel left Baltimore on August 13 and proceeded to Winter Quarter Shoal, off the coast of Virginia, where several miles of lines were sounded without discovering any uncharted shoal.

At Delaware Breakwater, on the 15th, observations were made to determine the magnetic variation in this vicinity. For this purpose two complete sets of observations were made by swinging the ship and noting the deviation of the standard compass. One set was made in the morning and the other in the afternoon, the deviation being noted on the sixteen main points of the compass by swinging the ship in each set with the starboard and with the port helm.

From August 16 to November 4 Mr. Welker was absent from the ship on other duty, and the account of the work of the party during this period is given under the name of Assistant J. B. Boutelle, who was temporarily in command.

An attempt was made to discover a shoal reported in the vicinity of Boon Island Light-house, Maine, but without success.

This work was completed on the 9th, after several days' delay on account of unfavorable weather, and the vessel then proceeded to New York to make a special examination in the vicinity of Sandy Hook Light-ship, where a shoal had been reported. The shoal was found and developed, the entire locality being thoroughly covered by sounding and by going over the area with a channel sweep.

The work was again delayed by unfavorable weather and was not completed until November 25, when the vessel sailed for Baltimore, arriving there on the 27th.

HYDROGRAPHY.

FLORIDA.
MARYLAND.
SOUTH CAROLINA.
VIRGINIA.

F. A. YOUNG, Commanding,
Steamer *Endeavor*.

J. A. McGREGOR, *Watch Officer*.	July 1 to Aug. 8.
R. McD. MOSER, *Watch Officer*.	Sept. 4 to Nov. 9.
H. G. LOCKE, *Chief Engineer*.	
D. R. JEWELL, *Aid*.	Feb. 2 to June 30.
E. W. KRAMER, *Aid*.	July 1 to July 12.
B. D. BARKER, *Aid*.	July 16 to Nov. 9.
J. H. SIMPSON, *Deck Officer*.	

SUMMARY OF RESULTS.

Potomac River—July 1 to November 8.

275 miles lines sounded.
20 477 soundings made.
1 tide station occupied.

Key West—February 23 to May 31.

472 miles lines sounded.
18 484 soundings made.

Port Royal—June 8 to 17.

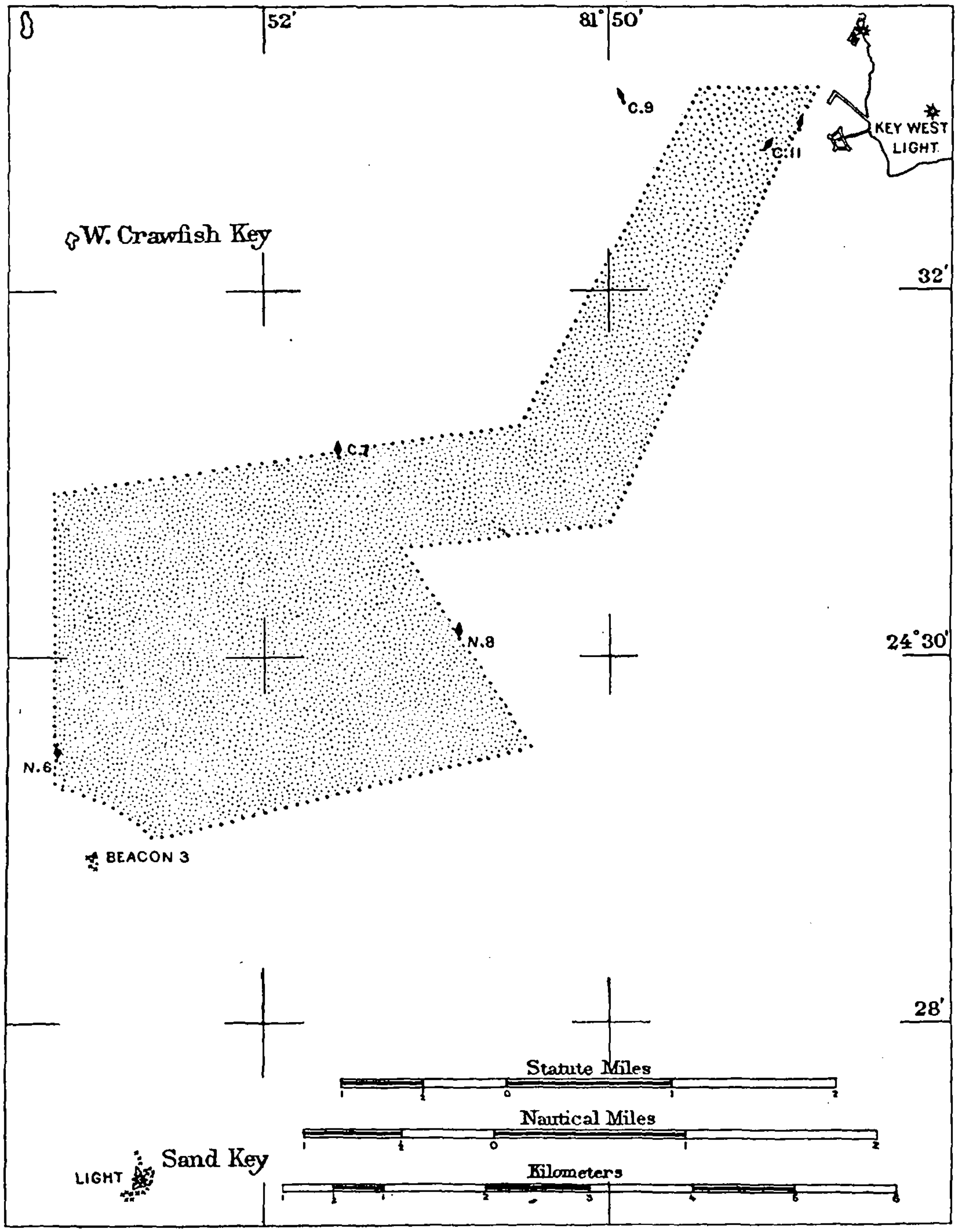
2 miles lines sounded.
1 geographic position determined.

On July 1 the hydrographic resurvey of Kettle Bottom Shoals in the Potomac River was in progress by a party on the steamer *Endeavor* under the command of Assistant Young. The work was continued whenever the weather and other conditions permitted until November 8, when the work closed for the season, and the vessel sailed for Baltimore.

The work consisted in developing the shoal spots, which are very numerous in that portion of the river between Cobb Point Bar Light and Lower Cedar Point Light-house, and the progress was slow, as the shoal spots are generally small and difficult to locate. A small buoy was placed over each spot selected for examination, and radial lines of soundings were made from it as a center in various directions, covering the area in its vicinity.

A hydrographic survey was also made of Mattox Creek and Munroe Bay, and tide observations were made at Colonial Beach the entire season. Between July 7 and 12 the vessel was at Norfolk having repairs made, and the launch was absent on special

No. 18.



Hydrography, Florida.

duty August 27 to September 11. From September 6 to 8 the *Endeavor* was detailed to patrol duty in the Potomac regatta, under direction of Assistant D. B. Wainwright, and on the 9th was hauled out at Alexandria, Va., to clean her bottom and paint the propeller. The vessel arrived at Baltimore on November 9.

On February 15 Assistant Young, commanding the *Endeavor*, sailed from Norfolk, Va., for Key West, Fla., with Mr. Charles H. Lewis on board as pilot. The vessel reached her destination on the 23d, and some necessary repairs were made. The hydrographic work began on March 2, and systems of lines normal to each other were sounded at intervals of 30 meters. The greater portion of this work was done with the channel sweep in use, and many shoal spots were discovered in this way which were not indicated by the soundings, in spite of the fact that they were unusually close together. A shoal in the southeast channel on which the U. S. S. *Montgomery* touched in entering the harbor was located and its position determined, and it was found that the channel buoy was 200 meters away from its proper position.

Necessary repairs to the boilers of the vessel were made between April 26 and May 7.

The hydrographic work was completed on May 31.

In his report Assistant Young expresses his appreciation of the courtesy and kindness shown him by Capt. G. A. Bicknell, U. S. Navy, commandant of the naval station at Key West, in supplying the ship with coal and water and in allowing the use of the machine shop to make repairs to the ship. He also commends the proficiency and zeal displayed by the officers in performing the duties assigned to them.

On June 5 the ship sailed for Port Royal, S. C., and reached there on the 8th.

The geographic position of the new Hilton Head front range light was determined, and a line of soundings was made on the Hilton Head range from the bell buoy to the sea buoy, a distance of about 2 miles, which completed the field work for the season. The vessel was detained in Port Royal until June 17, and reached Norfolk on the 19th.

MIDDLE DIVISION.

LEVELING. TEXAS. G. C. BALDWIN.

F. H. SEWALL, *Aid.*

SUMMARY OF RESULTS.

303 kilometers of line completed.
76 bench marks established.

The extension of the standard levels in Texas was assigned to G. C. Baldwin, Aid, Coast and Geodetic Survey. He reached Taylor, Tex., on November 3, 1903, completed the necessary preparations for field work, and began observations on November 5.

The levels began on bench marks previously established at Holland and ended at New Braunfels. The route followed the Missouri, Kansas and Texas Railway to San Marcos, via Smithville, and the International and Great Northern Railroad from that place to New Braunfels. From Elgin a branch line was leveled along the Houston and Texas Central Railway to Austin, and thence 13 kilometers across the country to station Barton of the triangulation along the ninety-eighth meridian. From New Braunfels another branch line was leveled 7 kilometers across the country to station Seguin West Base of the triangulation along the ninety-eighth meridian. Seventy-six permanent bench marks were established during the season; 49 of these were new and 27 had been previously established by the United States Geological Survey. One of the monuments marking the longitude station in the grounds around the capitol at Austin and the monuments at the triangulation stations Barton and Seguin West Base were used as bench marks. The usual method of work was followed and the line was leveled at least once in each direction. Temporary bench marks were established at intervals of 1 to 2 kilometers for the purpose of comparing the results obtained from the forward and backward lines.

The extremely rough character of the country between Austin and triangulation station Barton caused some delay in the work, but no other serious obstacles were encountered during the season.

Mr. Sewall shared in the work of making the observations during the entire season.

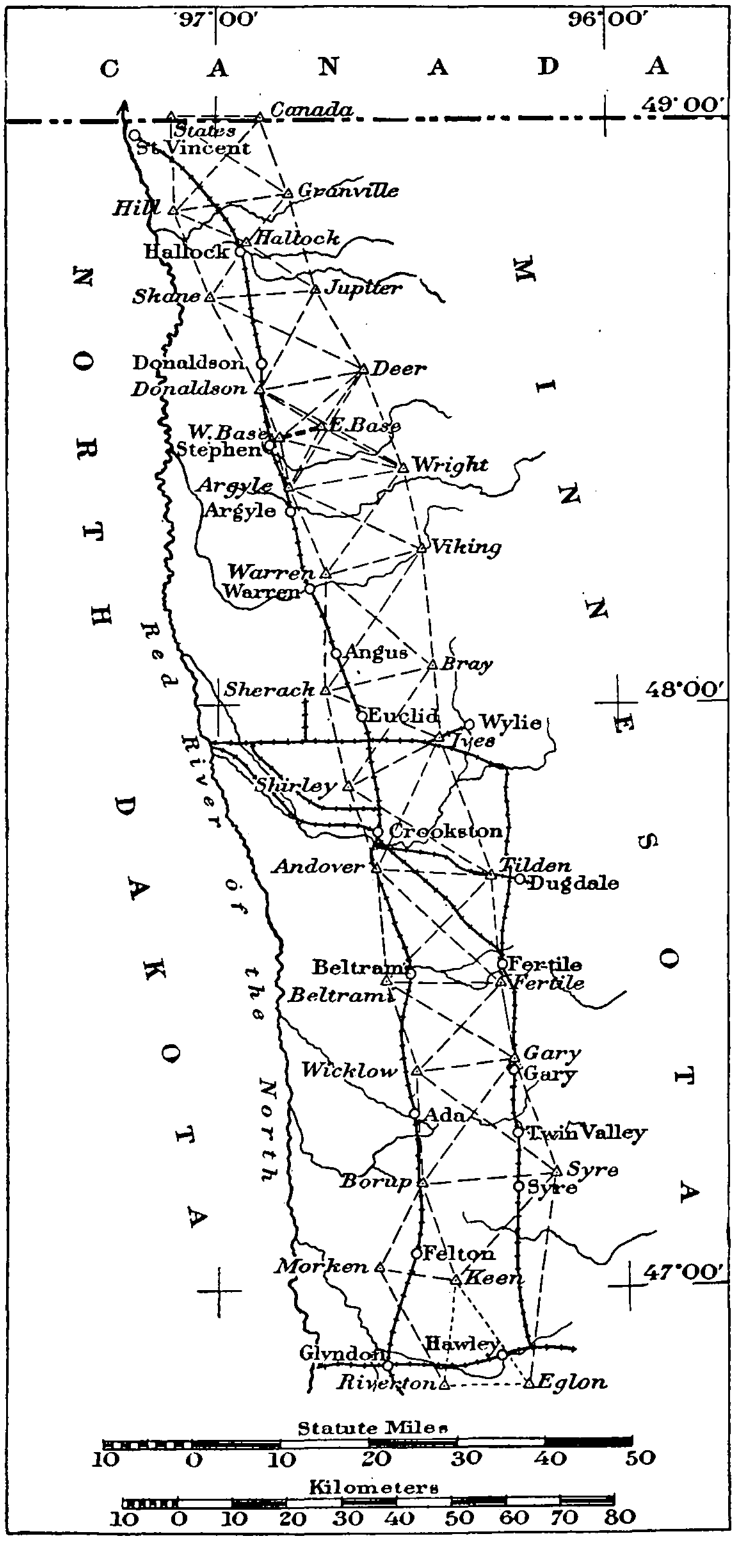
Velocipede cars were used as the means of transportation, and the thanks of the Survey are due the railway companies mentioned for their courtesy in granting the privilege of using these cars on their tracks.

RECONNAISSANCE. MINNESOTA. W. H. BURGER.
SIGNAL BUILDING.

SUMMARY OF RESULTS.

Reconnaissance:
    4 100 square miles area covered.
    55 triangulation stations selected.
Signal building:
    16 signals erected.

No. 19.



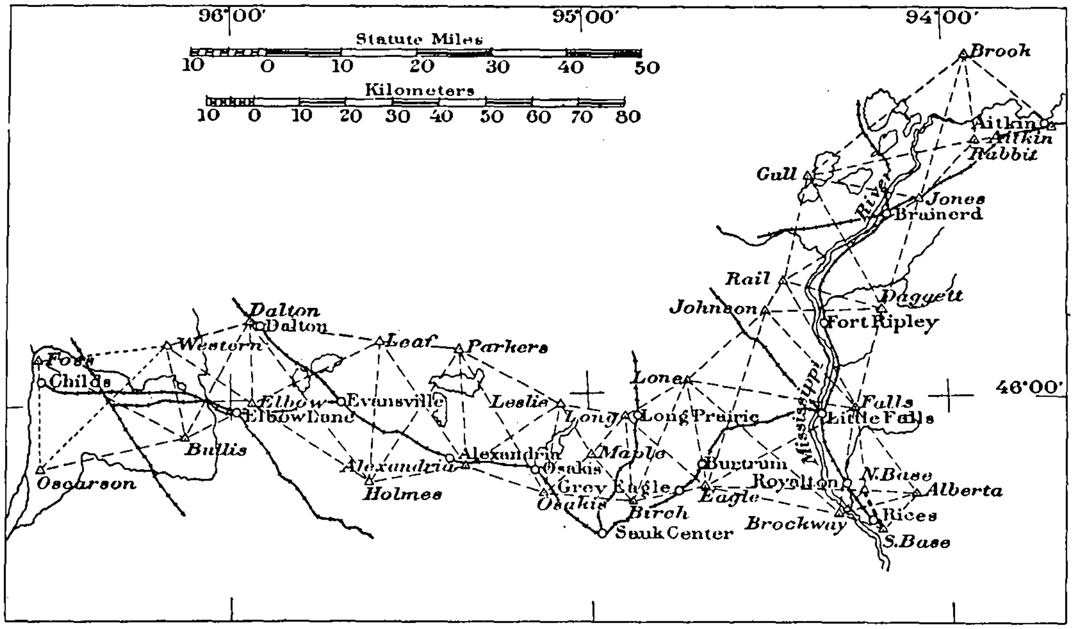
Reconnaissance, Minnesota.

On July 1, 1903, the reconnaissance and signal-building parties under the direction of Assistant Burger were actively engaged in field work, as stated in the preceding Annual Report, in the vicinity of Felton.

The work made rapid progress, and the reconnaissance was completed to the boundary line between the United States and Canada on July 31. The work follows the valley of the Red River of the North on the east side of the river, and the triangulation stations on the west side of the scheme are all near the Great Northern Railway. The use of the grain elevators at the railway stations materially aided in the progress of the work.

On August 1 the party proceeded to Stephen, Minn., and selected a site for a base line a short distance from the town. After marking the ends of the base line, the party and outfit went by rail to Fergus Falls, Minn., for the purpose of extending the reconnaissance east from the vicinity of that place. The work began on August 14 and was extended east to the Mississippi River, and a connection was made with the triangulation of the Mississippi River Commission at Brockway station. The work then follows the Mississippi River to the vicinity of Aitkin, where the work stopped for the season. The work was again connected with the triangulation of the Mississippi River Commission at Brainard station, and other stations are available for this purpose. A base line was selected and marked near Rice, Minn., and on October 7 the field work closed for the season. The progress of the reconnaissance, July 1 to October 7, equals 480 kilometers, measured along the axis of the scheme.

No. 20.



Reconnaissance, Minnesota.

Mr. Burger commends all the members of his party for their faithfulness and zeal in performing the duties assigned to them. He states that Signalman J. S. Bilby and Foreman W. C. Nohl deserve special praise, and that, to a great extent, the rapid progress of the work was due to Mr. Bilby's experience and to his ability to perform all duties assigned to him.

ASTRONOMIC OBSERVATIONS.
TRIANGULATION.

MINNESOTA.
NORTH DAKOTA.
SOUTH DAKOTA.

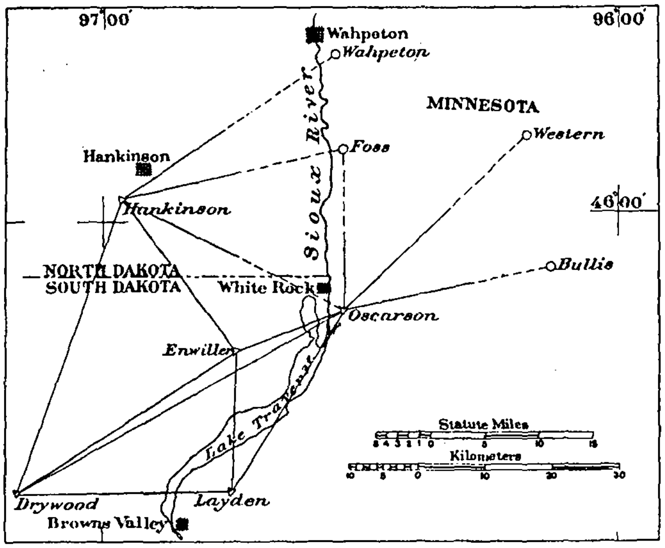
W. H. BURGER.

W. A. KEMPER, *Aid.* June 24 to June 30.
E. R. WITMAN, *Recorder.*
J. S. BILBY, *Signalman.*
E. E. TORREY, *Foreman.* May 24 to June 19.

SUMMARY OF RESULTS.

Astronomic observations:
1 azimuth determined.
Triangulation:
500 square miles area covered.
5 stations occupied.

No. 21.



Triangulation.

The extension of the triangulation northward along the ninety-eighth meridian, in Minnesota, was assigned to Assistant Burger. A signal building party was organized at Brown Valley, Minn., on May 10, in charge of J. S. Bilby, and signals were erected at six triangulation stations before the end of June. The observing party was organized at Brown Valley on May 24, and the measurement of angles began at triangulation station Drywood on May 30. Stations Layden, Enwiller, Hankinson, and Oscarson were then occupied in the order named, and the observations at Oscarson were in progress at the close of the fiscal year.

Mr. E. E. Torrey died in camp on June 19, 1904, after many years of faithful service as foreman in various parties of the Survey.

Unfavorable weather caused some delay in the work in the early part of June.

TRIANGULATION. TEXAS. O. W. FERGUSON.
MINNESOTA.
SOUTH DAKOTA.
W. H. BURGER, *Assistant.* Nov. 10 to Jan. 11.

SUMMARY OF RESULTS.

Minnesota and South Dakota.—July 1 to October 17.

3 000 square miles area covered.
29 stations occupied.
90 geographic positions determined.

Texas.—November 10, 1903, to January 11, 1904.

2 400 square miles area covered.
26 stations occupied.
82 geographic positions determined.

The triangulation along the ninety-eighth meridian northward in South Dakota was in progress on July 1 under the direction of Assistant Ferguson, and the party had reached station Crane. The following primary stations were then occupied before the work closed on October 17, viz: Caldwell, Miner, Drakocola, Brock, Hansen, Jeska, Larson, Weiss, Oakwood, Lake, Horswill, Olson, Elfring, Franklin, Helgen, Mound, Boating, Waubay, Pickerel, Preachers Hill, Drywood, Layden, Brown Valley Northwest Base, and Brown Valley Southeast Base.

In addition to these stations, six auxiliary stations were occupied. All the necessary observations were completed on October 17 and preparations were immediately made to continue the triangulation southward in Texas from the vicinity of Lampasas. A portion of the outfit, which was not needed in Texas, was stored at Brown Valley, and the rest of it was shipped by rail to Texas. The party started south on October 22 and reached Lampasas on the 25th. Repairs were made to the outfit and all other preparations were completed to place a signal-building party and two observing parties in the field.

The signal-building party started to work on November 4, under charge of Signalman J. S. Bilby, and on November 10 the light keepers were in place and the observers were ready to begin observations.

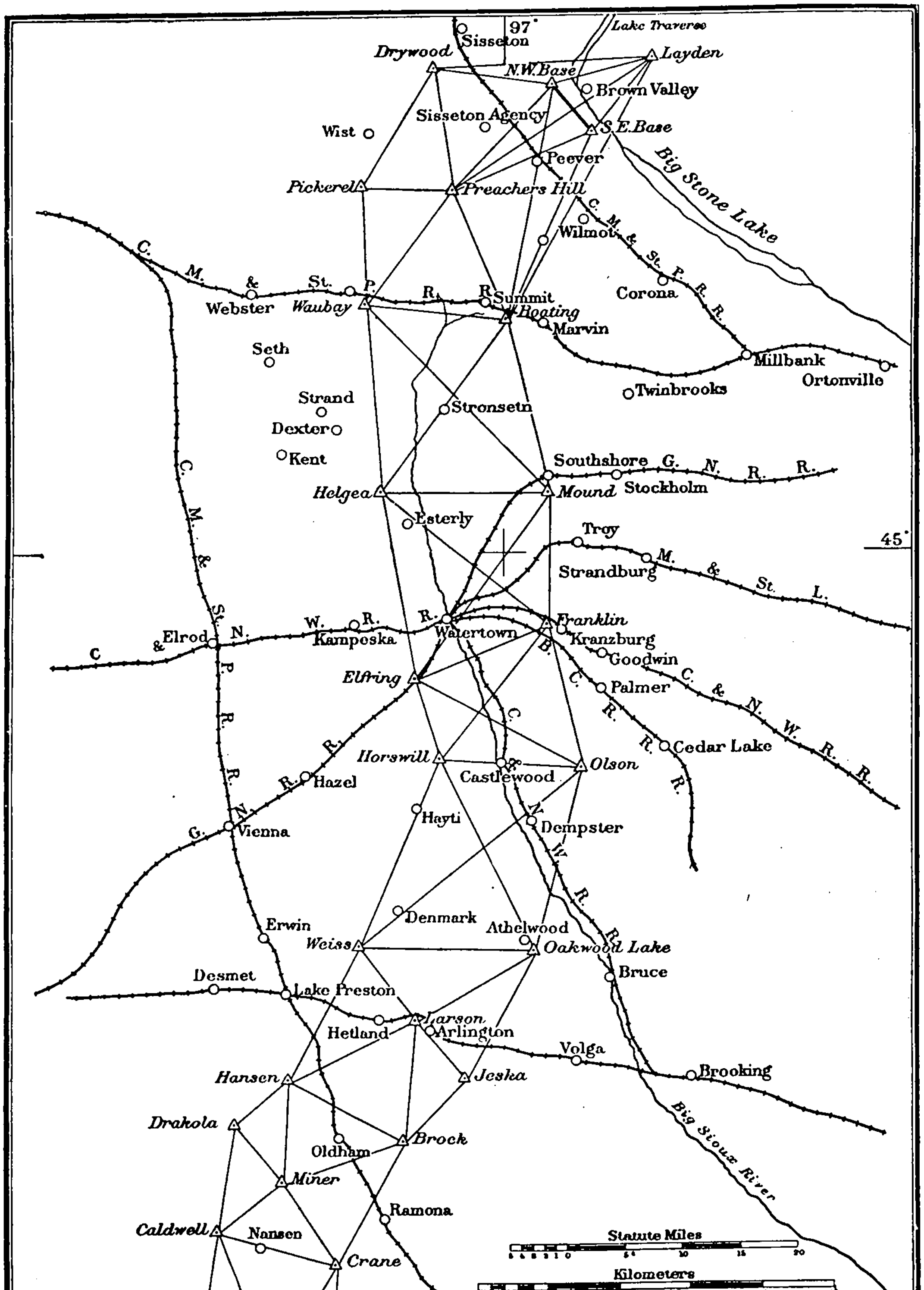
Assistant W. H. Burger had reported for duty as chief of the second observing party and remained with Mr. Ferguson during the occupation of the first two stations, May and Gabriel, and the observations at these stations were divided between these two observers.

On November 19 Mr. Burger began work with a separate party and from that date until the close of the season the two observing parties were at work continuously whenever the weather and other conditions permitted until January 11, when the observations were completed for the season.

The following triangulation stations were occupied, viz: May, Gabriel, Post, Buzzard, Travis, Shovel, Shingle, Barton, Cedar, Carpenter, Loneman, Krueger, Hugo, Gus, Bear, Mission, Tieken, Seguin East Base, Seguin West Base, Mott, Herndon, Central, Thomas, Lavernia, Serita, and Stockdale.

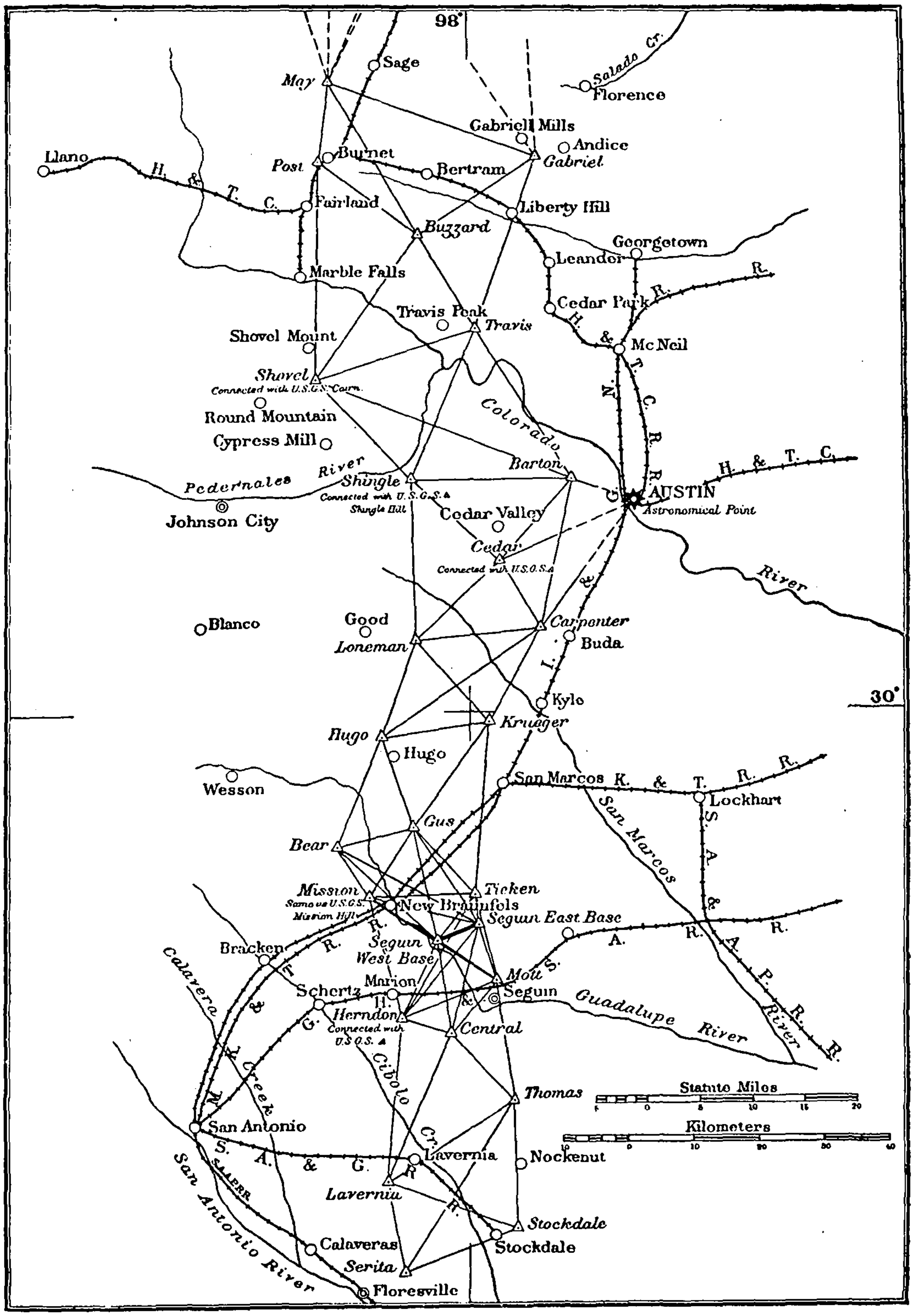
The observations were made in the afternoon and at night, the vertical angles being

No. 22.



Triangulation, South Dakota.

No. 23.



Triangulation, Texas.

measured first, then the horizontal angles for secondary and tertiary determinations, and finally, the observations on the primary triangulation stations were made.

In South Dakota the observations began at 3 p. m. and continued until 11.30 when the conditions were suitable, and in Texas the observing hours extended from 2.30 p. m. until 11 p. m.

The outfit was placed in storage at Floresville, Tex., and on January 18 the party was disbanded.

Mr. Ferguson reports the valuable assistance rendered by Assistant Burger, and makes favorable mention of Signalman J. S. Bilby, Foremen E. E. Torrey and C. E. Schurch, and Recorders E. R. Witman and W. A. Barber.

ESTABLISHMENT OF TIDE GAUGE. TEXAS. H. L. MARINDIN.

Advantage was taken of Assistant Marindin's presence in New Orleans, La., on duty with the Mississippi River Commission, by directing him to establish a self-registering tide gauge at Galveston, Tex. He reached Galveston on November 18 and immediately visited the office of Capt. Edgar Jadwin, Corps of Engineers, U. S. Army, in charge of the harbor improvement at Galveston, for information as to the best available site for the tide gauge. The officer in charge of the office offered the use of a tide-gauge house at Fort Point, the best available situation for the gauge. The necessary repairs were made and a self-registering tide gauge was mounted and placed in running order. The tide staff was referred to permanent bench marks by leveling and the work was completed on November 29.

MAGNETIC OBSERVATIONS. KANSAS. L. B. SMITH.

R. E. NYSWANDER, *Magnetic Observer.*

Stations occupied.

Cottonwood Falls.
Council Grove.
Emporia.
Marion.
Newton.

The extension of the magnetic survey in Kansas was assigned to Mr. L. B. Smith, Magnetic Observer.

On June 8, Mr. R. E. Nyswander, Magnetic Observer, reported to him for instruction in magnetic work. Observations were made on two days at the observatory at Baldwin, and then Mr. Smith accompanied Mr. Nyswander to Council Grove and Emporia, where the elements of the earth's magnetism were determined previous to June 22. On that date Mr. Smith returned to Baldwin and Mr. Nyswander proceeded to make magnetic observations at the other stations named in the list. The work was in progress at Newton at the close of the fiscal year.

TIDE OBSERVATIONS. TEXAS.

A self-registering tide gauge was established at Galveston, Tex., in November, and a record of the tides was obtained during the remainder of the year. From November to April, J. P. Fine was the observer; and after May 1, this position was held by J. D. Warren.

MAGNETIC OBSERVATIONS. KANSAS. MISSOURI. WM. F. WALLIS.

W. C. BAUER, *Magnetic Observer.*[*]	
L. B. SMITH, *Magnetic Observer.*	Jan. 1 to June 30.
R. E. NYSWANDER, *Magnetic Observer.*	Mar. 15 to June 5.
H. I. WOODS, *Magnetic Observer.*	July 1 to Aug. 15.

The direction of the work at the Magnetic Observatory at Baldwin, Kans., was assigned to Magnetic Observer W. F. Wallis. He was present at Baldwin and assisted in the work July 1 to 31, and after that date he conducted the work at the Magnetic Observatory at Cheltenham, Md., under the direction of Assistant L. A. Bauer, but still retained the direction of the work at Baldwin. From August 1 to December 31, Mr. W. C. Bauer was in immediate charge of the work at Baldwin and from January 1 to June 30 Mr. Smith was in immediate charge. A self-registering magnetograph was in continuous operation during the year, and absolute observations for the determination of the base lines were made once a week and of the scale values once a month. On the 1st and 15th of each month, the magnetograph was run at a rapid rate for two hours to cooperate in the international programme of observations undertaken June 1, 1903.

Two hands, D. C. Sowers and J. P. Ault, were employed at this observatory and performed such duties as were assigned to them.

Mr. H. I. Woods, Magnetic Observer, made observations to test his instruments at the Magnetic Observatory at Baldwin, Kans., and on July 4 proceeded to Missouri and determined the elements of terrestrial magnetism at the following places:

Albany.
Bolivar.
Bowling Green.
Chillicothe.
Clinton.
Edina.
Fayette.
Gallatin.
Lexington.
Marshfield.
Mexico.
Osceola.
Plattsburg.

On August 15 he was compelled by sickness to close field for the season.

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[*] Service not continuous. Employed at such intervals as proved to be necessary.

WESTERN DIVISION.

LEVELING. WASHINGTON. G. C. BALDWIN.

SUMMARY OF RESULTS.

159 kilometers of line completed.
46 bench marks established.

The extension of the standard levels eastward from Seattle, Wash., was assigned to G. C. Baldwin, Aid, Coast and Geodetic Survey, and he reached Seattle on May 1. A party was organized and preparations were made for the field work, which began on the 7th. The line began on the reference bench marks for the tide gauge at Seattle and was extended along the Northern Pacific Railway to Auburn, and thence eastward along the same railroad to Clealum, where the party was at work on June 30. The work was done in the usual manner, and all portions of the line were leveled at least once in each direction. Instead of establishing temporary bench marks, as usual, a nail driven into the wooden posts erected by the railroad company at nearly all mileposts to support extra rails, was used. The rods were supported at turning points on the rails of the roadbed, except that foot pins were used as often as possible when trains passed and during very windy days. In the progress of the work it was carried through the Stampede Tunnel, 2 miles long. While working in the tunnel, small electric reading lights were used by the observer and rodmen, and the rods were illuminated by using acetylene gas lamps. The work in this tunnel and the steep mountain grades over a portion of the line retarded the progress of the work considerably.

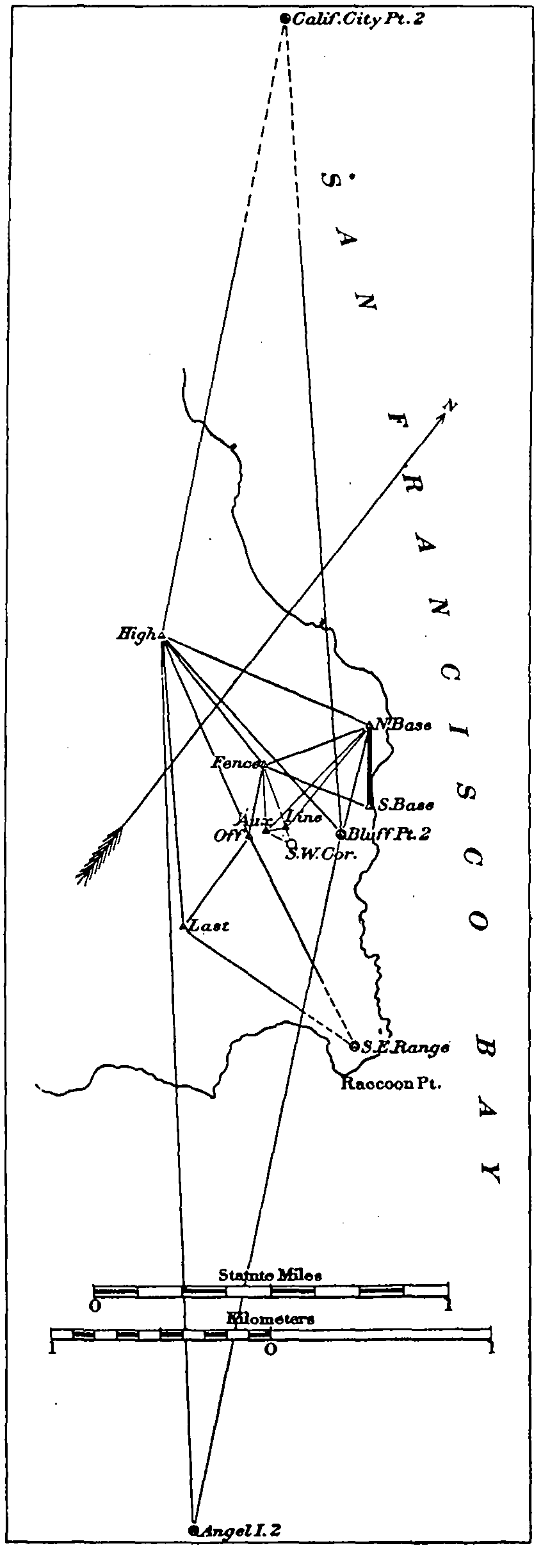
The officials of the Northern Pacific Railway were unwilling to grant the privilege of using velocipede cars on their tracks, but they generously placed a freight car at the disposal of the party and hauled this car from place to place as requested. No charge was made for this service, which greatly facilitated the progress of the work in the sparsely settled region over which a portion of the route passed. The thanks of the Survey are due the company for the above and other courtesies extended to the party.

The chief of the party commends the service of all the members, and especially mentions the efficient work done by Mr. George W. Myers, Recorder.

HYDROGRAPHY. CALIFORNIA. H. C. DENSON.
TOPOGRAPHY.
TRIANGULATION.

In accordance with a request from the Secretary of the Navy a survey was made of a tract of land near California City Point, San Francisco Bay. This work was assigned to Assistant H. C. Denson under the general direction of Assistant A. F.

No. 24.



Triangulation, California.

Rodgers, in charge of the suboffice at San Francisco, Cal. He reported to Assistant Rodgers on October 9, and the work in the field covered the period from October 23 to January 6. A self-registering tide gauge was established on October 23, and a continuous record was obtained for two and one-half months. A short base line was measured with a steel tape, from which a triangulation covering the area to be surveyed was extended to a connection with the triangulation of San Francisco Bay. Cross-section lines were run at intervals of 25 feet by leveling, from the line of mean low water to an elevation of 40 feet, and the elevation was determined at each intersection. From these elevations contour lines at intervals of 2 feet up to 30 feet were determined with a plane table. The lines of mean high water and of mean low water were also determined. The cross-section lines were extended offshore to a depth of 50 feet. A line marked at intervals of 25 feet was fastened on shore and then stretched over the water, and the soundings were made at the points indicated by the marks, and the time was recorded at intervals of five minutes, in order to correct for changes of the tidal level. This system of doing the hydrographic work was suggested by Assistant Rodgers, and was entirely satisfactory. The progress of the work was slow on account of unfavorable weather, which delayed the completion of the work until January 6, when the party was disbanded.

HYDROGRAPHY. WASHINGTON. E. F. DICKINS, Commanding,
Steamer *Gedney*.

W. H. STANFORD, *Watch Officer*.
A. A. DUNNING, *Mate*.
J. R. HURLEY, *Assistant Surgeon*.
J. W. MAUPIN, *Aid*.
LARS JENSEN, *Pilot*.

SUMMARY OF RESULTS.

San Juan Channel, South Entrance.

10 square miles area covered.
102 miles lines sounded.
1 442 soundings made.
1 tide station established.

Hein Bank, Juan de Fuca Strait.

2 square miles area covered.
39 miles lines sounded.
598 soundings made.

Hydrographic examinations in San Juan Channel and in Juan de Fuca Strait were assigned to Assistant Dickins, commanding the steamer *Gedney*. He made preparations for the work at San Francisco and sailed for San Juan Channel on May 8. Coal and mess stores were obtained at Victoria, British Columbia, and the field work began on the 17th. The work in San Juan Channel was completed on the 27th and the examination of Hein Bank began the same day. The position of a dangerous rock on this bank was determined. The work was completed on the 30th, and the vessel proceeded to Seattle, via Victoria, British Columbia.

ASTRONOMIC OBSERVATIONS. MONTANA. WM. EIMBECK.
MAGNETIC OBSERVATIONS. E. D. PRESTON.

SUMMARY OF RESULTS.

Astronomic observations:
    1 longitude determined.
Magnetic observations:
    3 stations occupied.

The determination of the longitude of Chinook, Mont., from Helena as a base station was assigned to Assistants Eimbeck and Preston, who were placed in charge of cooperating parties.

Mr. Eimbeck reached Chinook on September 11, 1903, and immediately selected a suitable site for the longitude station. A pier was erected to support the astronomical transit, and a small observatory was constructed for temporary use. After considerable delay the observatory was connected by wire with the Western Union Telegraph lines at the railroad station, but the preliminary test of the line connection with Helena could not be made until September 20. Further delay was caused by cloudy weather, and the observers were not ready to exchange stations until October 7, when the first part of the work was completed.

Mr. Eimbeck waited in Chinook until Mr. Preston arrived, and went to Helena on the 11th. It was cloudy on the 12th, but observations were obtained on the 13th, 14th, and 15th, thus completing the determination of the difference of longitude between Helena and Chinook.

While at Helena Mr. Eimbeck measured a short base line and connected the longitude station with one of the triangulation points of the United States Geological Survey, and determined the geographic position of three church steeples at the request of the officer of that Survey who was extending the topographic survey in the vicinity.

Mr. Eimbeck left Helena on October 24 en route to Washington.

Mr. Preston reached Helena on September 14 and immediately began preparations for the work. There was some delay in securing workmen to build a pier and to connect the astronomic station with the main line of the Western Union Telegraph Company, and the station was not ready for astronomic observations until September 23. While waiting for the completion of this work, observations were made to determine the elements of the earth's magnetism. On September 23 preliminary observations were made, but bad weather prevented regular observations until the 28th, and the necessary observations were not completed until October 7. On the 9th Mr. Preston proceeded to Chinook to exchange stations with Mr. Eimbeck, and made magnetic observations on the 12th and 13th, and again on the 19th and 20th.

The astronomic observations at Chinook were completed on the 15th. On October 24 he went to Glasgow, Mont., and made observations to determine the elements of the earth's magnetism at that place. He completed the work on the 26th. and closed field work for the season on that date.

ASTRONOMIC OBSERVATIONS. RECONNAISSANCE. TRIANGULATION.

CALIFORNIA. OREGON. WASHINGTON.

O. B. FRENCH.

SUMMARY OF RESULTS.

July 1 to November 20.

Astronomic observations:
  4 azimuths determined.
Reconnaissance:
  7 200 square miles area covered.
  19 triangulation stations selected.
Triangulation:
  11 350 square miles area covered.
  19 stations occupied.
  78 geographic positions determined.

April 2 to June 30.

Reconnaissance:
  10 000 square miles area covered.
  9 triangulation stations selected.
Triangulation:
  10 000 square miles area covered.
  9 stations occupied.
  25 geographic positions determined.

The extension of the primary triangulation in Oregon was in progress on July 1 by a party under the direction of Assistant French, and on that date the observing party was ready to move from station Roman to station Spencer. The following stations were then occupied in the order stated, viz: Spencer, Peterson, Mary, Yam, Hult, Barnes, Larch, Rocky Butte, River, Oregonian, Warren, Harney, Rauch, South Base, and University.

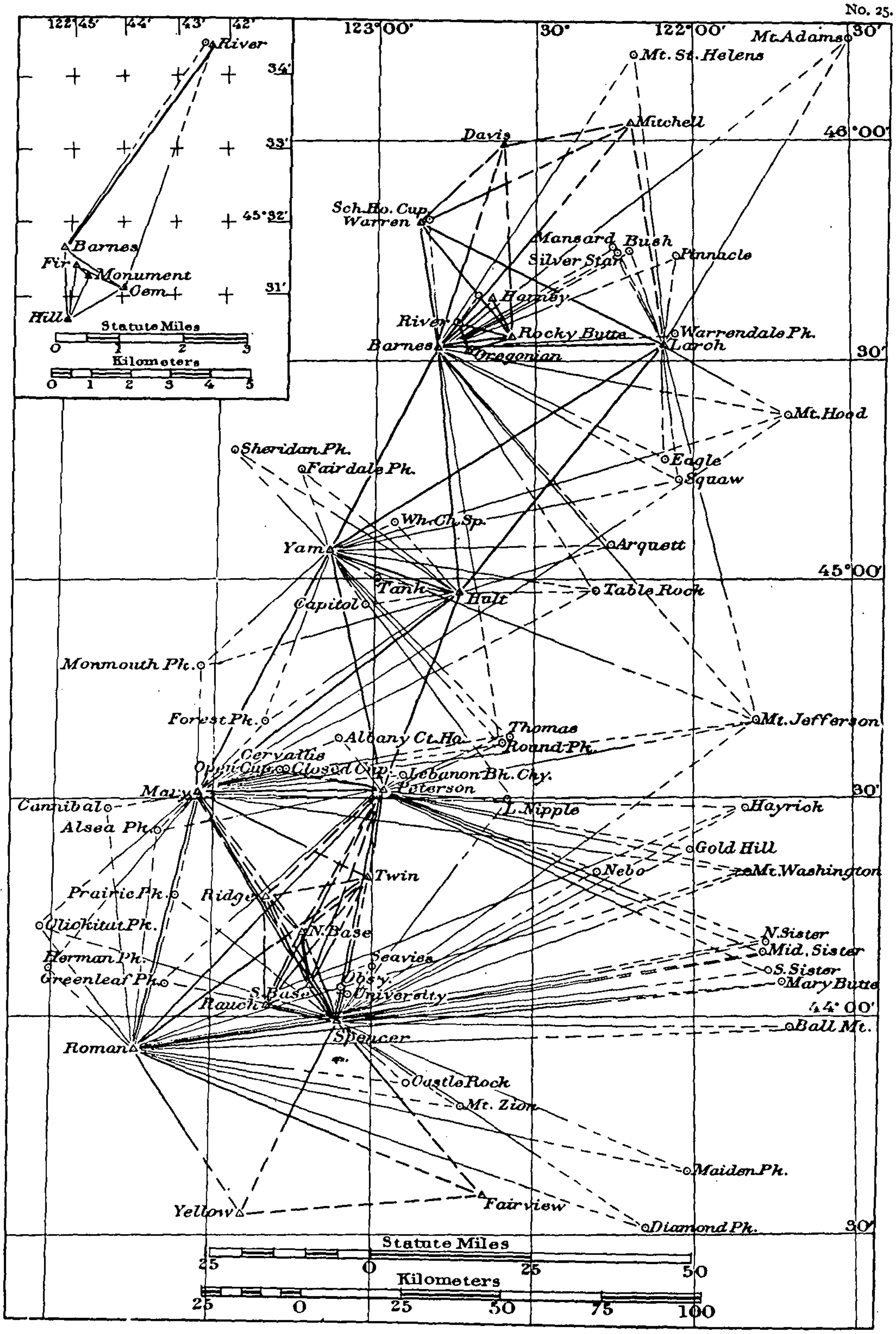
Rocky Butte, River, Oregonian, and Harney were occupied as secondary points to connect the Columbia River triangulation and the bench mark and astronomic station at Portland, Oreg., with the work in hand. University was used to connect the bench mark and astronomic station near Eugene, Oreg.

Four additional secondary stations were occupied to connect a general land survey monument in the vicinity of Portland. The astronomic azimuth of a line in the main scheme of triangulation was determined at four stations, viz: Spencer, Mary, Yam, and Barnes.

It was necessary to erect signals at 6 out of the 19 stations. Heliotropes, lamps, and signals or targets were used on this work. In spite of these precautions the work was considerably delayed by unfavorable weather conditions. The observations for horizontal angles were made in the afternoon and at night until midnight whenever the lights could be seen. The signals or targets were rarely available for observations except on lines less than 20 miles long, and then only under favorable conditions. The light from the lamps was too indistinct for good observations on lines over 40 miles long unless the atmosphere was fairly clear.

The positions of a number of mountain peaks were determined. At Portland connection was made with a bench mark established by the United States Geological

No. 25.



Triangulation, Oregon and Washington.

Survey and with the Coast and Geodetic Survey astronomic station. A connection was also made with the triangulations along the Columbia River and along the Willamette River. The geographic position of the monument marking the intersection of the Willamette meridian and the First Standard Parallel, of the United States General Land Office, was determined.

At Eugene connection was made with a bench mark of the United States Geological Survey and with the old observatory on Skinners Butte.

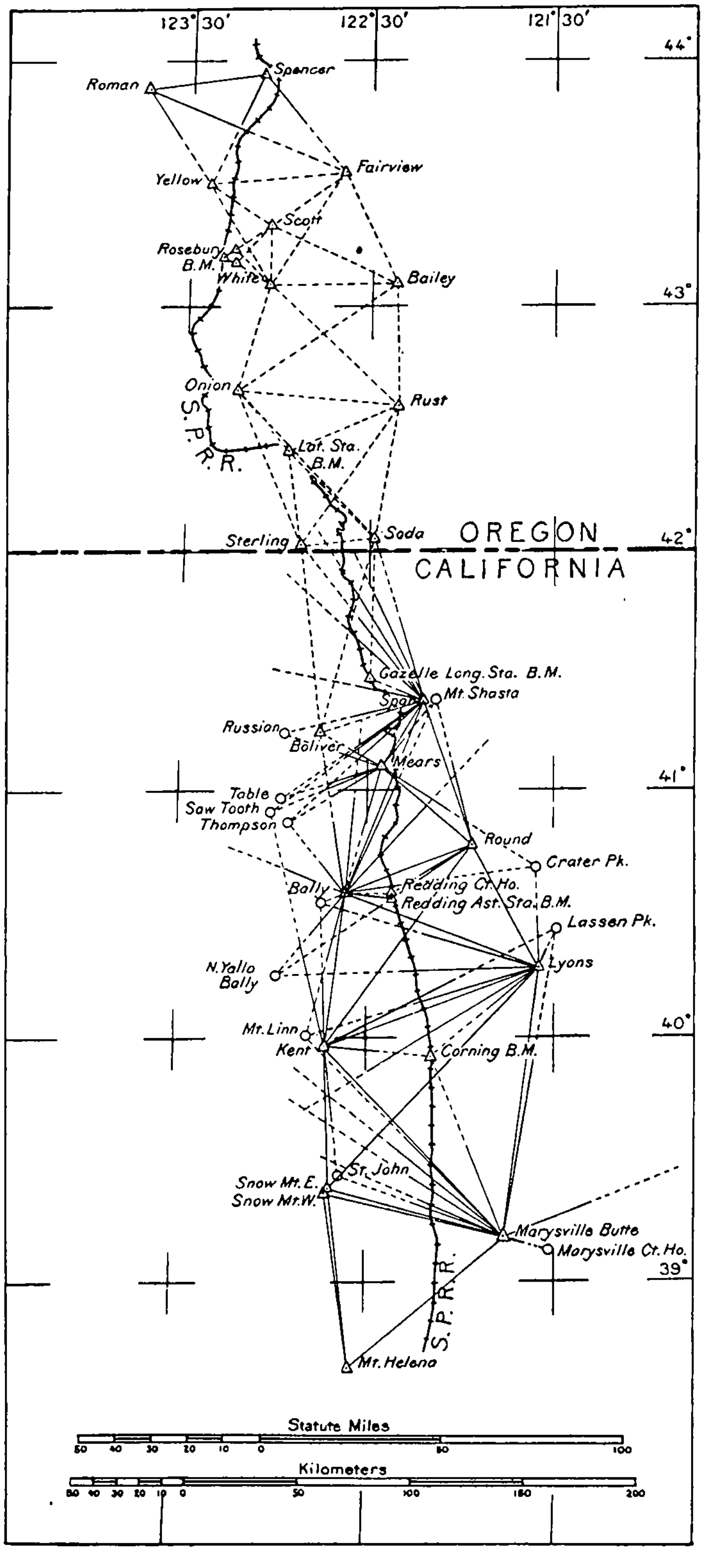
The work of preparing the stations for occupation, of opening trails, etc., was done by a subparty in charge of the foreman, D. A. Lewis, who did his work in a thorough, expeditious, and complete manner. There were only three stations where it was necessary to use pack animals.

Observations were discontinued on October 14, and the party proceeded to Eugene, where the property was stored and the party disbanded.

Mr. French started on the 18th to extend the reconnaissance to the southward from the line Yellow to Fairview, and continued the work until November 20, aided by Foreman Lewis. Fourteen stations were visited on this work and a scheme of triangulation was selected which extends the work 350 miles southward to a junction with the transcontinental triangulation along the thirty-ninth parallel on the line Mount Helena to Marysville Butte.

Work on the primary triangulation north of San Francisco was resumed in April by Assistant French. He reached Tacoma, Wash., on April 2, and began the work of reconnaissance immediately. Stations were selected to connect the Tacoma longitude station with the triangulation and a site for a base line was also selected. Five days were spent at Eugene, Oreg., putting the camp outfit in order and completing the organization of the party. On April 12 the outfit for the building party was sent by rail to Corning and for the observing party to Marysville, Cal, while Assistant French visited two stations on reconnaissance. The building party in charge of D. A. Lewis, Foreman, started from Corning on April 21, and prepared the following stations for occupation before June 30, viz: Kent, Round, Bally, Redding, Astronomic Station, Mears, Spur, Boliver, Gazelle, Sterling, and Soda. At Round, the lines to the other stations were cut through timber and at two of the stations the construction of trails was especially difficult. At Mears station, it was necessary to build ladders for use in reaching the station. Mr. Lewis is commended by his chief for his faithful attention to his work and for accomplishing so much in the face of so many difficulties. The observing party was left at work preparing Marysville Butte station while Mr. French visited Snow Mountain to verify the reconnaissance and post a heliotrope. He returned to Marysville Butte on May 2, and the observation of angles began on the following day. There was considerable delay at this station caused by unfavorable weather, failure of heliotrope to show, etc., and finally a severe storm destroyed the tent and injured the instruments by rolling some of them off the low signal on which they were mounted to the rocks below. Deep snow was encountered at Snow Mountain, and the wind was very strong nearly all the time. The observations at Lyons were made by Mr. J. S. Hill, Aid, while Mr. French was on reconnaissance in the vicinity of Mount Shasta. Mr. Hill also made the observations at station Bally while Mr. French was on reconnaissance near the California–Oregon boundary. The following stations were occupied in the order named: Marysville Butte, Snow Mountain, Kent, Lyons, Round, Redding,

No. 26.



Triangulation and reconnaissance, California and Oregon.

Bally, Mears, and Spur. The observations were in progress at Spur on June 30. Observations to determine an azimuth were made at Marysville Butte, Snow Mountain, Kent, Lyons, and Round. Observations for time were also made at these stations. Observations were made at all stations to determine the double zenith distance of the other stations visible from the observing point and the positions and elevations of all prominent mountain peaks were determined. Mr. J. S. Hill reported for duty in the party at Marysville Butte on April 27.

MAGNETIC OBSERVATIONS. CALIFORNIA. D. L. HAZARD.

Advantage was taken of the presence of Mr. D. L. Hazard in San Francisco on other duty by instructing him to make magnetic observations at a few stations in that vicinity. The old magnetic station in San Francisco at thePresidio is no longer available, and a new one was established and occupied on Presidio Hill. Stations were then occupied in the following places, and at all these stations observations were made to determine the elements of the earth's magnetism: Berkeley, Goat Island, San Jose, Santa Cruz, and Stanford University. The work was done between April 21 and May 12, at such times as the demands of Mr. Hazard's assignment in connection with magnetic observations on board ship permitted.

LEVELING. IDAHO. WYOMING. H. D. KING.

SUMMARY OF RESULTS.

534 kilometers of line completed.
72 bench marks established.

On July 1, the standard levels were being extended westward in Wyoming by a party under the direction of Aid H. D. King, and the work had reached a point 13 miles east of Greenriver. The leveling instrument was accidentally injured on July 8, and this caused several days' delay, but with this exception the work proceeded without interruption until July 31, when the levels joined the line from the westward at a point about 2 miles west of Azusa, Wyo.

The route followed the Union Pacific Railroad and the usual method of leveling was followed, all portions of the line being leveled at least once in each direction.

On August 1, the party proceeded to Pocatello, Idaho, a station on the Oregon Short Line Railroad; and on August 3 began leveling northward from that place. This region is more favorable for leveling operations than western Wyoming and the wind does not blow so continuously. The track is laid on the ground without ballast, and portions of it have been sprinkled with oil. In addition to this the trains were not so numerous as on the Union Pacific Railroad.

In September a change in the method of supporting the level rods was introduced. On the previous work the rods were always held on "foot pins" or "foot plates" made stable for the purpose, but in this month the observer satisfied himself that the use of the steel rail as the rod support was desirable from the fact that more progress could be made and that no loss of accuracy would result from its use. The rods were placed on marks made on the rails, and the use of the rails became more and more general as the season advanced until a point was reached where the "foot pins" were "only used in emergencies." The observer recommends this method in regions "where the rainfall is light and comparatively few trains run." The work was continued to Owyhee, Idaho, where the field work closed for the season on October 26 and the party was disbanded.

The usual methods were followed except as noted above, and all portions of the line were leveled at least once in each direction. Permanent bench marks were established at suitable intervals, and numerous temporary bench marks were used as the means of comparing the results obtained in the forward and backward lines.

Velocipede cars were used as the means of transportation throughout the season, and the thanks of the Survey are due the Union Pacific and Oregon Short Line Railway companies for their courtesy in granting the privilege of using their tracks.

LEVELING. IDAHO. UTAH. WYOMING. R. L. LIBBY.

SUMMARY OF RESULTS.

302 kilometers of line completed.
33 bench marks established.

On July 1 the standard levels were being extended eastward from Ogden, Utah, by a party under the direction of Aid R. L. Libby, and the work had reached a point in the vicinity of the Aspen Tunnel on the Union Pacific Railway. This tunnel is more than a mile long and repairs were in progress in the tunnel (with a construction train running in and out) making it impracticable to level through the tunnel, and the line was carried over the top of the mountain. Heavy grades on the railroad and strong wind also delayed the work and slow progress was made. On July 31 the levels joined the line from eastward at a point 2 miles west of Azusa, Wyo.

The route followed the Union Pacific Railway and the usual method of leveling was followed, all portions of the line being leveled at least once in each direction.

The party then went to Ogden, Utah, and extended the levels northward from that place along the Oregon Short Line Railway to Pocatello, Idaho, where the work closed September 30 on bench marks established earlier in the season by Aid H. D. King.

In August the use of steel "foot pins" as rod supports was abandoned and the rods were held on the rails of the railroad, a mark being made on the rail to indicate the exact spot. The observer satisfied himself after several trials "that the rail returned to its former position after a train passed." With this exception the usual method was followed and all portions of the line were leveled at least once in each direction.

Velocipede cars were used as the means of transportation, and the thanks of the Survey are due the railway companies, mentioned above, for their courtesy in granting the privilege of using their tracks.

CHARGE OF SUBOFFICE. CALIFORNIA. AUG. F. RODGERS.
TIDE OBSERVATIONS.

The suboffice of the Survey in San Francisco was continued under the charge of Assistant Rodgers, who attended to numerous duties, many of them matters of routine, as the representative of the Superintendent on the Pacific coast. All matters referred to the suboffice were promptly attended to. Various officers were temporarily attached to the suboffice during the year, and others were on duty there completing the records of the field work done under their direction. Assistant Rodgers had general direction of a special survey in San Francisco Bay near California City, made by Assistant H. C. Denson at the request of the Navy Department.

A continuous record of the tides at the Presidio station was obtained, with H. S. Ballard as Tide Observer. Mr. Ballard is commended for his faithful attention to duty. Mr. James Sullivan, Chief Engineer, is also commended for his useful and efficient service while temporarily attached to the suboffice. Robert E. Carson served as messenger until January 4, when he became ill. He died on June 26 and was succeeded by Henry Bernhardt, who held the position until April 7. Peter A. Thomasen and George A. McEldowney held the position at different times during the remainder of the year.

LEVELING. IDAHO. F. H. SEWALL.
OREGON.

SUMMARY OF RESULTS.

199 kilometers of line completed.
79 bench marks established.

The extension of the standard levels westward from Owyhee, Idaho, was assigned to F. H. Sewall, Aid, Coast and Geodetic Survey. He reached Nampa on May 4, and began leveling the next day at Owyhee, Idaho, starting from bench marks established at that place during the previous fiscal year. The route followed the Oregon Short Line Railroad to Huntington, Oreg., and thence along the line of the Oregon Railroad and Navigation Company, and reached the vicinity of Durkee, Oreg., by the end of June.

Velocipede cars were used as the means of transportation, and the thanks of the Survey are due the corporations mentioned for their courtesy in granting this privilege.

All portions of the line were leveled at least once in each direction and temporary bench marks were established at frequent intervals, to afford the means of comparing the results obtained by the lines in opposite directions, in addition to the number of permanent bench marks stated above. The work was in progress at the close of the fiscal year.

TIDE OBSERVATIONS. WASHINGTON.

A self-registering tide gauge was maintained throughout the year at Seattle, Wash. W. C. Meyer, Observer.

DIVISION OF ALASKA.

HYDROGRAPHY. TOPOGRAPHY. TRIANGULATION.	ALASKA.	E. F. DICKINS, Commanding, Steamer *Gedney*.

August 11 to September 30.

W. H. STANFORD, *Watch Officer.*
C. E. MORFORD, *Aid.*
G. C. BALLARD, *Assistant Surgeon.*
J. M. MILLER, *Aid.*
A. J. STILES, *Aid.*

SUMMARY OF RESULTS.

Hydrography:
- 53 square miles area covered.
- 162 miles lines sounded.
- 1 093 soundings made.
- 2 tide stations established.
- 1 hydrographic sheet completed.

Topography:
- 24 square miles area covered.
- 48 miles shore line surveyed.
- 1 topographic sheet completed.

Triangulation:
- 187 square miles area covered.
- 36 stations occupied.
- 49 geographic positions determined.

June 23 to 30.

W. H. STANFORD, *Watch Officer.*
A. A. DUNNING, *Mate.*
J. R. HURLEY, *Assistant Surgeon.*
J. W. MAUPIN, *Aid.*
LARS JENSON, *Pilot.*

The survey of Davidson Inlet, Alaska, was assigned to Assistant Dickins, commanding the steamer *Gedney*. The vessel left San Francisco on July 12 and proceeded to Seattle, where certain necessary repairs were made to put the ship's boilers in good order.

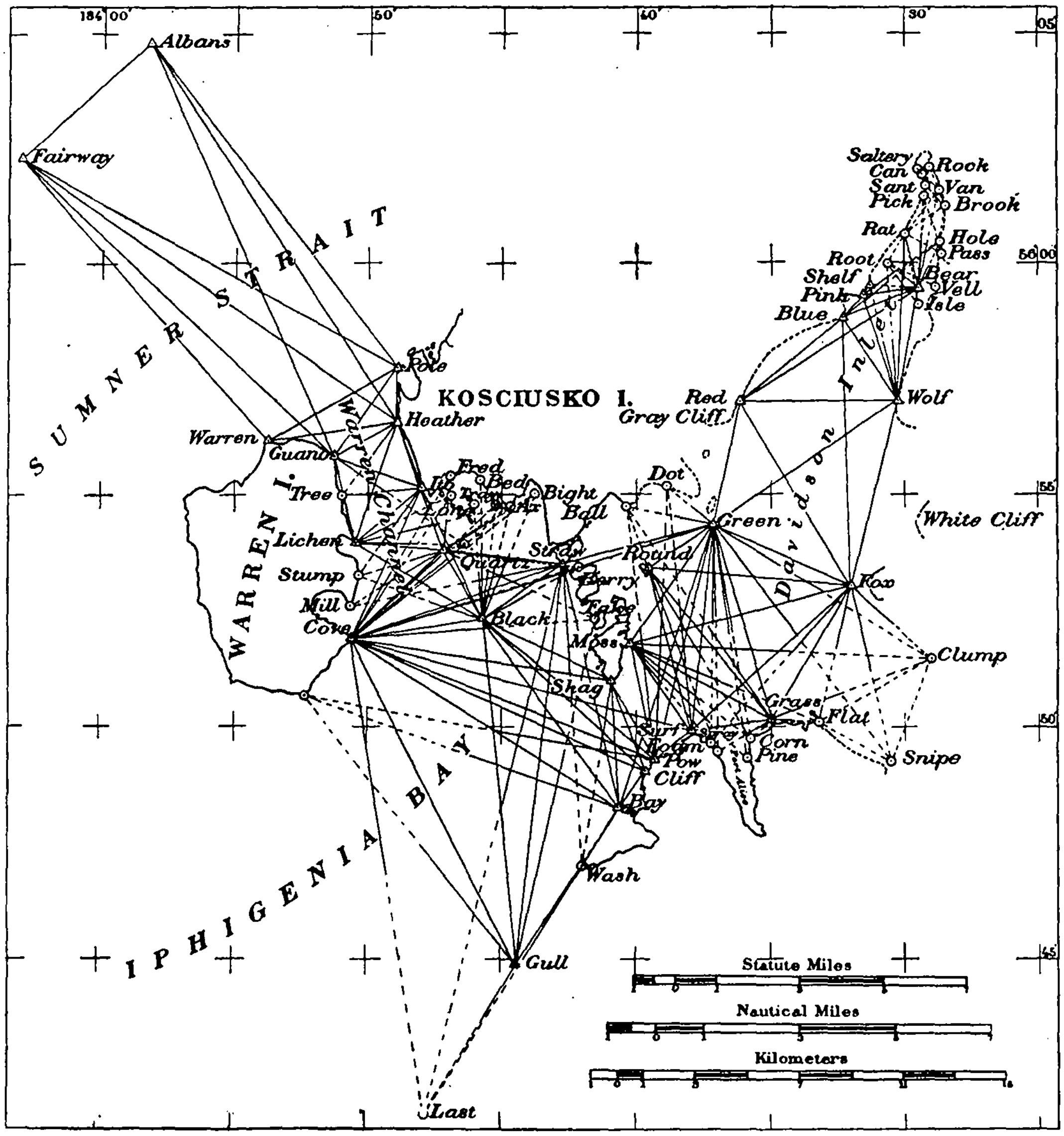
On August 5 the vessel sailed for Alaska, with the launch *Cosmos* in tow, via Victoria and Union Bay, British Columbia, and on the 11th anchored at the north end of Mary Island, Alaska.

Three of the old triangulation stations were recovered and occupied for the purpose of determining the geographic position of the light-house, and a topographic survey of the light-house reservation was made.

The vessel then proceeded to Ketchikan for the purpose of locating a reported danger at the south entrance to Tongass Narrows. A rock of small extent, with deep water all around it, was found, directly in midchannel and a temporary buoy was placed over it and the inspector of the light-house district was notified.

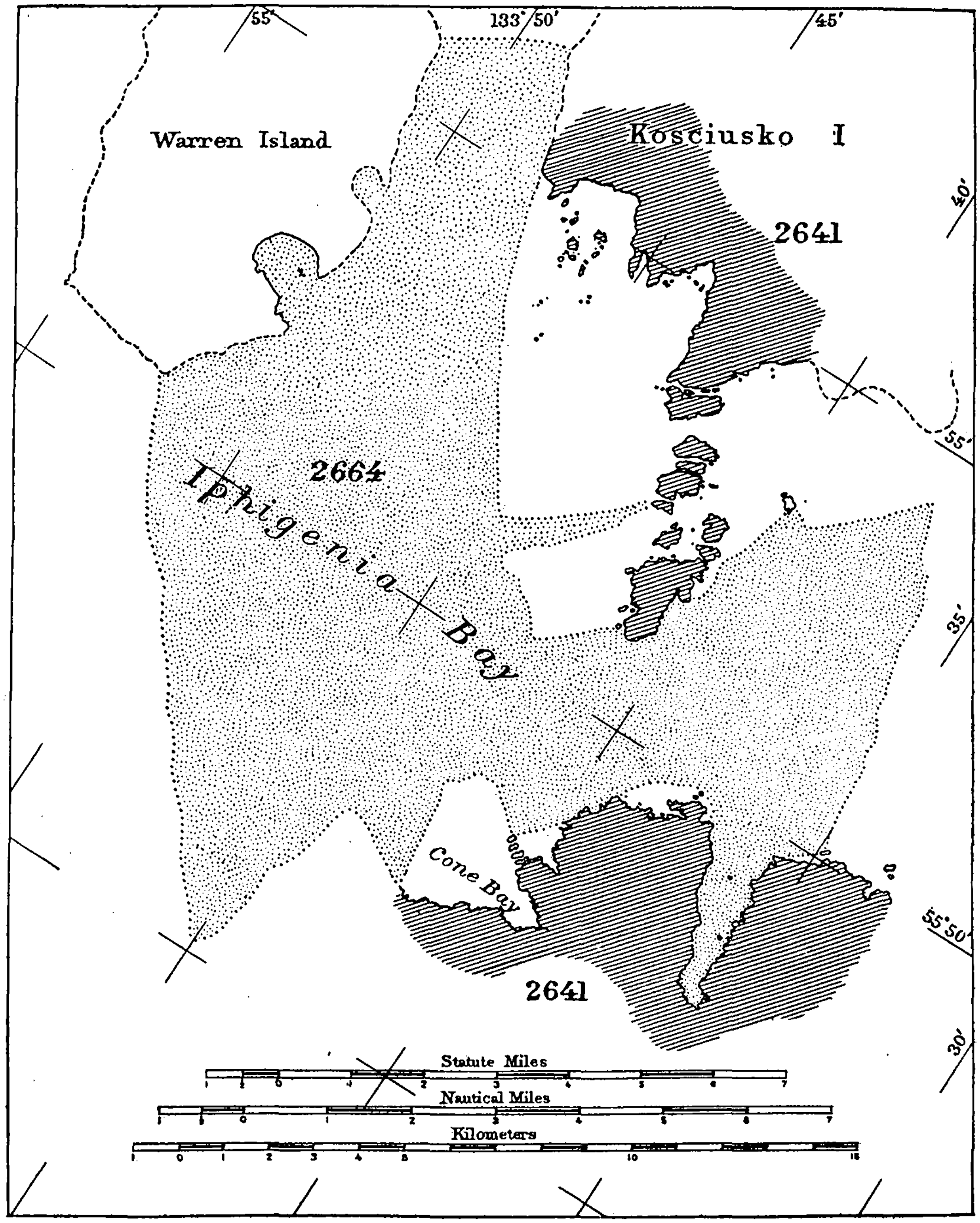
The vessel reached Shakan on Saturday, August 15. A general reconnaissance of the neighboring waters and shores was made in the *Cosmos* and signals for the triangulation were erected. A triangulation party was placed on the *Cosmos* in charge of Mr. Morford, and on August 27 the *Gedney* sailed for Sitka to bring up Launch No. 117. This launch was put in order, the necessary supplies were obtained and the vessel, with

No. 27



Triangulation, Alaska.

No. 28.



Hydrography and topography, Alaska.

the launch in tow, arrived at the working ground on the 6th. Next day a tide gauge was established and a reconnaissance was made for a safe anchorage, which was found in an arm or bay on the south side of Davidson Inlet just inside the entrance, and this body of water was named Port Alice. On the night of the 7th it began to blow and by morning it was blowing hard and a heavy sea was rolling in, which washed away the tide gauge in the forenoon. The ship and launches crossed Iphigenia Bay and found a safe and quiet anchorage in Port Alice. On September 11 another tide gauge was established, and on the 24th the topography and hydrography were begun. The topographic work was done by Mr. Morford with Mr. Stiles as his aid, and the hydrographic work by Mr. Stanford, Watch Officer, and Mr. Miller, Aid, with Doctor Ballard as recorder, both parties using launches, while the commanding officer extended the triangulation up the Inlet, toward the Holbrook Fishery, using the *Cosmos*.

There was great difficulty in keeping the signals up, and so field work was closed on the 30th of September. The vessel then proceeded to Sitka, via Fort Wrangell, and stored the *Cosmos* and Launch No. 117. On October 10 the vessel sailed for Seattle, and reached that place on October 23.

On October 13, while passing the light-house on Five Finger Islands, a signal was received desiring to communicate with the ship, and a boat came off containing the first officer and five men of the steamer *Farallon*, with the information that this vessel had broken her shaft and lay anchored in an exposed position in Frederick Sound. The *Gedney* proceeded to the locality and towed the *Farallon* to a safe anchorage off Tonka Cannery, in Wrangell Narrows.

The *Gedney* left Seattle on October 29 and reached San Francisco on November 4, after passing through a southeast storm lasting four days.

Mr. Dickins states that the officers of the ship all attended to their duties faithfully and well, and were always ready and willing to perform all duties assigned to them. He reports that the pilot, Capt. A. C. Jansen, was an exceptionally good man for the place, being well acquainted with all parts of southeast Alaska and taking a great interest in the work. Captain Jansen's advice was often of great assistance, and he is thoroughly trustworthy and reliable.

Work in Davidson Inlet was resumed in June by Assistant Dickins, commanding the steamer *Gedney*. The vessel sailed from Seattle on June 6 for Alaska, via Union Bay, British Columbia, for coal, and reached Sitka on the 12th. The *Cosmos* and Launch No. 117 were put in order and the ship reached Warren Cove on the 23d, and the erection of signals began the same day. A tide gauge was erected and tide observations began on the 28th. The triangulation work commenced on the 29th, and all the work was in progress at the close of the fiscal year.

MAGNETIC OBSERVATIONS. ALASKA. H. M. W. EDMONDS.

S. J. BARNETT, *Magnetic Observer*. July 8 to Aug. 30.

The work at the Magnetic Observatory at Sitka, Alaska, was continued during the year under charge of H. M. W. Edmonds, Magnetic Observer. A continuous record of the changes in the magnetic elements was obtained by the self-registering magnetograph, and the temperature changes were recorded by the thermograph. Observations were made at least once every week to determine the absolute value of the magnetic elements and observations for time were made whenever the weather permitted. The maximum and minimum temperature was recorded daily and other meteorological observations were made. A seismograph was added to the instrumental outfit on November 14, and it was installed in a small room added to the astronomic observatory for that purpose. Observations with this were obtained on sixty-five days before the close of the year.

Mr. S. J. Barnett, Magnetic Observer, was assigned to the party for the purpose of making observations to determine the magnetic elements at numerous stations in the vicinity of Juneau to investigate the marked magnetic disturbance in this locality, and especially on Douglas Island. The instruments were compared at Sitka and then observations were made at Juneau and at 41 stations on Douglas Island, which completed the field work.

Base Measurement.
Hydrography.
Magnetic Observations.
Physical Hydrography.
Topography.
Triangulation.

ALASKA.

J. F. Pratt, Commanding,
Steamer *Patterson*.

H. W. Rhodes, *Assistant.*
A. L. Giacomini, *Watch Officer.*
Geo. N. McLoughlin, *Assistant Surgeon.*
A. R. Hunter, *Watch Officer.*
H. M. Hathaway, *Deck Officer, First Class.*
D. R. Jewell, *Aid.*
J. W. Milburn, *Aid.*
H. L. Beck, *Aid.*
C. C. Craft, *Aid.*
P. C. Whitney, *Aid.*
R. J. Christman, *Draftsman.*

SUMMARY OF RESULTS.

Base measurement:
- 1 base line measured.

Hydrography:
- 10 square miles area covered.
- 75 miles lines sounded.
- 2 058 soundings made.
- 1 tide station established.
- 2 current stations occupied.
- 1 hydrographic sheet completed.

Magnetic observations:
- 4 stations occupied.

Physical hydrography:
- 2 068 miles lines sounded.
- 475 deep-sea soundings made.
- 3 hydrographic sheets completed.

Topography:
- 3 square miles area covered.
- 12 miles shore line surveyed.

Triangulation:
- 95 square miles area covered.
- 20 stations occupied.
- 46 geographic positions determined.

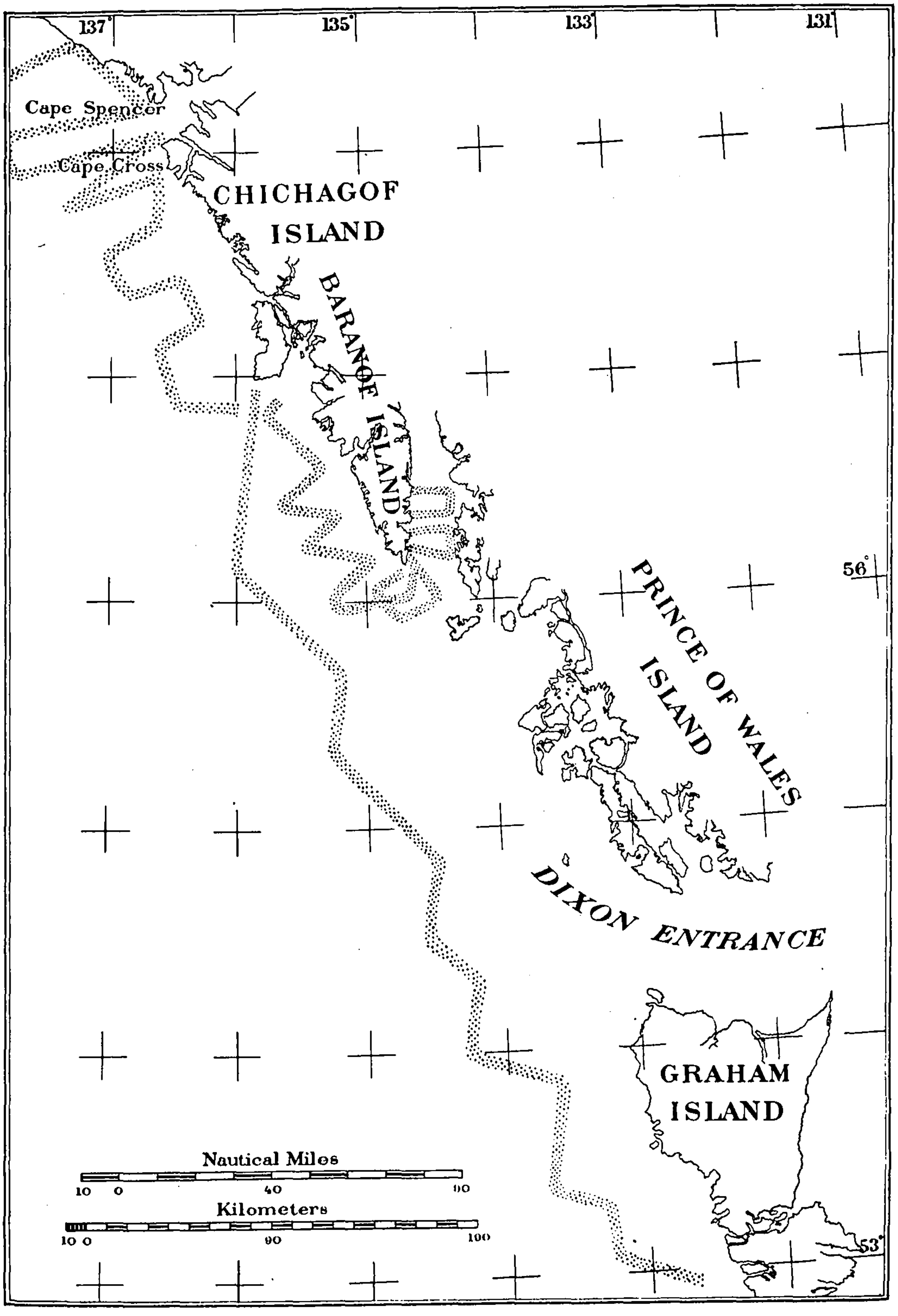
On July 1 the party on the steamer *Patterson*, with Assistant Pratt in command, was engaged in running a line of deep-sea soundings from Juan de Fuca Strait to Alaska to obtain information desired by Gen. A. W. Greely, Chief Signal Officer, U. S. Army, to be used in laying a cable from Seattle, Wash., to Alaska, as stated in the previous Annual Report. The line of soundings reached Sitka Sound on July 3, and was extended to the entrance to Chatham Strait on the 8th. Soundings were made in the lower portion of Chatham Strait on the 11th, 13th, and 16th, and the relative positions of Hazy Islands, off the entrance to the strait, were determined by sextant angles. The ship then proceeded to Juneau to furnish information to the cable ship *Burnside*, and returned to Sitka on the 21st. A reconnaissance was made between Cape Bingham and Cape Edgecombe for the purpose of determining the position of objects on shore to be used in connection with the deep-sea soundings off this locality. On July 27 the line between Sitka Sound and Prince William Sound was begun and continued until August 7, when the work was suspended off Cape St. Elias.

Magnetic observations were made at a station on Yakutat Bay.

The survey of Controller Bay was begun on August 8 and continued until September 19 whenever the weather was favorable and other conditions permitted. The triangulation was extended from a line already established in the Copper River Delta to the eastward as far as the northeast corner of Kayak Island, and a base line was measured on Octalee Spit. The topographic work consisted of the survey of a portion of Kanak Island and a small portion of the shore line at the mouth of Bering River. Hydrographic work was done in the lower portion of Octalee Channel.

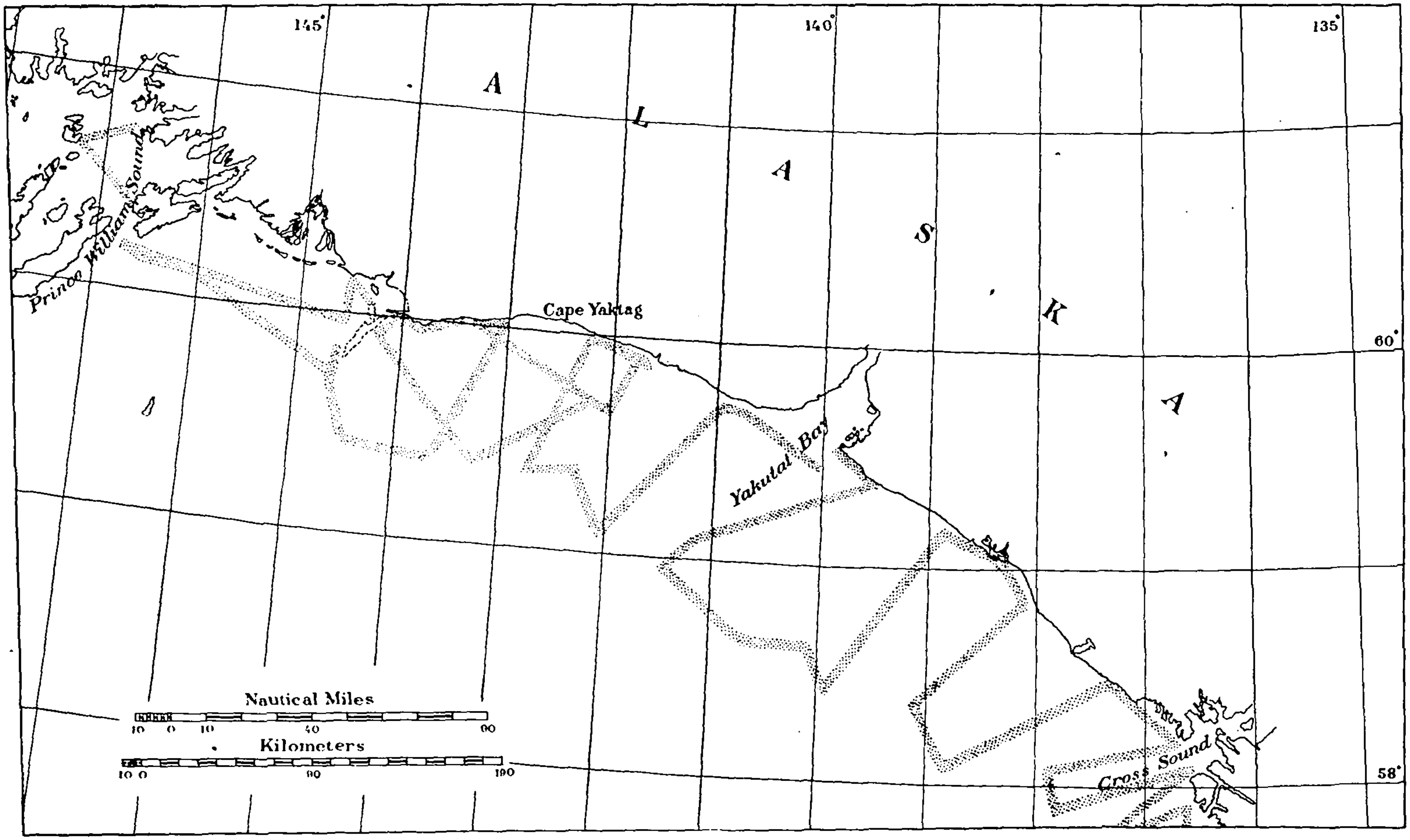
On September 19 telegraphic orders were received to close work and proceed to Kiska, Alaska, for work in that vicinity. The vessel went to Orca for coal and then sailed for Dutch Harbor, and reached that place on the 29th. En route, on the 25th, a crack developed in the outer corrugation of the port furnace, which proved to be too serious to permit the voyage to Kiska. Eight days were spent in making temporary repairs, and on October 10 the vessel sailed for Seattle, and reached that place on the 20th.

No. 29.



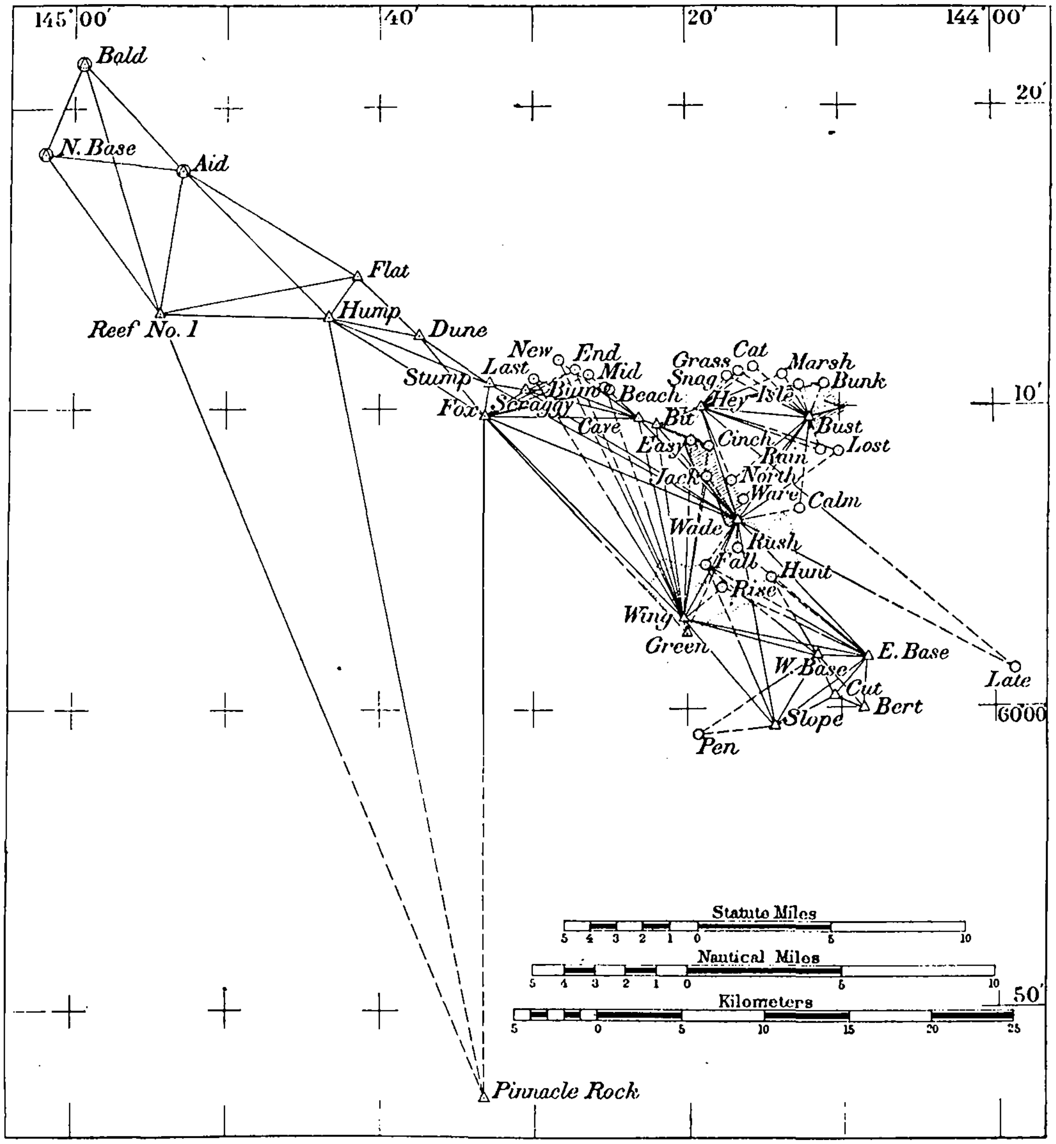
Deep-sea soundings, Alaska.

No. 30.



Deep-sea soundings, Alaska.

No. 31.



Hydrography, topography, and triangulation, Controller Bay, Alaska.

HYDROGRAPHY. ALASKA. H. P. RITTER.
TOPOGRAPHY.

H. BERNHARDT, *Observer.*
T. V. CONNOR, *Recorder.*
B. M. MCATEE, *Recorder.*

SUMMARY OF RESULTS.

Hydrography:
- 65 square miles area covered.
- 218 miles lines sounded.
- 5 362 soundings made.
- 6 current stations occupied.
- 2 hydrographic sheets completed.

Topography:
- 154 square miles area covered.
- 20 miles general coast line surveyed.
- 1 topographic sheet completed.

On July 1 the survey of Prince William Sound, Alaska, was in progress under the direction of Assistant Ritter. A brief statement in regard to the work, May 18 to June 30, appears in the previous Annual Report, but the following general statement refers to the work of the whole season, May 18 to September 30, while summary of results applies only to the work between July 1 and September 30.

The hydrographic work extends along the eastern side of Prince William Sound from the southern end of Bligh Island, across the entrance to Fidalgo Arm, and thence to Knowles Head. The soundings extend offshore to deep water, 200 fathoms or more. The area sounded includes the waterway between the mainland in the vicinity of Knowles Head and Goose Island and that portion of Fidalgo Arm extending from the entrance inland as far as Fish Bay. The soundings also covered the minor bays in this region known as Fish, Landlocked, and Bowie bays, and Snug Corner Cove. Tide observations were made in Snug Corner Cove. They began on June 1 and were continued until September 19. From June 1 to July 14 they were made continuously, day and night, and consisted of hourly readings, with readings every ten minutes from thirty to sixty minutes before and after each high and low water. After July 14 the readings were made only during the day. Whenever the steamer *Taku* was at Orca for coal or stores, simultaneous readings were made on the staff at that place and at Snug Corner Cove. Current observations were made at a number of stations during the season in the vicinity of Knowles Head and Goose Island, and at the entrance to Fidalgo Arm.

The topographic work augmented the work of previous seasons by extending it some distance inland. The country thus mapped embraces the northern shore of Valdez Arm from Point Fremantle to the vicinity of Saw Mill Bay; Bligh Island; the area between Tatilack Narrows and Gelena Bay; the vicinity of Copper Mountain; vicinity of Knowles Head; and both sides of Fidalgo Arm from the entrance back to Fish Bay. In addition to this the shore line on both sides of Fidalgo Arm and in the adjacent bays, from the entrance to Fish Bay, was surveyed.

The small steamer *Taku* and a launch were used by the party during the season and the party lived in camp on shore. The work for the season closed on September

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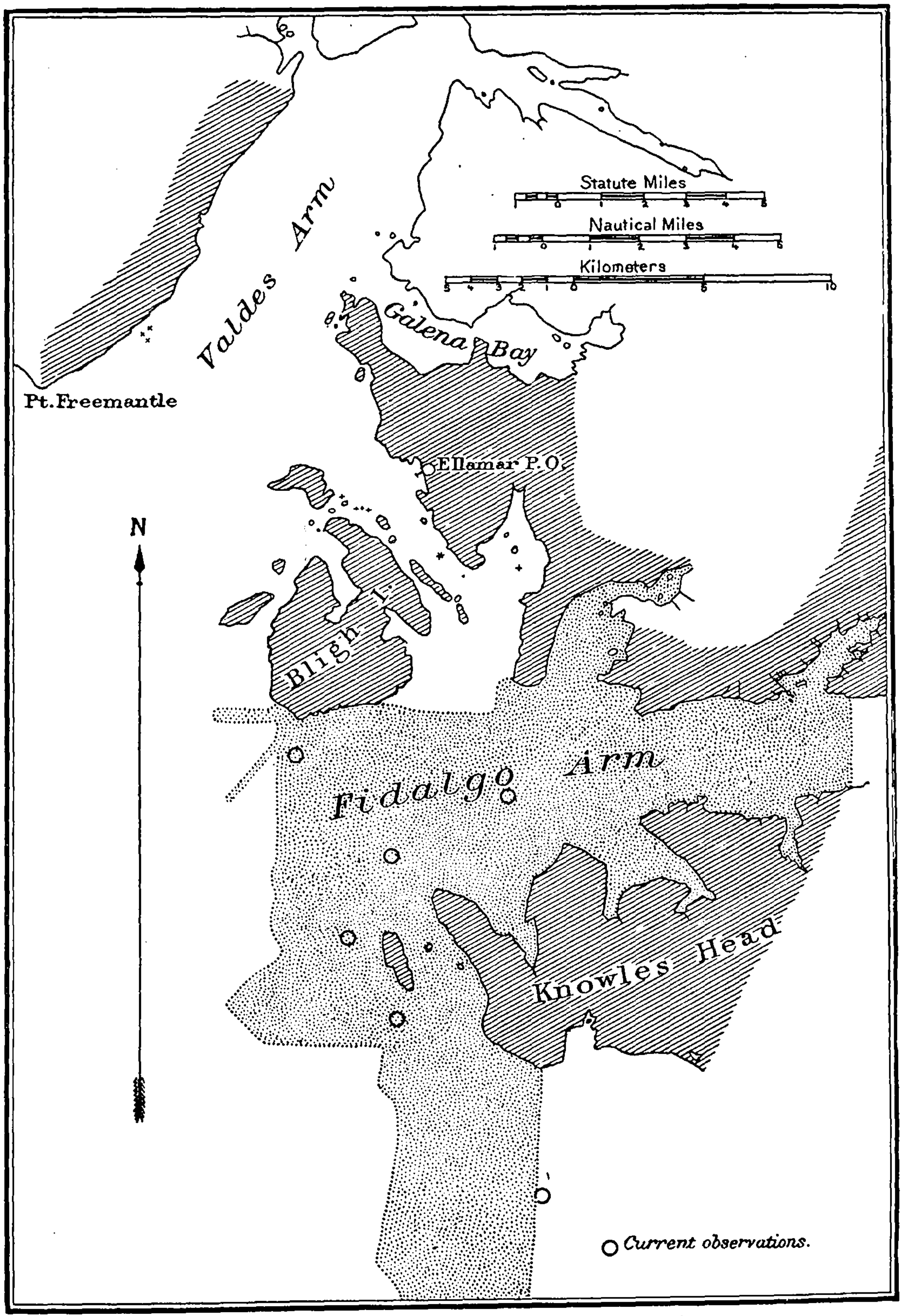

Hydrography and topography, Prince William Sound, Alaska.

20, when the party proceeded to Orca and stored the outfit for the winter. The party sailed for Seattle on October 1 and arrived on October 15.

Mr. Ritter reports the courtesy and assistance extended to the party during the season by Mr. Walter Storey, superintendent of the Alaska Packers Association, and by Mr. W. H. P. Brownell, superintendent of the Pacific Packing and Navigation Company's cannery. He also states that much of the success of the season's work was due to the proficiency and cheerful cooperation of Messrs. Henry Bernhardt, J. R. Westdahl, Thomas V. Connor, and B. M. McAtee.

OUTLYING TERRITORY.

ASTRONOMIC OBSERVATIONS. BASE MEASUREMENT. MAGNETIC OBSERVATIONS. TIDE OBSERVATIONS. TRIANGULATION.	HAWAII.	W. D. ALEXANDER.

SUMMARY OF RESULTS.

Astronomic observations:
- 1 azimuth determined.

Base measurement:
- 1 base line measured.

Magnetic observations:
- 4 stations occupied.

Triangulations:
- 73 square miles area covered.
- 13 stations occupied.
- 13 geographic positions determined.

The trigonometrical connection of the island of Niihau with Kauai, Hawaii, was assigned to Assistant Alexander. He made preparations for the work and reached Kauai on December 4. Mr. S. M. Kerns of the Surveyor's office was detailed by his chief, Mr. W. E. Wall, to assist in the work, and he went at once to Niihau where he measured a base line and occupied seven triangulation stations which he established on the island. He also observed the magnetic declination at Nonopapa and at Kii. On Kauai the distance from Puu Lani to Puu o Papai, previously determined was used as a base from which to extend the triangulation necessary to furnish the positions needed in the connection. Dr. A. C. Alexander assisted in this work and occupied the two stations Puu ka Pele and Puu Opae.

An azimuth was observed on Kauai.

Acknowledgement is made to Mr. B. D. Baldwin, manager of the Makaweli plantation, to Mr. A. F. Knudson, of Kehaha, and to Mr. Aubrey Robinson, one of the proprietors of Niihau, who extended hospitality and courtesies to members of the party.

Magnetic observations were made at Honolulu and at Waimea.

The work was completed and the party returned to Honolulu on December 23.

The observation of the tides by means of a self-registering gauge was continued during the year at Honolulu.

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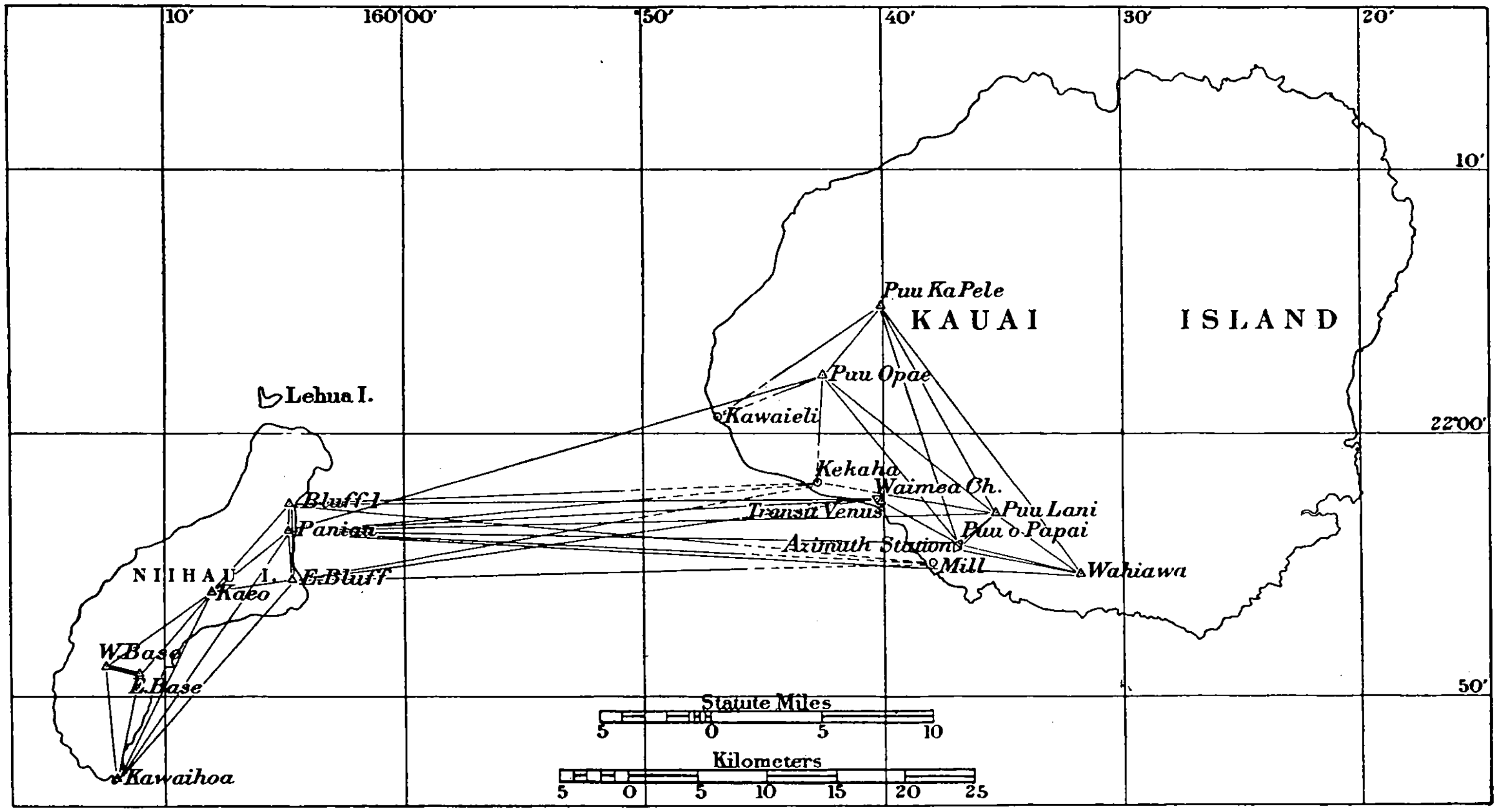

Triangulation, Hawaii.

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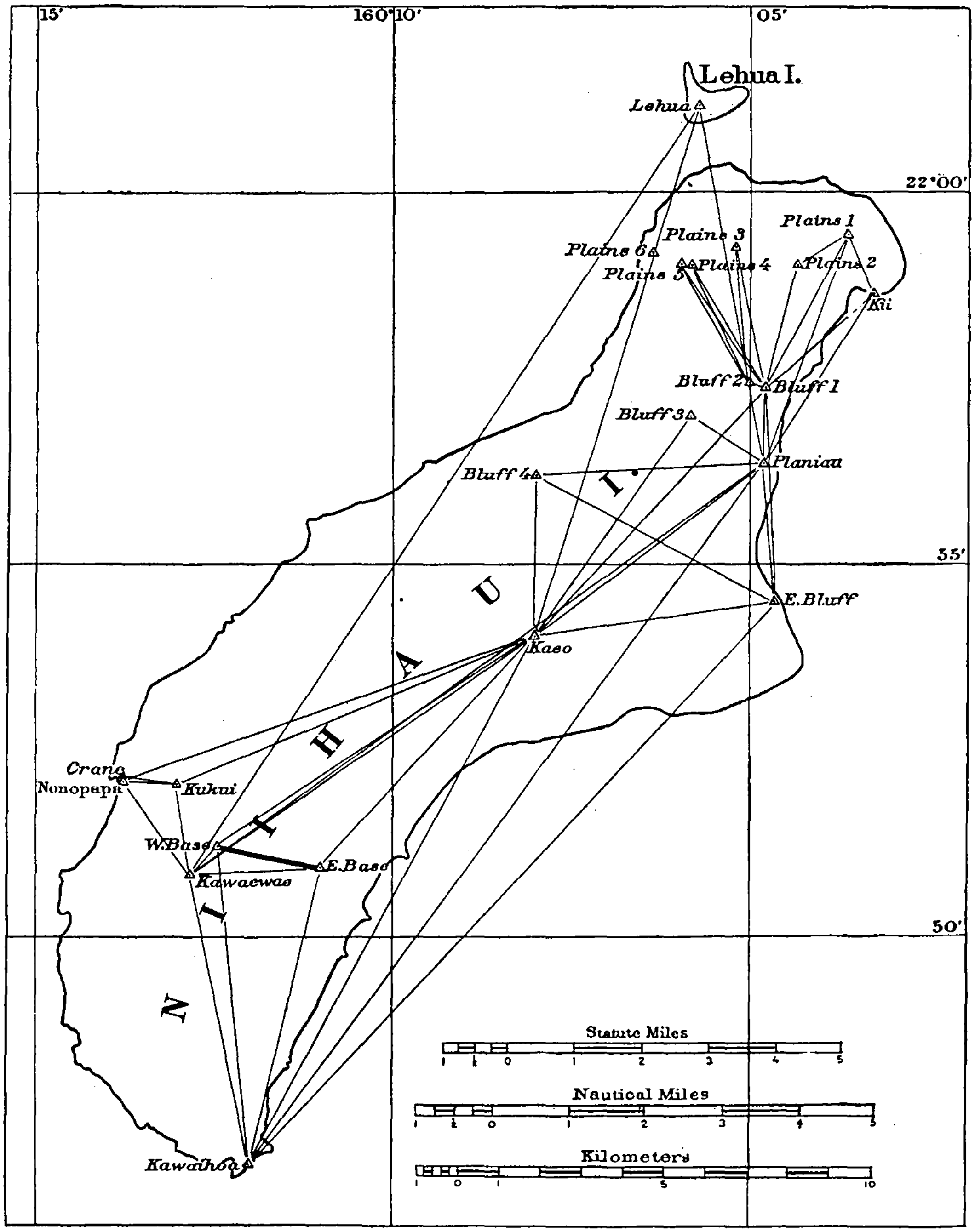


Triangulation, Hawaii.

MAGNETIC OBSERVATIONS. HAWAII. S. A. DEEL.

The work at the Honolulu Magnetic Observatory in Hawaii was done by Magnetic Observer Deel, under the direction of Assistant Fremont Morse, July 1 to October 31, and on November 1 the charge of this work was transferred to Mr. Deel. A practically continuous record of the relative changes in the magnetic elements was obtained on the self-registering magnetograph throughout the year. The absolute values of these elements were determined once a week. Observations to determine time were made three times in each month.

A new recording apparatus was installed on January 5 and the work of testing it began immediately, and was in progress on June 30.

The seismograph was kept in operation during the year except for eight days (April 16 to 22) when no suitable photographic paper was available. Meteorological observations were made throughout the year. A small building was erected to be used for office work and quarters.

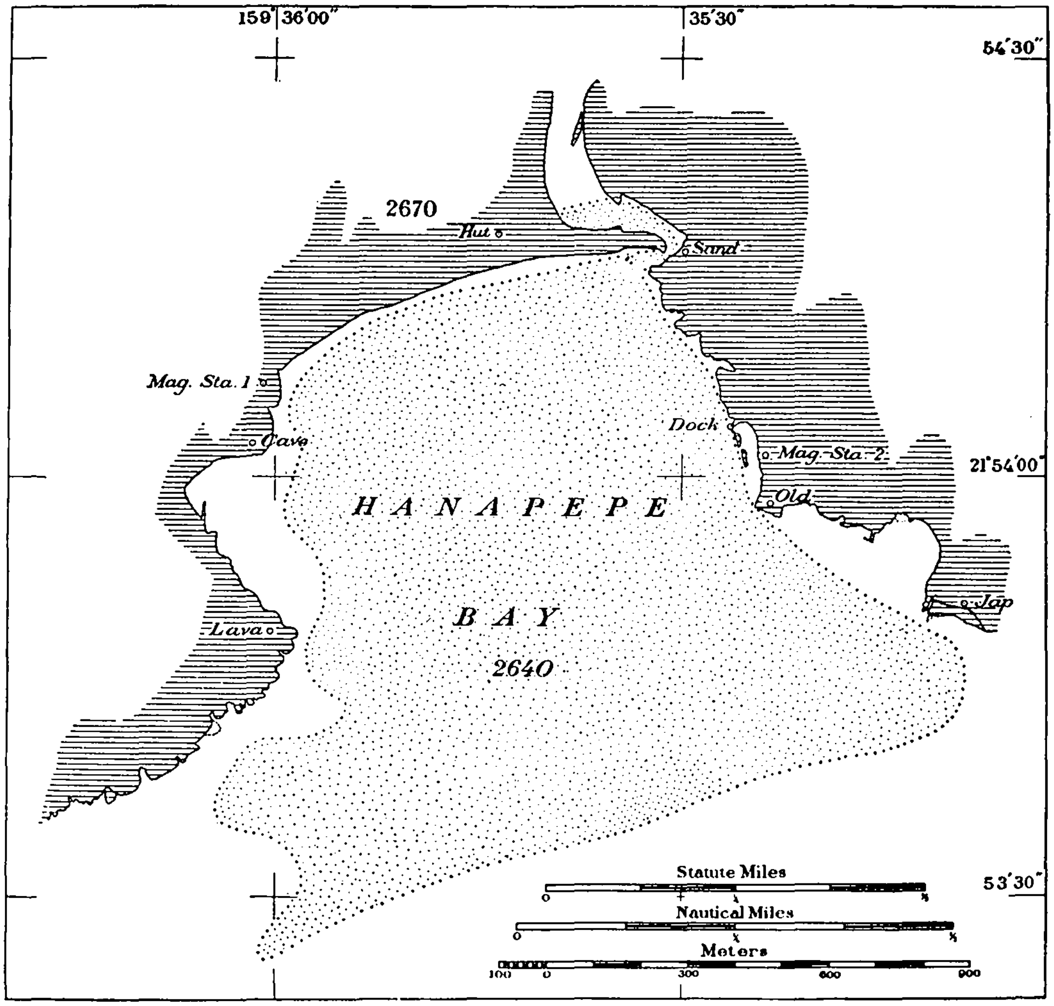
HYDROGRAPHY. HAWAII. H. D. KING.
MAGNETIC OBSERVATIONS.
TOPOGRAPHY.

The survey of Hanapepe Bay, Kauai, Hawaii, was assigned to Aid H. D. King. He reached Honolulu on February 8, and after making the necessary preparations to begin the work, proceeded to Eleele on the 12th. A tide gauge was established and some of the old triangulation stations were recovered. The lines between these were used as bases to determine the additional hydrographic signals needed. The topography was limited to the delineation of the shore line. The hydrographic work was done from a boat not suited to the work and with a native crew who understood very little English, as the only means available. The weather was very unfavorable and the person engaged as recorder proved to be incompetent. In spite of these conditions the work was continued until March 9, and on the 11th the party returned to Honolulu. The continued rough weather made it advisable to close operations as soon as the absolutely essential work was completed.

Magnetic observations to determine the declination were made at two stations, and the correction for the compass declinometer used was determined at the Honolulu Magnetic Observatory.

J. W. Milburn, Aid, assisted in the work enumerated above.

No. 35.



Hydrography and topography, Hawaii.

ASTRONOMIC OBSERVATIONS. PACIFIC ISLANDS. EDWIN SMITH. FREMONT MORSE.

On July 1 the work of extending the longitude connection across the Pacific Ocean was in progress, with Assistants Smith and Morse in charge of cooperating parties. On that date Mr. Smith sailed from Honolulu for Guam, while Mr. Morse remained at Honolulu for the purpose of determining the difference of longitude between these two stations by joining the cable temporarily at Midway Island.

Mr. Smith reached Guam on July 14, and in the afternoon of the same day went ashore at Soumaye, where the cable had landed, and through the courtesy of Mr. Daniel Coath, the superintendent of the Guam cable station, was enabled to bring his outfit ashore the next day and establish himself near the proposed longitude station. Mr. Coath was instructed by Mr. George G. Ward, vice-president and general manager of the Commercial Pacific Cable Company, to facilitate the work of the longitude party in every way in his power, and the assistance rendered by him was most important and necessary to the success of the work.

Mr. Smith called on the governor of Guam, and he also courteously offered to do everything in his power to facilitate the work.

The work was greatly delayed by rainy weather, but everything was in readiness on the 27th, and on that date the cables were joined at Midway Island and signals were exchanged with Honolulu, but they were not suitable for use in the longitude work, and the attempt to eliminate Midway as a longitude station was abandoned. Mr. Morse then proceeded to Manila, and reached there on August 31. The officers of the cable company at Manila did everything in their power to expedite the work of preparation, and Maj. W. A. Glassford, Signal Corps, U. S. Army, had the observatory and cable office connected by telegraph and telephone wires. The thanks of the Survey are due these gentlemen for their courtesy and kindness, and especially to Major Glassford for the promptness and energy displayed in erecting the wires mentioned above.

Observations were made and signals exchanged between Manila and Guam on September 8, 12, 14, 15, and 16, thus completing the work at Manila.

Transportation from Guam to Manila was easily obtained, but there was no regular communication in the opposite direction, and consequently the plan of having the observers exchange stations was abandoned and Mr. Morse sailed from Manila on September 19 for Honolulu, via Hongkong, en route to Midway. He reached Honolulu on October 15, and was fortunate in securing his passage to Midway on the U. S. S. *Iroquois*, which sailed from Honolulu on October 29 and reached there on November 3. There are no facilities or supplies at Midway except those of the cable company, and everything needed for an indefinite stay there was procured in Honolulu and carried on the *Iroquois*. Everything was ready for observations on the 13th, but clouds prevented work until the 16th, when the observations began and were continued on all available nights until December 5, when the ten nights' work desired was completed.

While at Gaum Mr. Smith made magnetic observations at five stations, viz, Agana, Dano Island, Merizo, Soumaye, and Umata. Mr. Smith sailed from Guam for Manila on January 10, en route to Honolulu. He reached Cavite about 5 p. m. on January 15, and fortunately found the *Pathfinder* anchored near by. A steamer was due to sail the next morning for Hongkong, and Assistant Gilbert, commanding the *Pathfinder*, made it possible for Mr. Smith to take this steamer by transporting him and the outfit to Manila the next morning, thus enabling him to make close connection with the steamer for Honolulu. These details are stated to show the difficulties in the way of prompt transportation in this region, which greatly delayed the work.

Mr. Smith reached Honolulu on February 8 and promptly prepared for work; but bad weather interfered and no observations were made until February 22, and the necessary work was not completed until March 24, as Honolulu proved to be an exceptionally unfavorable place for astronomic observations. On the date mentioned, March 24, 1904, the determination of the difference of longitude between San Francisco and Manila, begun during the previous fiscal year, was completed, except for the determination of the personal equation of the observers, and the observers deserve credit for the manner in which the numerous difficulties and obstacles encountered were overcome. Mr. Morse returned to Honolulu on the U. S. S. *Iroquois* on April 16, but transportation to San Francisco could not be obtained until April 26. An effort was made to observe for personal equation of the observers, but bad weather prevented work except on two nights, and the results were unsatisfactory.

Messrs. Smith and Morse reached San Francisco on May 2, and the observations for personal equation were completed on May 9, and the field work closed on that date.

In closing his report, Mr. Smith expresses the highest appreciation of the attention and kindness shown the observers by the officers of the cable stations, and of the generous cooperation of Mr. George G. Ward, vice-president and general manager of the Commercial Pacific Cable Company. Without this aid the work would have been extremely difficult if not impracticable.

COMBINED OPERATIONS. PHILIPPINE ISLANDS. G. R. PUTNAM. J. E. MCGRATH.

The important work of surveying the coast of the Philippine Islands was continued under the direction of Assistants Putnam and McGrath, July 1 to April 30 and May 1 to June 30, respectively, who represented the Superintendent in all matters requiring immediate decision.

In performing this duty they adopted plans for field operations, issued instructions for field work, compiled all data secured, and prepared and published charts of the waters surveyed. Notices to Mariners and Sailing Directions were prepared and published. They were aided in this work by such advice and instructions issued from Washington as became necessary.

The work continued under the plan of cooperation between the Philippine Commission and the Coast and Geodetic Survey adopted in 1901 and stated in the Annual Report for 1902.

The field parties were at work in various localities, as shown in the following statement and in the following abstracts from the reports of the chiefs of the parties.

FIELD WORK.

North coast of Luzon.—The triangulation and topography was extended from Bontolan Point to Bolinao, where the field work was suspended at the beginning of the rainy season. This survey shows the actual shore line and correct representation of all towns, roads, natural features, and prominent landmarks. The triangulation stations on which it is based have been carefully marked and will supply bases for extensions of future cadastral surveys and for studies for works of public improvement.

Point Dile to Culili Point.—A hydrographic survey was made of this section of the coast of Luzon, including surveys of Port Currimao and Salomague Harbor.

Manila Bay.—An inshore hydrographic survey was made of the waters of Manila Bay from Malate to a point 4 miles SW. of Sangley Point, including a large scale survey of Bacoor and Canacao Bays; the topography was completed from Cavite to a point on outside coast due west of Cavite Viejo; a topographic survey was made of the coast line around Malabon; and an examination was made for a shoal off the east end of Caballo Island, marked doubtful on recent charts, but no such danger was found in the position hitherto given.

Danao River and approaches.—The lower part of this river, to the highest point serviceable for navigation, and the coast line around to Escalante, was surveyed. This embraces the only protected harbor on the north coast of *Negros.*

North coast of Panay.—A complete survey (triangulation, topography, and hydrography) was made of this coast from Capiz to Fort Batan with the exception of topography and hydrography of Sapian Bay, the change of monsoon preventing the completion of Sapian Bay.

Lagonoy Gulf.—A complete survey was made of Lagonoy Gulf and Tobaco Bay, embracing the triangulation, topography, and hydrography. This includes south coast of Catanduanes Island from Point Nagumbuaya to Sialot;. *Luzon* from Point Bungus to Bagacay, and from northwest point of San Miguel Island to northeast end of Batan Island. The shape of the coast line of Catanduanes Island was materially changed by this survey, but the most important result was the proof of the freedom of the waters of the gulf from large areas of shoals hitherto shown on the charts.

Iloilo Strait and approaches were surveyed on a large scale. The triangulation was extended from a line joining Dumangas Point, *Panay*, with the northeast point of Guimaras Island, to a line joining Point Dolores, Guimaras Island with Talisaya Point, *Panay*. The topography was extended from Dumangas Point, *Panay*, to Tigbauan and from northeast point of Guimaras Island to Point Dolores on west coast of Guimaras Island. A detailed survey was made of Iloilo River. The hydrography extended from a section 8 miles east of Siete Pecados Light, including the Iguana Bank, to a junction with the work of the Navy in Iloilo Harbor, the navy work being supplemented by the survey of a section extending from Lusaran Light-House northward, which includes Ports Santa Ana and Igan. This survey removes the doubt felt as to the practicability of the use of the eastern approach to Iloilo by large vessels, and shows that a good safe passage for vessels drawing 30 feet exists.

Guimaras Strait.—The survey of this strait was begun on January 10, and continued until March 27, when the steamer had to return to Manila for docking and repairs. The triangulation was extended from center of the strait to its southern end;

the topography was embraced within the same limits and the hydrography covers almost an equal area. In the course of the work Rosario Rock was found to be three-fourths mile northwest of the position shown on the charts, and a very much more dangerous condition was found to exist on Pandan Shoal. The survey also shows considerable changes in the appearance of the coast line and in the area covered.

Geographic positions.—The latitudes and longitudes of Cuyo (on Cuyo Island) and San José de Buenavista, *Panay*, were determined during the year, thus completing the list of desirable points for which necessary telegraph connection could be secured at the time.

Magnetic observations.—To secure information necessary for charts, magnetic observations have been made at eight stations. Meridian lines have been laid out at the astronomic stations, and azimuth determinations in connection with all the triangulation work, to enable surveyörs with ordinary instruments to readily lay off true meridians from any two intervisible triangulation stations.

Tide observations were made at ten stations. Nine of these were in connection with the various hydrographic operations. At Manila the tide record is a continuous one for the year; at Iloilo a similar record was obtained for ten months. These supply valuable data for the predictions in the annual tide tables published by the survey for the Philippine Islands.

Personnel.—The field work has been executed by the following chiefs of parties: J. J. Gilbert, Assistant (July 1 to January 31), and Ferdinand Westdahl, Assistant (February 1 to June 30), general survey work with steamer *Pathfinder;* John E. McGrath, Assistant, astronomic determinations; W. B. Fairfield, Assistant, astronomic, magnetic observations, topography, and triangulation work; William Bowie, Assistant, general survey work; H. F. Flynn, Assistant (July 1 to December 31), astronomic determinations, magnetic observations, triangulation, and topography; R. B. Derickson, Assistant, general survey work with steamer *Research;* John Bach, Observer, triangulation and topography.

Steamers.—The Coast and Geodetic Survey steamer *Pathfinder* was employed in surveys in the archipelago previous to May 27, when it was found necessary to send her to Hongkong for repairs.

The steamer *Research* was actively employed throughout the year, with the exception of the period between March 27 and June 10. During this time she returned to Manila for repairs, and then went back to her working ground.

Five different shipbuilding concerns submitted tenders for the construction of the new steamer which was provided for by the Commission, and the terms of the Hongkong and Whampoa Dock Company proving to be the best, a contract was made with them on January 27, which was approved by the civil governor. On February 3 Mr. Charles C. Yates, Assistant, proceeded to Hongkong to act as the inspecting officer of construction and the progress on the vessel was very satisfactory; two-fifths of the contract price has already been earned. The steamer is framed, engine, bed plates, and cylinders are cast, crank and propeller shaft forged, small boats framed, and ship's fittings are well under way. According to the terms of the contract the steamer should be ready for her trial trip on October 15, 1904.

OFFICE WORK.

The scheme of organization of the Manila suboffice continues the same as heretofore reported, and its detailed operations are as follows: In November extensive changes were made in the quarters in the Intendencia Building, enlarging greatly the space assigned to the computing and drawing sections, improving the light and air conditions and placing an admirably situated chamber at the disposal of the office as a store room for instruments and general property of the Survey.

Computing.—The Computing Division continued in charge of Mr. E. R. Frisby, who was regularly assisted by Mr. F. F. Pangan, Junior Computer, and Mr. Ignacio Cruz, Junior Clerk. Messrs. McGrath, Ferguson, Fairfield, Flynn, Assistants, Coast and Geodetic Survey, Mr. Staples, Aid, Coast and Geodetic Survey, and Mr. Bach, Observer, were employed in the division at different times on computations necessary for the completion of the field work executed by them and while awaiting orders for the field.

The following is a statement of the work executed in this division during the time covered by this report:

TRIANGULATION.

Office reduction of angles and computation of triangle sides, geographic positions, base measurements, computation of heights and incidental azimuth and time determinations.

Vigan to Aparri	N. and W. coast of *Luzon.*
Capiz to Batan	N. coast of *Panay.*
Iloilo Strait and approaches	Point Dumangas to Talisaya Point.
Danao River	N. coast of *Negros.*
Puerto Galera	*Mindoro.*
Mangarin Bay and Ilin Strait	*Mindoro.*

Correcting computed triangulation to accord with new data:

San Fernando to Bolinao	W. coast of *Luzon.*
San Fernando Harbor	W. coast of *Luzon.*
Santo Tomas Harbor	W. coast of *Luzon.*
Bolinao Harbor	W. coast of *Luzon.*
Sual Harbor	W. coast of *Luzon.*

ASTRONOMIC COMPUTATIONS.

Differences of longitude:
- Cuyo, *Cuyo*, and Iloilo, *Panay.*
- San Jose de Buenavista and Iloilo, *Panay.*
- Ormoc, *Leyte*, and Surigao, *Mindanao.*
- Calapan, *Mindorc*, and Romblon, *Romblon.*
- Batangas, *Luzon*, and Romblon, *Romblon.*
- Masbate, *Masbate*, and Romblon, *Romblon.*
- Boac, *Marinduque*, and Romblon, *Romblon.*

Abstracts of 17 volumes containing observations to determine differences of telegraphic longitude were prepared and the adjustment of the longitude net in the Archipelago was made.

TERRESTRIAL MAGNETISM.

Observations for magnetic declination, dip, and horizontal intensity at:
- Batangas
- Calapan
- Iligan
- Surigao
- Boac
- Catbalogan
- Legaspi
- San Jose de Buenavista
- Calbayoc
- Cuyo
- Romblon
- Valle Hormosa

Magnetic declination were computed at 18 other stations.

HYDROGRAPHY.

Tabulations of hourly tide readings were made from records with self-registering gauges at the following stations for the periods stated:

Manila, 10 months.
Iloilo, 9 months.
Capiz, 2 months.
Inampulugan Island, 2 months.
Puerto Galera, 2 months.
Mangarin Bay, 2 months.
Port Sual, 8 months.

The regular list for issue of the Notices to Mariners now calls for 734 copies of each edition, and 11 numbers were published in the period covered by this report.

Drawing.—The chief duties of the Drawing Division are: the inking of topographic sheets and the plotting, inking, and verification of such hydrographic sheets as can not be completed in the field; the preparation of projections for field parties; and the preparation of finished drawings for chart publications. At the date of the last report the force of draftsmen comprised Messrs. P. B. Castles and J. P. Keleher in charge of the subdivisions of the division, and 10 native draftsmen. In January the force of native draftsmen was increased to 15, and on the departure of Mr. Castles the entire charge of the division devolved upon Mr. Keleher, who is still in charge.

Reduction of tide staff readings and comparisons with a principal station were made for Siete Pecados, Santa Ana, Batan, Dagupan, and Bolinao.

Reductions of soundings were made as follows:

	Volumes.
Lingayen Gulf	24
Iloilo	18
Guimaras Strait	8
Capiz and Batan	7
Puerto Galera	7
Mangarin Bay	7
Danao River	5

MISCELLANEOUS.

Duplicates were prepared and verified of all records not completed in field and of all computations and abstracts of results prepared or received in the suboffice. Information in the shape of descriptions of stations, instrumental constants, and triangulation sketches was supplied to field parties and in reply to requests from various sources. The local values for magnetic declination and standard geographic data were prepared for charts in process of construction.

Sailing Directions.—In the nautical information section, Mr. J. C. Dow, Nautical Expert, in charge, continued the preparation of the "Notices to Mariners," wherein the earliest information of all changes of which reliable information can be secured and which are of importance to mariners is communicated to the public. In addition to this work Section II, Philippine Island Sailing Directions, southwest and south coast of *Luzon* from Manila to San Bernardino Strait, was revised and published; Section III, Sailing Directions for the coasts of *Panay*, *Negros*, *Cebu*, and adjacent islands, and Section IV, Sailing Directions for the coasts of *Samar* and *Leyte* and the east coast of *Luzon* were revised, rewritten to a large extent, and sent to the printer. The preparation of the Sailing Directions necessitated trips of inspection to the sections noted and actual verification (where no recent surveys have been made) of all new material that had been collected. The nautical information section in Manila offers all the cooperation within its power to the maritime interests and every possible assistance that lies within the capacity of a hydrographic office is always at the service of shipping interests. The demand for the Sailing Directions is evidence of the importance of the work.

The work of verifying every step in the production of the charts which insured the independent checking of every sounding, position and feature which they contain was done by the Chief of the Bureau, the Chief Draftsman, Mr. Charles C. Yates, Assistant, July 11 to December 31, and Mr. William Bowie, Assistant, April 23 to June 30.

The work of the native draftsmen is surprisingly excellent and their services are worthy of great praise, but as only two of them ever had experience in the class of work on which they are now engaged, scarcely anything can be left to their initiative and the work of supervision has to be incessant and untiring.

Statement of work executed between July 1, 1903, and June 30, 1904.

Topographic sheets inked.

No.	Title.	Scale.
1	Plane table location of hydrographic signals, Lingayen Gulf	1-60 000
2	Northward from San Fernando	1-20 000
3	Darigayos and vicinity	1-20 000
4	Candon and vicinity	1-20 000
5	Santa Cruz to Bangar	1-20 000
6	Solvec Point to Santiago	1-20 000
7	Point Dile to Solvec	1-20 000
8	Lapog Bay to Point Solot	1-20 000
9	Currimao	1-5 000
10	Lapog	1-20 000
11	Pasuguin	1-20 000
12	Dir	1-5 000
13	Cape Bojeador	1-20 000
14	Bangui to Puac Point	1-20 000
15	Puac Point to Masisi	1-20 000
16	Masisi to Abulug River	1-20 000
17	Abulug River to Aparri	1-20 000
18	Danao River (upper section)	1-5 000
19	Danao River (lower section)	1-5 000
20	Danao River—entrance to Escalante	1-10 000
21	Capiz and Approaches	1-20 000
22	Batan and Approaches	1-20 000
23	Agodaya Point to Alegria Point	1-20 000
24	Guimaras Strait, Inampulugan Island	1-20 000
25	Iloilo Strait (middle portion)	1-10 000
26	Oton and westward	1-10 000
27	Iloilo	1-10 000
28	Iloilo Strait (Naburul Island to Lusaran Light-house)	1-10 000
29	Iloilo Strait, Molo and vicinity	1-10 000
30	Northwest coast of Guimaras (Bondulan Point to Naburul Island)	1-20 000
31	Iloilo River	1-2 500
32	Eastern entrance Iloilo Strait	1-20 000
33	Nayon River to Point Caiman	1-20 000
34	Port Galera and Varadero Bay	1-10 000
35	Dagupan, Lingayen Gulf	1-10 000

Hydrographic sheets.

No.	Title.	Scale.
1	Bolinao to San Fernando	1-60 000 plotted, inked, verified.
2	Point Verde to Panacalan Island	1-15 000 plotted, inked, verified.
3	Northwest of Bolinao	1-15 000 plotted, inked, verified.
4	Dagupan River and entrance	1-10 000 plotted, inked, verified.
5	Northwest part of Lingayen Gulf	1-15 000 plotted, inked, verified.
6	San Isidro to Point Verde	1-10 000 plotted, inked, verified.
7	General sheet, Lingayen Gulf	1-60 000 plotted, inked, verified.
8	Mangarin Bay	1-20 000 plotted, inked, verified.
9	Mangarin Bay	1-10 000 plotted, inked, verified.
10	Port Galera	1-5 000 plotted, inked, verified.
11	Varadero Bay	1-5 000 plotted, inked, verified.
12	Danao River (entrance and lower part of river).	1-5 000, plotted, inked, verified.
13	Danao River (uper part)	1-5 000, plotted, inked, verified.
14	Danao River to Escalante	1-10 000, plotted, inked, verified.
15	West part of Sorsogon Bay	1-20 000, plotted, inked, verified.
16	San Pedro Bay	1-40 000, plotted, inked, verified.
17	South coast of *Samar*	1-40 000, plotted, inked, verified.
18	Southwest coast of *Leyte*	1-40 000, verified.
19	Calauga Bay	1-20 000, verified.
20	Lagonoy Gulf (south shore of Catanduanes Island).	1-40 000, verified.
21	Lagonoy Gulf, inshore	1-40 000, plotted, inked, verified.
22	Lagonoy Gulf, general hydrography	1-80 000, verified.
23	Tabaco Bay and eastward	1-40 000, verified.
24	Iloilo Harbor	1-10 000, plotted, inked.
25	Eastern entrance Iloilo Strait	1-15 000, plotted, inked (half completed).
26	Iloilo River	1-25 000, plotted, inked.
27	Iloilo Strait	1-10 000, plotted, inked.
28	West coast of Guimaras Island, between Naburul Island and Lusaran Light-House.	1-10 000, plotted, inked.
29	Capiz and westward	1-15 000, plotted, inked (half completed).
30	Batan and approaches	1-15 000, plotted, inked (half completed).
31	Southwest coast of *Leyte*	1-40 000, verified.
32	San Pedro Bay	1-40 000, verified.
33	Dagupan (Lingayen Gulf)	1-10 000, plotted, inked, verified.

Charts completed.

No.	Title.	Scale.
4715	Southeastern part of *Luzon*	1-400 000, sent to Washington for publication.
4718	*Panay*, *Negros*, and *Cebu*	1-400 000, sent to Washington for publication.
4719	*Leyte* and Surigao Strait	1-400 000, sent to Washington for publication.
4221	Albay Gulf and part of Lagonoy Gulf	1-100 000, chart printed.
4426	Southwest coast of *Leyte*	1-100 000, chart printed.
	Plan of Maasin	1-10 000, chart printed.
4262	Cagayan River	1-80 000, chart printed.
4264	Salomague	1-20 000, chart printed.
4344	Port Galera and Varadero Bay	1-10 000, chart printed.
4451	Approaches to Catbalogan	1-50 000, chart printed.
4450	San Juanico Strait and Tacloban Harbor.	1-50 000, chart printed.
	Tacloban Harbor	1-20 000, chart printed.
4263	Port San Vicente	1-20 000, chart printed.

Charts completed—Continued.

No.	Title.	Scale.
4343	Puerto Princesa	1-40 000, chart printed.
4219	Passages between *Luzon* and *Masbate* and Sorsogon Bay.	1-100 000, sent to Washington for publication.
4321	Southern part of *Mindoro* and Semerara Islands, plan of Mangarin Bay.	1-100 000, sent to Washington for publication.
4613	Iligan Bay	1-40 000, sent to Washington for publication.
	Plans:	
	Misamis	1-100 000, sent to Washington for publication.
	Jiminez	
	Inamucan	
4241	Sual Harbor	1-15 000, sent to Washington for publication.
4643	Anchorages on south coast of *Mindanao*	Sent to Washington for publication.
4453	Harbors of Marinduque and Tablas Islands.	Sent to Washington for publication.
4455	Harbors on coast of *Masbate*	Sent to Washington for publication.
4454	Harbors on Burias and Ticao Islands	Sent to Washington for publication.
4452	Danao River and approaches	1-10 000, sent to Washington for publication.

Miscellaneous work.

Nine topographic sheets showing surveys from Vigan to Claveria were traced for the provincial government of Ilocos Norte.

One draftsman was employed for two weeks in the determination of the areas of the friars' land (under the bureau of engineering).

A number of projections were prepared for field parties and some tracings were made for the army, constabulary, and treasury. The time of one draftsman was exclusively required to color lights, buoys, and beacons, and correct the published charts to date of issue.

MISCELLANEOUS DIVISION.

Mr. W. H. MacDonald, Chief Clerk. This division attended to the correspondence of the office, kept the files, copied all accounts, reports, and descriptive sheets, made a record of all party and office expenses, checked the inventories, and supervised all repairs, and had the care of all government property. Mr. MacDonald also had charge of the distribution of the published charts and the accounts with chart agents and attended to the distribution of all publications.

The number of charts distributed for official use or disposed of by sale in the islands from July 1 to June 30 was	4 251
Number of charts received from the Coast and Geodetic Survey Office in Washington from July 1, 1903, to June 30, 1904	4 125
The number of charts printed in Manila, July 1, 1903, to June 30, 1904 was	3 366

Between July 11 and February 2, in addition to his duties in connection with chart verification, Mr. Charles C. Yates, Assistant, was engaged in the preparation of preliminary plans and specifications for the construction of a launch and the steamer which is now being built at Hongkong, China.

The Survey is indebted for many favors to the bureaus and offices of the general and insular governments, and particular acknowledgment is made of valuable information and material help received from the bureaus of coast guard, transportation, and engineering, from the chief quartermaster, the chief engineer officer, and the chief signal officer of the United States Army in the Philippines, and from the masters of the merchant marine, and who attest by their ready response to requests for cooperation, their appreciation of the efforts being made to improve the charts and Sailing Directions of the Philippine Islands up to the requirements of modern standards.

The cost of the Survey, as in the past year, has been met by a division of expenses between the United States and the insular government. The United States has defrayed all the expenses for the field officers and experts detailed for service in the islands, the lithographing, engraving and publishing of charts, and furnished the instrumental outfit and supplies from the United States. The insular government has defrayed the local field and office expenses, maintained the steamer *Research*, and is paying for the construction of the surveying vessel now being built at Hongkong.

TOPOGRAPHY. PHILIPPINE ISLANDS. JOHN BACH.
TRIANGULATION.

The survey of the west coast of Luzon north from Santa Cruz was assigned to Observer John Bach. He reached Santa Cruz on March 24 and began work immediately. A small triangulation was extended along the coast to the northward, and on June 30 was in progress in the vicinity of Agno. A topographic survey was also made along the coast within the same limits. Mr. P. A. Staples, Aid, served in the party during the season.

BASE MEASUREMENT. PHILIPPINE ISLANDS. WILLIAM BOWIE.
HYDROGRAPHY.
TOPOGRAPHY.
TRIANGULATION.

JOHN BACH, *Observer.*	
C. M. SPARROW, *Aid.*	Sept. 26 to Jan. 25.
P. A. STAPLES, *Aid.*	Feb. 5 to Feb. 25.

SUMMARY OF RESULTS.

Base measurement:
- 1 base line measured.

Current observations:
- 5 stations occupied.

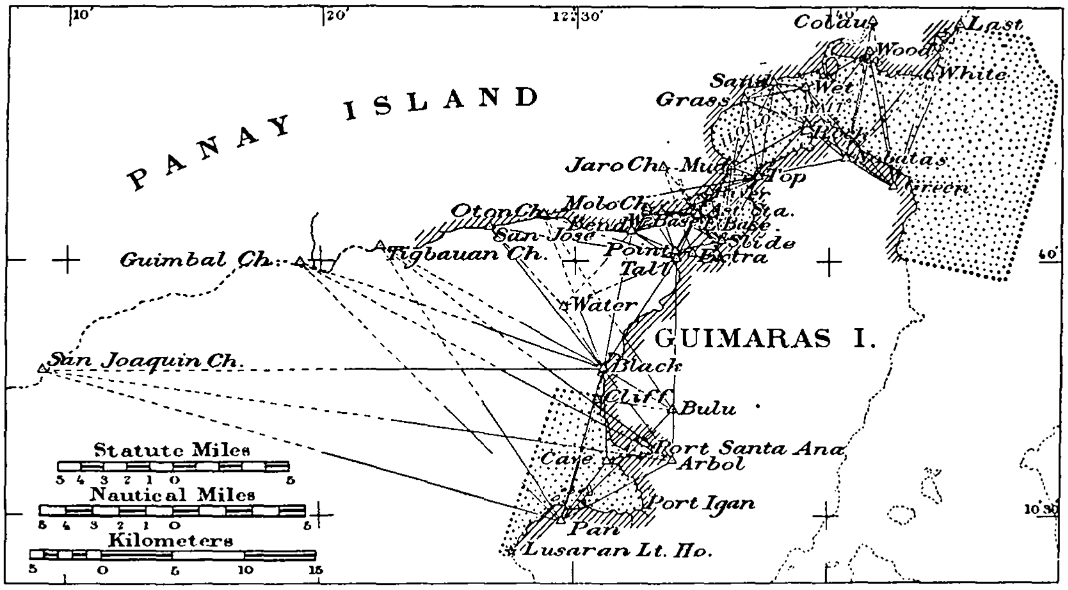
Hydrography:
- 287 square miles area covered.
- 969 miles lines sounded.
- 31 790 soundings made.
- 3 tide stations established.
- 5 current stations occupied.
- 5 hydrographic sheets completed.

Topography:
- 108 miles shore line surveyed.
- 18 miles shore line rivers surveyed.
- 7 miles shore line creeks surveyed.
- 15 miles roads surveyed.
- 8 topographic sheets completed.

Triangulation:
- 289 square miles area covered.
- 30 stations occupied.
- 91 geographic positions determined.

The survey of the region in the vicinity of Iloilo, Panay, was assigned to Assistant Bowie. He organized a party in Manila and started Mr. John Bach, Observer, to the field on August 3 in charge of the party and outfit. He proceeded to Iloilo and began work on the 6th. Mr. Bowie left Manila on the 8th and found the party at work when he reached Iloilo.

No. 36.



Hydrography, topography, and triangulation, Philippine Islands.

A self-registering tide gauge was established at Iloilo and a base line was measured in the vicinity. A topographic and hydrographic survey, based on triangulation, was then made to cover Iloilo Harbor and Strait to its eastern entrance, where the reefs and shoals lining the strait were thoroughly developed.

The Iloilo astronomic station was connected with the triangulation after completing the work to the eastward, and the triangulation and topography were extended from the base line to the southwest corner of Guimaras Island and westward along the coast of Panay for a distance of 12 miles. The positions of some spires and mountain peaks within 36 miles to the westward were determined. A complete hydrographic survey was made of that portion of the west coast of Guimaras Island between Nabural Island and Lusaran Light-house, including Ports Santa Ana and Igan. A detailed hydrographic survey was made of the Iloilo River and of the approach to the United States Army pier and landing at Buena Vista, Guimaras Island. The topography included the details visible from the shore line. Current observations were made at five stations, at one of which, in Iloilo Harbor, the observations were continued for twenty-four hours at spring tide. A continuous record was obtained on the self-registering tide gauge during the progress of the work, and it was left in operation in charge of a native under the direction of the provincial supervisor. For reduction of soundings distant from this gauge, observations were made on staff gauges established at Siete Pecados and at Port Santa Ana.

The field work closed on February 25 and the party returned to Manila. Mr. John Bach did the triangulation work and assisted in the hydrographic and topographic work. Mr. Sparrow did topographic work and Mr. Staples assisted in the hydrographic work. Mr. Bowie reports that all these officers did their work faithfully and well.

PHILIPPINE ISLANDS.

R. B. DERICKSON, Commanding,
Steamer *Research*.

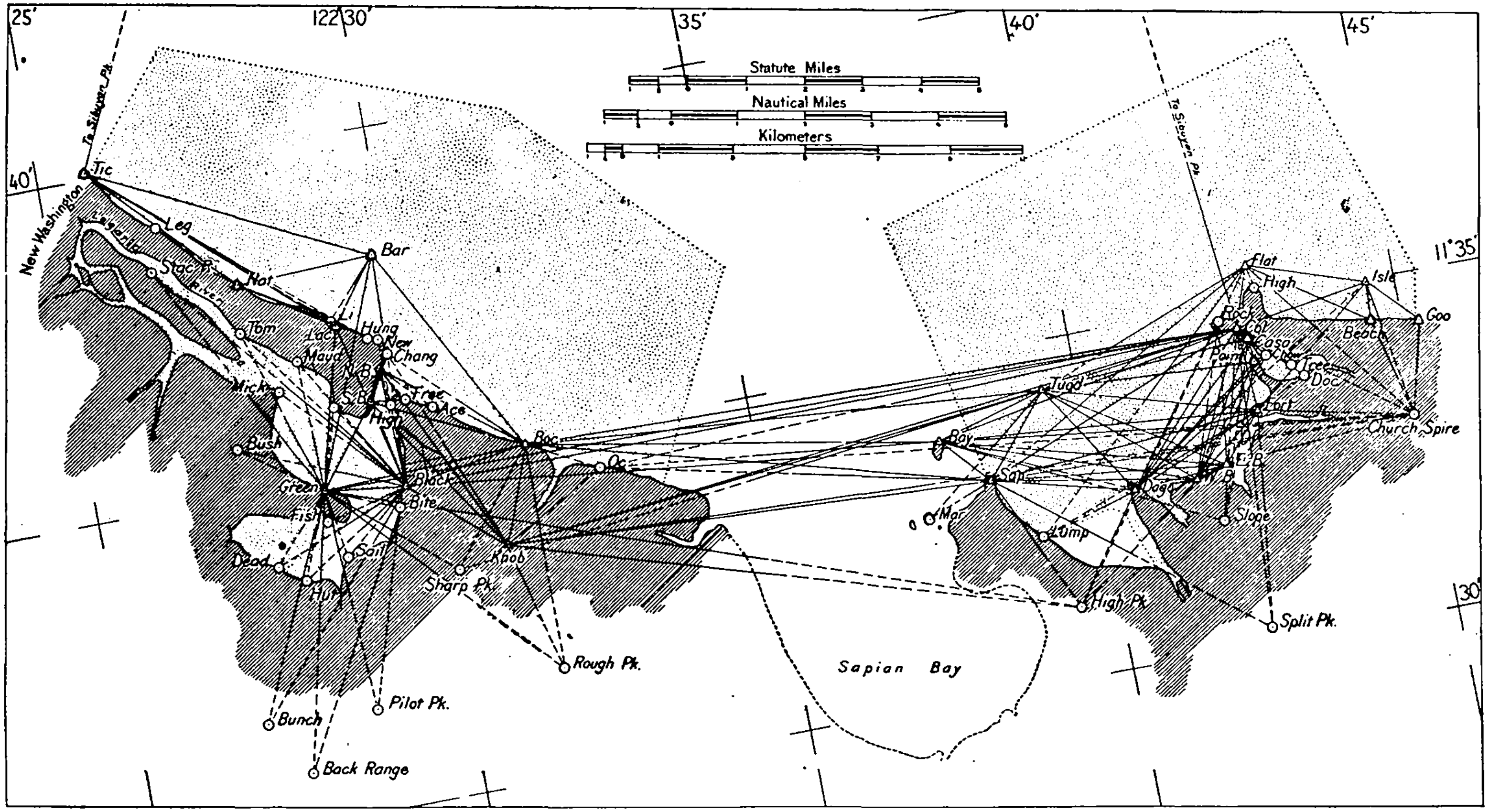
ASTRONOMIC OBSERVATIONS.
BASE MEASUREMENT.
HYDROGRAPHY.
MAGNETIC OBSERVATIONS.
TOPOGRAPHY.
TRIANGULATION.

N. G. GRAYSON, *Watch Officer.*	July 1 to June 4.
G. W. HUTCHESON, *Chief Engineer.*	
W. W. MARKOE, *Surgeon.*	July 1 to Sept. 20.
F. B. LOREN, *Aid.*	
M. ELLIOTT, *Observer.*	

SUMMARY OF RESULTS.

Astronomic observations:
  1 azimuth determined.
Base measurement:
  3 base lines measured.
Hydrography:
  1 590 miles lines sounded.
  42 584 soundings made.
  6 tide stations occupied.
  8 current stations occupied.
  2 hydrographic sheets completed.
Magnetic observations:
  4 stations occupied.
Topography:
  134 square miles area covered.
  85 miles shore line surveyed.
  15 miles roads surveyed.
  3 miles shore line of creeks surveyed.
  7 miles shore line of rivers surveyed.
  2 topographic sheets completed.
Triangulation:
  155 square miles area covered.
  24 stations occupied.

No. 37.



Hydrography, topography, and triangulation, Panay, P. I.

On July 1 the survey of the entrance of Danao River, Negros, was in progress under the direction of Assistant Derickson, commanding the steamer *Research*. The old triangulation stations were recovered and the topographic survey was extended 6 miles up the river and along the coast to Escalante. A traverse line was run across the land between Escalante Bay and Danao River and the survey of the shore line was extended around Point Ocre. The hydrographic survey was made in connection with the other work. The difficulty of obtaining fresh water delayed the work considerably during the season. This work closed on August 5. The necessary preparations were made, and the survey of Capiz Roads on the north coast of Panay began on August 17. A triangulation was extended from the geographic station at Capiz to Port Batan and a survey was made of the shore line between these places. A hydrographic survey was made of Port Batan and of Capiz Roads, but the shifting of the monsoon prevented the completion of the hydrographic survey connecting these two places and the development of the outside reefs. The work closed on December 12 and the vessel proceeded to Iloilo.

The survey of the south end of Guimaras Strait was resumed on January 10. The triangulation was extended across Guimaras Island and Strait to the west coast of Negros from the points previously established in the survey of Iloilo Straits. A short base line was measured on Susan Island for immediate use, and this was subsequently connected with the main scheme of triangulation. The topographic survey included both shores of Guimaras Straits and the intermediate islands, the south end of Guimaras Islands, and the Unisan group of islands, the work being done by Mr. F. B. Loren. A hydrographic survey was made of the main channels and the banks and reefs were developed. The work was suspended on March 27 and the *Research* proceeded to Manila for repairs.

On June 10 the work on the north coast of Panay, suspended in December on account of the monsoon, was resumed and was in progress at the close of the year.

TOPOGRAPHY. PHILIPPINE ISLANDS. W. B. FAIRFIELD.
TRIANGULATION.

The survey of the west coast of Luzon south from Santa Cruz was assigned to Assistant Fairfield. He reached Santa Cruz on February 11 and began work immediately. A small triangulation was extended along the coast to the southward, and on June 30 had reached the vicinity of Iba. A topographic survey of the coast was made within the limits named, by Mr. C. M. Sparrow, Aid in the party.

ASTRONOMIC OBSERVATIONS. PHILIPPINE ISLANDS. H. F. FLYNN.
BASE MEASUREMENT.
TOPOGRAPHY.
TRIANGULATION.

E. F. DEACON, *Recorder*. July 1 to Sept. 13.
C. E. CULLEN, *Recorder*.

SUMMARY OF RESULTS.*

Astronomic observations:
  2 azimuths determined.
  1 latitude determined.
Base measurement:
  2 base lines measured.
Triangulation:
  31 stations occupied.

On July 1 the triangulation and topographic survey along the north coast of Luzon, P. I., was in progress by a party under the direction of Assistant Flynn, and had reached Bangue, Ilocos Norte. The work was continued along the coast until October 11, when the work was completed to Linao, Cagayan.

Preparations were made to return to Manila, but the party was delayed waiting for a steamer until the 24th, and did not reach Manila until the 29th.

BASE MEASUREMENT.
HYDROGRAPHY.
PHYSICAL HYDROGRAPHY.
TOPOGRAPHY.
TRIANGULATION.

CHINA SEA.
PHILIPPINE ISLANDS.

J. J. GILBERT, Commanding,
Steamer *Pathfinder.*

H. S. SMITH, *First Watch Officer.*
R. H. HAWKES, *Surgeon.*
J. F. GOLDSBOROUGH, *Chief Engineer.* July 1 to Nov. 3.
L. M. HOPKINS, *Chief Engineer.* Nov. 3 to Jan. 27.
B. A. BAIRD, *Aid.*
W. C. DIBRELL, *Aid.*
J. M. COLEMAN, *Second Watch Officer.*
L. H. WESTDAHL, *Deck Officer, First Class.*
C. F. DEICHMAN, *Captain's Clerk.*

SUMMARY OF RESULTS.

Base measurement:
  1 base line measured.
Hydrography:
  841 square miles area covered.
  1 455 miles lines sounded.
  27 219 soundings made.
  6 hydrographic sheets completed.
Physical hydrography:
  600 miles lines sounded.
  35 soundings made.
Topography:
  200 square miles area covered.
  214 miles coast line surveyed.
  12 miles shore line of sloughs surveyed.
  14 miles roads and streets surveyed.
  5 topographic sheets completed.
Triangulation:
  1 900 square miles area covered.
  28 stations occupied.
  52 geographic positions determined.

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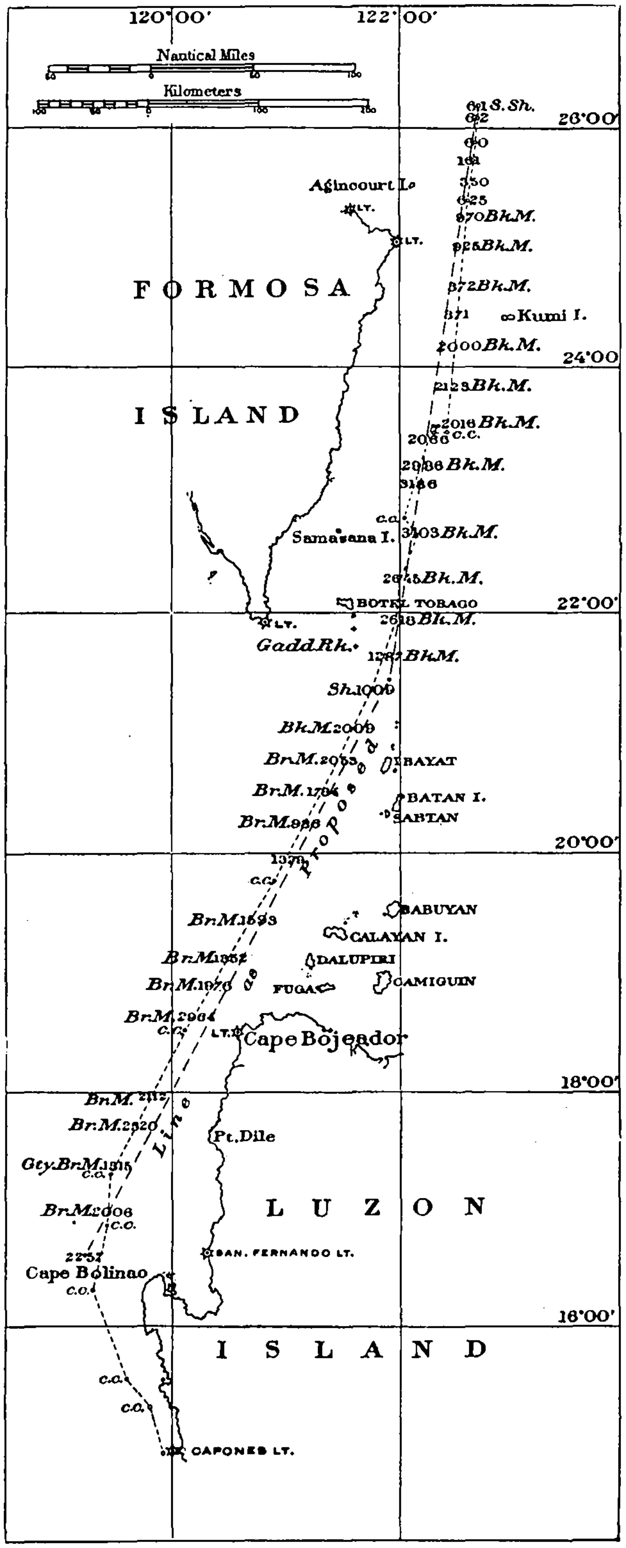
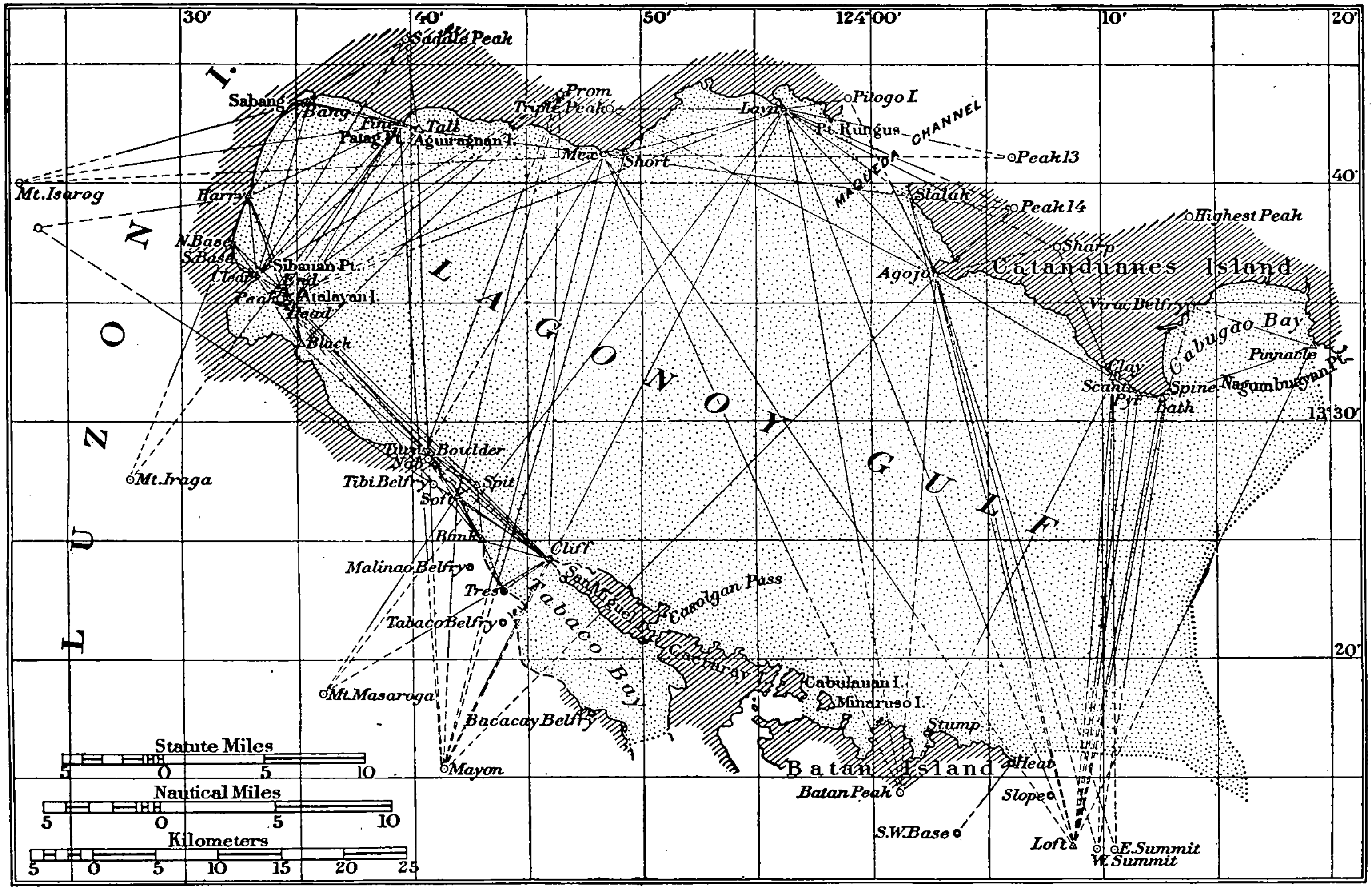
* Incomplete. Complete data not furnished by chief of party.

No. 38.



Deep sea soundings, China Sea.

No. 39.

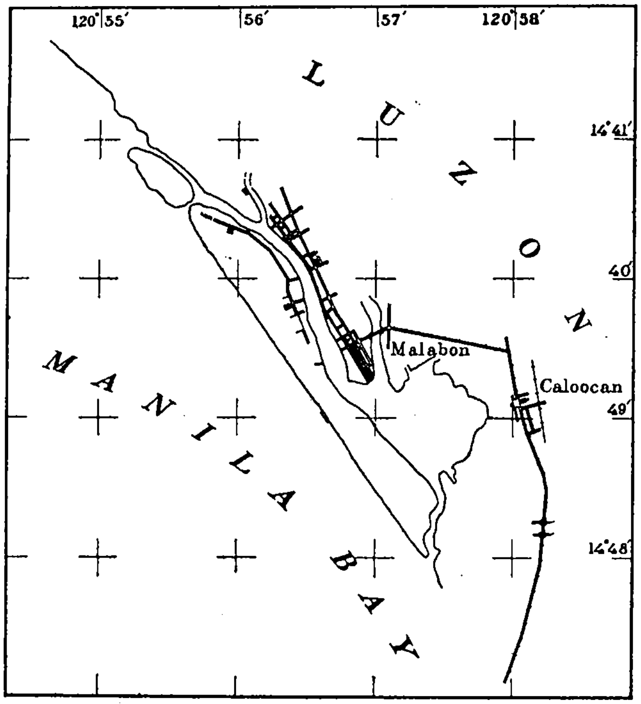


Hydrography, topography, and triangulation, Philippine Islands.

The steamer *Pathfinder*, with Assistant J. J. Gilbert in command, left Manila on July 15 for the purpose of running a line of deep-sea soundings from a point off Lingayen Gulf to a point northeast of the island of Formosa.

The reel holding the sounding-wire had been immersed in oil since 1900 and should have been in good condition, but the wire parted in attempting to make the first sounding when the sounding-rod was a short distance below the surface of the water. The wire was then tested by attaching a sinker, but the wire parted again after reaching bottom in 2 100 fathoms in the attempt to reel in. An unsuccessful attempt was made to refill the reel at sea and the vessel then proceeded to Amoy, China, to have her bottom cleaned and painted, and while there 4 000 fathoms of wire were placed on the reel.

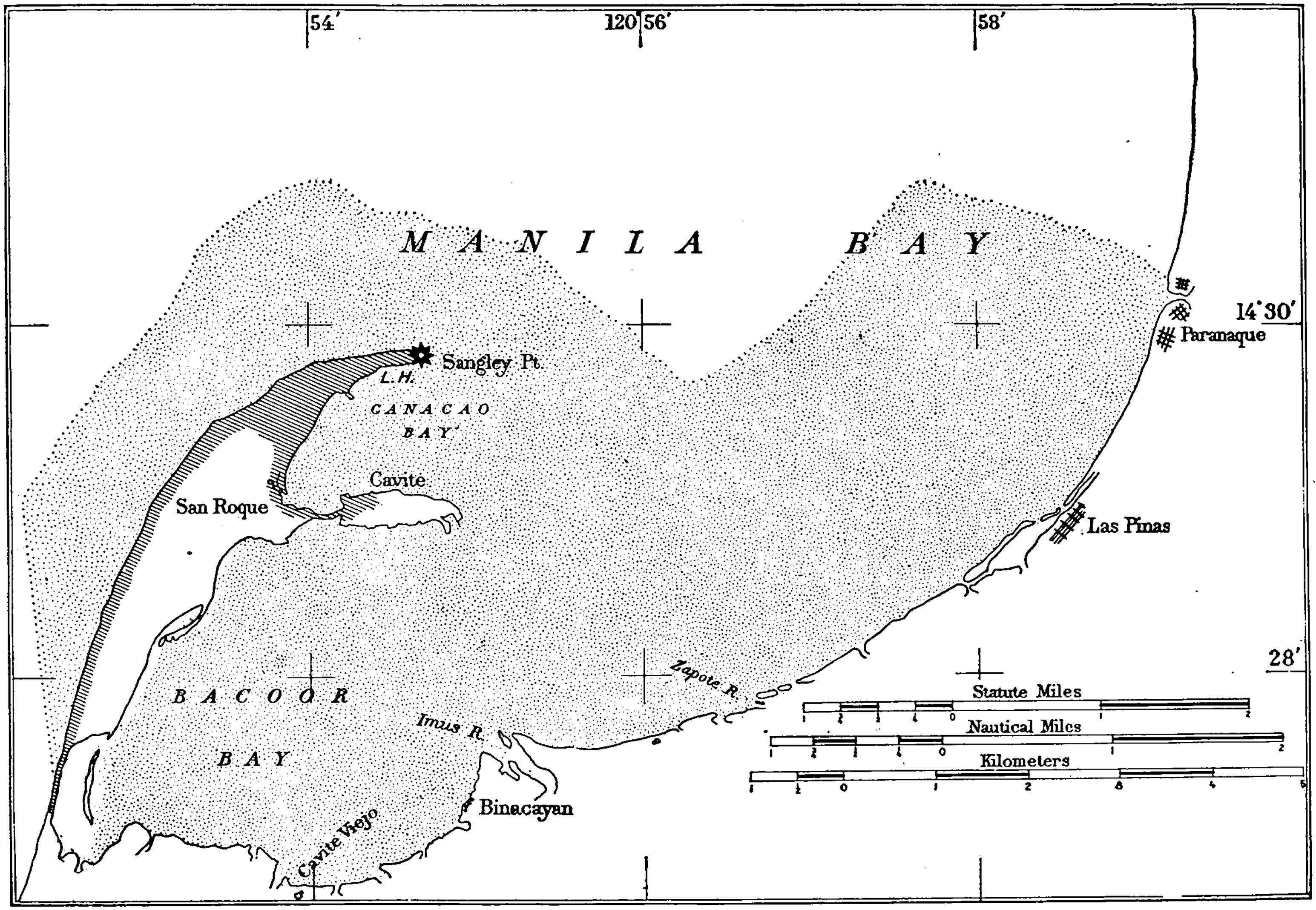
No. 40.



Topography, Philippine Islands.

The vessel left Amoy on the 23d and the next morning made a departure from Agincourt Island. The first sounding was made at 11 a. m. with the Tanner machine at a point 45 miles northeast from Agincourt Island. The vessel ran S. 10° E., sounding at intervals with the Tanner machine until 7 p. m., when the use of the Sigsbee machine began in 1 100 fathoms of water. Soundings were made at regular intervals, except when delayed by a break in the wire or some other accident, until 5.30 p. m. on the 29th, when the last sounding was made off the coast of Luzon, P. I. Courses and distances were recorded until the position of the ship was secured off Capones Light. The vessel returned to Manila on the 30th of July.

No. 41.



Hydrography and topography, Philippine Islands.

Preparations were made for the survey of Lagonoy Gulf, and the vessel left Manila on August 11 and reached the field of work on the 13th. Signals were erected and the triangulation, topography, and hydrography began and progressed as rapidly as the conditions permitted.

By the end of the month the work was brought up to Tabaco Bay, and three days later the unsurveyed portions of the topography around the bay was completed. After some delay in securing coal and other supplies, the triangulation was extended to the head of the gulf and the topographic and hydrographic surveys of the gulf were completed. On October 30 the last sounding was made and the vessel started for Manila. The next morning a line of sounding was started from a point near Maranduqui Island and continued at hourly intervals until night. The vessel reached Manila at 11.30 p. m. the same day.

In the survey of Lagonoy Gulf the topographic work began at East Point, Batan Island, and was extended all around the gulf to Nagumbuyan Point, including several miles in Tabaco Bay to fill in gaps in the previous work in this vicinity. The hydrographic work with the launches was extended out to the 100-fathom curve except to the east of Calanaga Bay, where it does not extend out quite so far. A self-registering tide gauge was maintained at Tabaco during the progress of the work, but no other tide observations were made.

On December 14 supplementary survey work was taken up by the party on the *Pathfinder* in Manila Bay, vicinity of Malabon, while some necessary repairs were being made, which kept the ship in the vicinity of Manila. This work included the topographic survey of Canacao Bay and the coast southwest from Sangley Point for a distance of 3 miles and the hydrographic survey from a point near Paranaque to the limit of the topography. Special work was done in Canacao Bay at the request of the commandant of the Cavite Navy-Yard. The positions of all mooring and wreck buoys within the area surveyed were determined. The work was completed on January 27.

ASTRONOMIC OBSERVATIONS. MAGNETIC OBSERVATIONS. PHILIPPINE ISLANDS. J. E. McGRATH. W. B. FAIRFIELD.

SUMMARY OF RESULTS.

Astronomic observations:
  1 azimuth established.
  2 latitudes determined.
  2 longitudes determined.
Magnetic observations:
  2 stations occupied.

The determination of astronomic base positions was assigned to Assistants McGrath and Fairfield. They made observations to determine their personal equation and completed all other necessary preparations at Manila. Mr. McGrath sailed for Iloilo, *Panay*, on August 24 and arrived there on the 28th. Preparations were immediately made to use the astronomic station at Iloilo as the base station from which to determine the longitude of Cuyo, *Cuyo*, and San José de Buenavista, *Panay*. The telegraph line between Iloilo and the latter place was in poor condition and caused additional delay to that caused by the exceptionally unfavorable weather. From September to November a great deal of rainy weather is usually to be expected at Iloilo, but during this period in 1903 an extraordinary amount of bad weather was encountered, and the observations to determine the difference of longitude between Iloilo and Cuyo were not completed until November 20. Observations were made at Iloilo to determine an azimuth for use in the triangulation in the vicinity. On December 1 the station at San José was ready for an exchange of signals, but the necessary observations to determine the longitude were not completed until December 13. The weather continued bad until the 17th, when the attempt to secure more observations was abandoned, and on December 21 Mr. McGrath sailed for Manila and reached there on the 24th.

The character of this work rendered it necessary to make many demands upon the officers of the Army and Philippine Constabulary for facilities and assistance at various points, and Mr. McGrath states his pleasure in acknowledging the unvarying courtesy and kindness with which all his requests were granted. At Ormoc, Manila, and Iloilo, the aid desired was instantly granted by the officers of the Quartermaster's Department, and the cooperation of the Signal Service could not have been more generous or more thorough.

Mr. Fairfield sailed from Manila for Cuyo, Cuyo, on August 23 and reached there on the 25th. He was ready for work on the 28th, but rainy weather prevailed and it was not possible to make observations for time and exchange signals with Iloilo on any night during the remainder of the month or during September.

In October almost the same unfavorable weather conditions prevailed. Observations were made on a few nights, but until the 29th it was either rainy or cloudy at Iloilo. A complete set of observations were made on the 29th, and the weather was clear on the 31st, but the telegraph line broke down and no signals could be exchanged. Broken sets of observations were made on October 3, 11, 14, 15, 19, and 20, when the necessary observations were completed. Observations to determine the latitude and magnetic observations were also made at Cuyo.

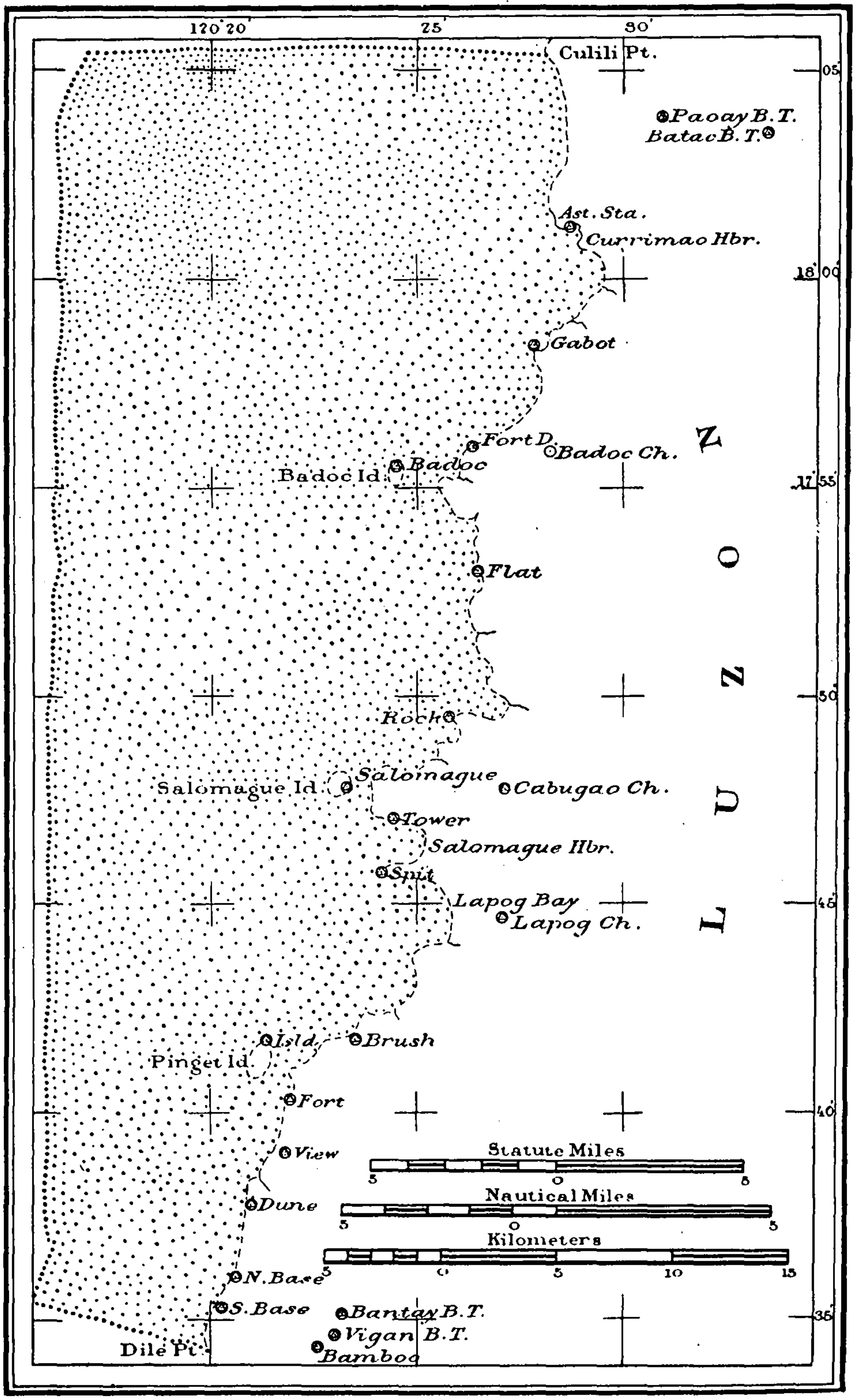
On November 29 Mr. Fairfield went to San José de Buenavista, Panay, and on December 1 was ready for observations, but bad weather prevailed until the 12th and 13th. On these dates good sets of observations were obtained. Bad weather again prevailed until the 19th, when the attempt to secure other observations was abandoned in order to take advantage of an opportunity to leave this unfrequented port, and Mr. Fairfield sailed for Manila, where he arrived on December 27.

Observations were made to determine the latitude at San José and magnetic observations were also made. The stations were marked in a permanent manner.

HYDROGRAPHY. PHILIPPINE ISLANDS. F. WESTDAHL, Commanding,
TOPOGRAPHY. Steamer *Pathfinder*.

B. A. BAIRD, *Assistant*.
W. C. DIBRELL, *Assistant*.
H. S. SMITH, *First Watch Officer*.
R. H. HAWKES, *Surgeon*.
L. M. HOPKINS, *Chief Engineer*.
J. M. COLEMAN, *Second Watch Officer*.

No. 42.



Hydrography, Philippine Islands.

SUMMARY OF RESULTS.

Hydrography:
 278 square miles area covered.
 1 068 miles lines sounded.
 22 547 soundings made.
 2 tide stations established.
 5 hydrographic sheets completed.
Topography:
 3 miles shore line surveyed.
 1 topographic sheet completed.

The hydrographic survey of the west coast of Luzon, between Point Candon an Currimao, was assigned to Assistant Westdahl, commanding the steamer *Pathfinde* The vessel sailed from Manila on March 8. A stop of two hours was made at th entrance to Manila Bay, and an examination was made for the purpose of locating shoal reported off the eastern end of Cavallo Island, but no shoal was found. Only general examination was possible, as no signals were available. The ship reached th working ground on March 9, and a self-registering tide gauge was established a Salomague, where observations began on the 15th. The triangulation stations wer recovered and signals were erected from Salomague Island to Pinguet Island to th southward, the positions of additional stations being determined whenever necessar To the northward a boat could not be used on account of the heavy swell, and so party was sent overland under a military escort provided by the insular authoritie Soundings were made from the boats whenever the heavy swell permitted, and wit the ship offshore at such times as the work inshore was not practicable. The wor was interrupted once in order to permit the vessel to return to Manila for coal. O the return trip the vessel experienced the effect of a northerly current of two miles p hour in the vicinity of Salomague. While sounding off point Culili the heavy swe was breaking on all reefs dangerous to the ship, and consequently soundings could b made close to them and to the sandy shore between Point Culili and Currimao.

A hydrographic survey of Currimao anchorage was made on a large scale and als a resurvey of the shore line. A tide staff was erected in the mouth of a small lagoo in a sheltered part of the bight and continuous observations were made during the tw days the sounding was in progress. This work was completed on May 14, and on th 16th the ship went west to Pinguet Island and took up the work in that vicinity. Wor was continued whenever the conditions permitted until May 27, when the vessel saile for Hongkong for repairs. The work for the season covered the coast from Point Dil to Point Culili, including surveys of Salomague and Currimao harbors on a large scal

HYDROGRAPHY. PORTO RICO. R. L. FARIS, Commanding,
MAGNETIC OBSERVATIONS. Steamer *Blake*.

L. M. FURMAN, *Watch Officer*.
J. T. GOLDSBOROUGH, *Chief Engineer*.
W. F. GLOVER, *Watch Officer*.
G. C. BALLARD, *Assistant Surgeon*.
GEO. OLSEN, *Watch Officer*.
H. M. TRUEBLOOD, *Aid*.
B. C. LILLIS, *Aid*.
F. T. LAWTON, *Aid*.

SUMMARY OF RESULTS.

Hydrography:
- 298 square miles area covered.
- 1 503 miles lines sounded.
- 32 960 soundings made.
- 3 tide stations established.
- 4 hydrographic sheets completed.

Magnetic observations:
- 18 stations occupied.

Hydrographic work on the east coast of Porto Rico and magnetic observations at sea were assigned to Assistant Faris, commanding the steamer *Blake*. The vessel left Baltimore on March 5, and magnetic observations were made the same day in Chesapeake Bay off the mouth of the Patuxent River, by swinging the ship, and on the following day in Hampton Roads. Mr. D. L. Hazard, Computer in the Division of Terrestrial Magnetism, assisted in this work and then landed at Norfolk.

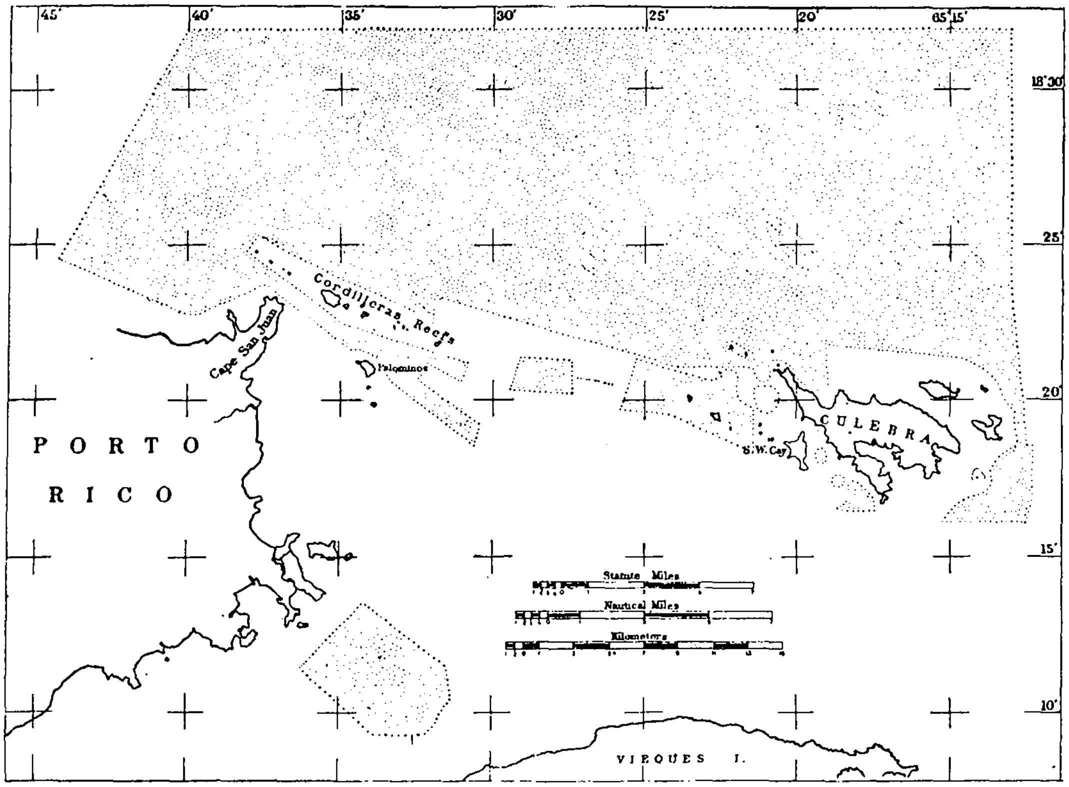
The vessel sailed from Norfolk on March 9 for San Juan, Porto Rico, and reached there on the 15th. During the voyage magnetic observations were made by swinging the ship every day when the weather was suitable. The vessel reached Vieques Sound on the 17th and on the 19th magnetic observations were made in the usual manner. From March 18 to May 30 the hydrographic work proceeded without material interruption. Almost half the work of the season consisted of reexaminations of passes and channels, leading into Vieques Sound, with the channel sweep. The previous work was extended offshore to deep water (over 350 fathoms) along the whole of the north shore of Vieques Sound from Virgin Passage to a point 7 miles to the westward of Cape San Juan. All this work was done with the deep-sea sounding apparatus except the development of the western part of Cordilleras Reef, which extends about 5 miles west of Cape San Juan. About 3 miles of this reef was examined closely with the channel sweep. A number of spots in the vicinity of Culebra and Culebrita islands were specially examined and additional buoys and ranges were charted in the vicinity of Culebra Island. About 20 square miles of area lying immediately to the eastward of Arenas Point bell buoy was closely and carefully resurveyed, by using two systems of lines and the channel sweep.

Tide observations were made at Fajardo during the season and temporary tide gauges were established at Target Bay and Mangrove Harbor and simultaneous readings were made on these gauges and on the gauge at Fajardo for purposes of comparison.

On May 30 magnetic observations were made on board and on shore at Obispo Cay, and the vessel proceeded to San Juan. On June 2 the ship sailed for Hampton Roads, Virginia, and reached there on the 8th. During the voyage magnetic observations were made daily, if the weather permitted. The ship was swung twice at sea and once at Hampton Roads on the day of arrival.

All the officers except the Chief Engineer and the Surgeon performed navigation duties and stood regular watches at sea. The officers all assisted in the general survey duties assigned to the ship. Assistant Faris expresses his appreciation of the willingness and zeal displayed by the officers in assisting in the hydrographic and magnetic work. He also makes special mention of the uniform kindness with which Capt. Andrew Dunlap, U. S. Navy, commandant of the San Juan Naval Station, treated the party upon all occasions.

No. 43.



Hydrography, Vieques Sound, Porto Rico.

MAGNETIC OBSERVATIONS. PORTO RICO. W. B. KEELING.

The work at the Porto Rico Magnetic Observatory on Vieques Island was continued by Mr. R. F. Soper, under the direction of Assistant L. A. Bauer, during July, and on August 1 the charge of this work was transferred to Magnetic Observer Keeling. A continuous record of the changes in the relative values of the magnetic elements was obtained on the self-registering magnetograph throughout the year. Observations to determine the absolute value of the declination and horizontal intensity were made twice every week and once a week to determine the vertical force. A seismograph was installed in August and observations began September 4. Fourteen well-defined seismic disturbances were recorded.

A small building was erected in December as an observatory for the absolute measures, and observations were made in it after January 4. Meteorological observations were made every day and observations for time were made once a week.

Special rapid registrations of the magnetic elements were obtained on the 1st and 15th of every month.

Mr. Keeling reports his appreciation of the faithful and conscientious service rendered by Mr. Eustaquio Morales (employed in the observatory) in performing all duties assigned to him.

HYDROGRAPHY. PORTO RICO. J. C. LANDERS.

J. B. MILLER, *Aid.*

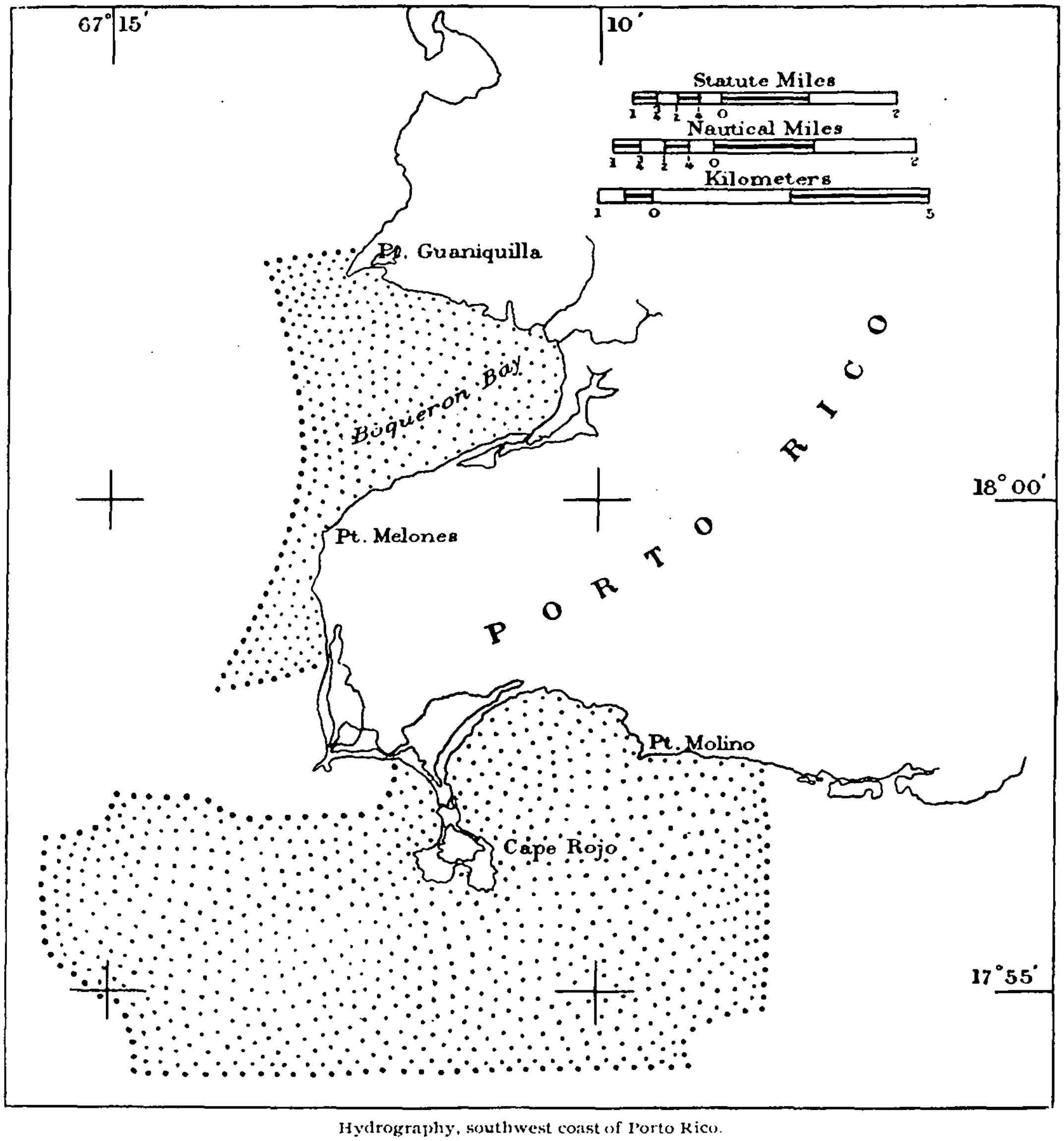
SUMMARY OF RESULTS.

22	square miles area covered.
449	miles lines sounded.
23 886	soundings made.
2	tide stations established.
2	hydrographic sheets completed.

Hydrographic work on the southwest coast of Porto Rico was assigned to Aid Landers. He left Baltimore with his aid, Mr. Miller, January 27, on board the Coast and Geodetic Survey steamer *Bache*, and arrived in Mayaguez February 13. The launch *Rudy* was taken from storage and put in order, under direction of the commanding officer of the *Bache*, Assistant P. A. Walker, but was not ready for use until March 2. The members of the party assisted in this work until February 23, when Mr. Miller and three men were established in camp at Guaniquilla Point, on the north side of Boqueron Bay, and began building signals at the triangulation points already established for use in the hydrographic work. Soundings began on March 8 and were continued whenever the conditions permitted until March 30, when the work in the bay was completed. Inside the bay lines of soundings were made east and west at intervals of 100 meters, and north and south at intervals of 200 meters. Outside the reef at the mouth of the bay the work was extended to cover the area not previously sounded, the lines forming a rectangular system, with intervals of from 100 to 150 meters.

After finishing the work in Boqueron Bay, the party was moved to Point Jaguey and preparations were made for the hydrographic work off Cape Rojo. The launch broke down and much of the outfit was moved in the whaleboat, which caused great delay, as only small loads could be carried. Signals were erected at old triangulation points and additional positions were determined. The hydrographic work began on April 15, but the launch was in bad condition and was sent twice to Mayaguez for repairs. In spite of delays from this and other causes, the work in the vicinity of Cape Rojo was completed on May 13. South and east of the cape a rectangular system of lines were sounded, with intervals of 200 meters. To the west the work was done in a way to form a proper extension of the survey made in 1901, covering the area between that work and the shore. After completing this work, the outfit was moved to Mayaguez and stored, and the party, except Mr. Miller, then proceeded to San Juan and reported for duty on board the steamer *Bache* on May 21.

No. 44.



Hydrography, southwest coast of Porto Rico.

Mr. Miller was detached from the party on May 15 and ordered to the Office. He is highly commended by Mr. Landers for the zeal, intelligence, and executive ability displayed in performing the duties assigned to him, consisting of signal building, measuring sextant angles, computations, etc.

MAGNETIC OBSERVATIONS. PORTO RICO. P. A. WELKER, } Commanding,
HYDROGRAPHY. J. B. BOUTELLE, }
Steamer *Bache*.

W. M. ATKINSON, *Watch Officer*.
G. E. MARCHAND, *Surgeon*.
M. F. FLANNERY, *Chief Engineer*.
WM. B. PROCTOR, *Watch Officer*.
E. C. SASNETT, *Aid*.
WM. SANGER, *Captain's Clerk*.
E. MUELLER, *Aid*.
E. V. MILLER, *Junior Captain's Clerk*.

SUMMARY OF RESULTS.

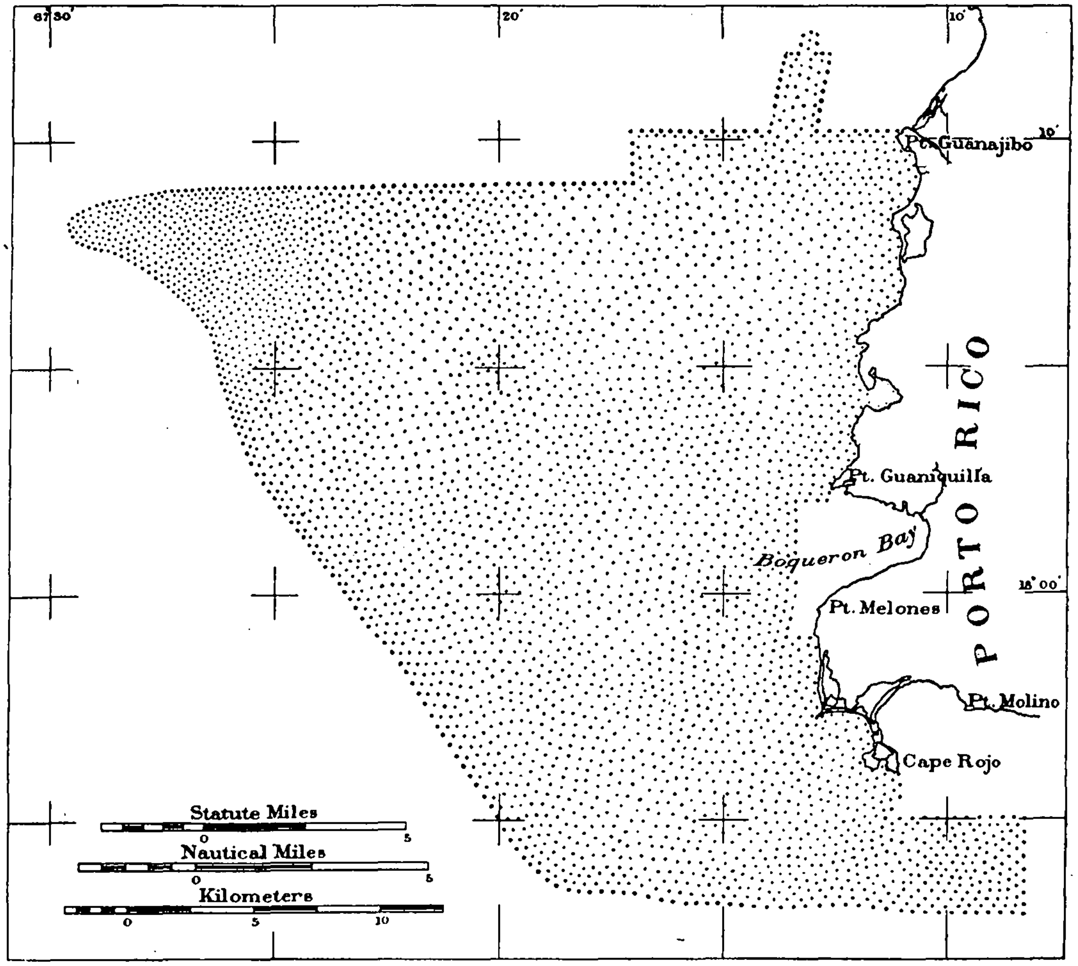
Magnetic observations at sea:
14 stations occupied.
Hydrography:
206 square miles area covered.
2 200 miles lines sounded.
60 983 soundings made.
2 tide stations occupied.
5 hydrographic sheets completed.

Hydrographic work on the coast of Porto Rico was assigned to Assistant Welker, commanding the steamer *Bache*, and he was also instructed to make magnetic observations at sea on the voyage to and from the island. The first set of these observations were made in Hampton Roads, Virginia, on February 2, and on the 4th the ship sailed for Porto Rico, and arrived at San Juan on February 10. Magnetic observations were made every day during the voyage. On the 13th the vessel proceeded to Mayaguez and the field work began immediately. The triangulation stations between Mayaguez and Cabo Rojo were recovered and additional positions were determined for the hydrographic work. The launch *Rudy* was put in order for Aid J. C. Landers, in charge of a shore party, and he was assisted in establishing his camp on Boqueron Bay.

On February 25 the sounding work off the coast began, and was continued without interruption whenever the weather conditions permitted, the ship and two launches being used in the work. From February 28 to April 22 the work was done under the direction of Assistant J. B. Boutelle, who was in command of the *Bache* during the absence of Assistant Welker on other duty.

The channels between the reefs were sounded with the channel sweep in use, and numerous special examinations for shoal spots were made. Lines of soundings from one-half to 1 mile apart were run, and intermediate lines were sounded whenever they appeared to be necessary. In the vicinity of the 100-fathom curve the channel sweep was set to a depth of 4½ fathoms, and lines were sounded at intervals of 100 to 300 meters. By May 14 all of the work inside of the 100-fathom curve from Tourmaline Reef to a junction with the work finished during the previous season, about 2 miles to the westward of Magarita Reef, was completed, and on that date observations to determine the magnetic elements were made on board ship and on shore at Mayaguez. This closed the work in this locality and the vessel proceeded to San Juan.

No. 45.

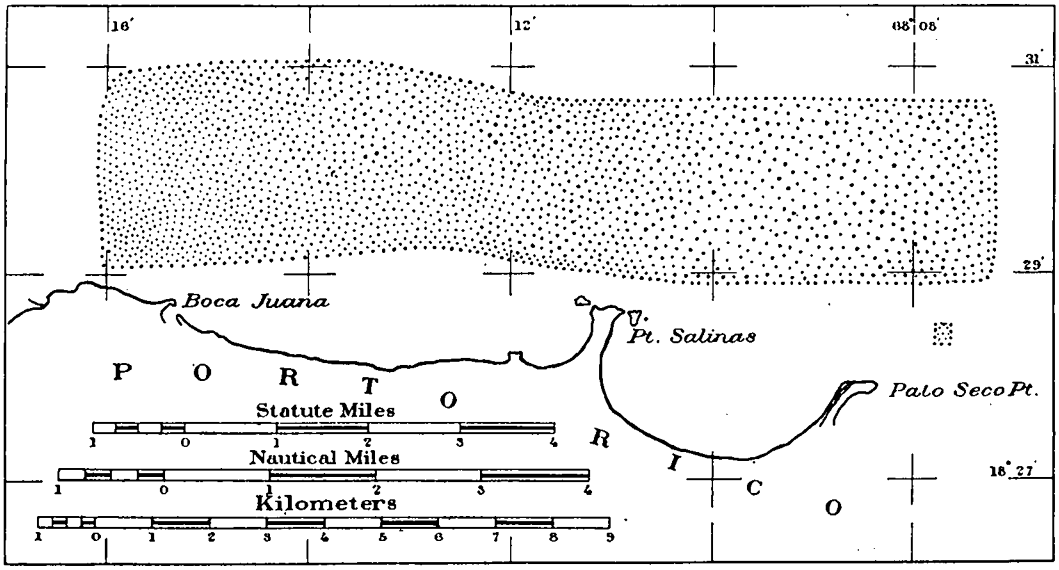


Hydrography, west coast of Porto Rico.

During this season the weather was almost continuously fair, with occasional rain squalls. The sea was generally rough as a result of the trade winds, but the work with the steamer was kept up continuously.

On May 18 the work off the north coast of the island to the westward of San Juan Harbor began, and was continued until the 26th, when the work in Porto Rico closed for the season. The trade winds were strong and the sea was usually so rough that only the morning hours could be used for sounding. A reported obstruction was located in the entrance to San Juan Harbor, and its position was determined. On May 26 magnetic observations were made on shore at San Juan. The vessel left San Juan on May 28, and reached Hampton Roads on June 3. On account of the rough seas and the rainy and cloudy weather during the voyage north, only one set of magnetic observations were obtained at sea. Another set was made in Hampton Roads.

No. 46.



Hydrography, north coast of Porto Rico.

In his report, Assistant Welker expresses his appreciation of the faithful and intelligent manner in which the officers of the ship performed the duties assigned to them, and states that much of the success of the season's work is due to the aid rendered by them.

SPECIAL DUTY.

EXAMINATION OF THE VIRGINIA OYSTER LANDS. J. B. BAYLOR.

On August 7, 1903, under authority of the Secretary of Commerce and Labor, Assistant Baylor was detailed to duty with the joint special committee of the general assembly of Virginia, appointed to investigate the present conditions of the State oyster lands.

This detail was made in compliance with the request of the chairman of the committee, Hon. W. D. Cardwell. Mr. Baylor made a survey of these oyster lands for the State authorities 1892–1895. and his assistance was especially valuable to the committee. He joined the committee at Norfolk on the date mentioned, and about two weeks were spent in making a personal inspection of the oyster lands.

SURVEY OF LOUISIANA OYSTER BEDS. J. B. BAYLOR.

The survey of the natural oyster beds and reefs in the State of Louisiana begun during the previous fiscal year, at the request of the United States Commissioner of Fish and Fisheries, was continued, in cooperation with the Louisiana Oyster Commission, by Assistant Baylor, who reached New Orleans on January 27. The determination of geographic positions by triangulation was continued until April 22, when field work closed for the season. Eighteen triangulation stations were occupied and twenty-four geographic positions were determined. The positions of numerous subsidiary stations were also determined within the 75 square miles of area covered by the triangulation. The work extends over the region between the mouth of the Mississippi River and Quarantine Bay, and along the east bank of the river and the shores of the bays to the eastward.

In their annual report, the Louisiana Oyster Commission acknowledges the value of this work in controlling the surveys made in subdividing the oyster bedding grounds, as it is possible to connect the division lines with one or more of the triangulation stations.

HEMPSTEAD HARBOR SPEED-TRIAL COURSE. J. B. BOUTELLE.

In response to a request from the New York Yacht Club, a speed-trial course was established in Hempstead Harbor, Long Island, New York. The work was assigned to Assistant Boutelle, and he completed the work between June 11 and 25. A line, 1 nautical mile long, was measured along the shore with a tapeline, and the distance between the marks so established was then determined by triangulation from old stations which were recovered in the vicinity. Front and back ranges were established at both ends of the course.

RESURVEY OF MASON AND DIXON'S LINE.

W. C. HODGKINS.

The resurvey of Mason and Dixon's Line, the boundary line between the States of Maryland and Pennsylvania, was in progress on July 1 under the direction of Assistant W. C. Hodgkins, who had been detailed for this duty in response to a request from the joint commission, established by the States named, for an officer of the Survey to direct the work which was done at the expense of the States.

Mr. Hodgkins's services being required for other special duty, the field work was done by Mr. R. H. Blain, his assistant, who acted under his direction except during the period July 27 to August 7, when Mr. Hodgkins was with the party in the field and made all necessary arrangements for the completion of the work. In spite of unfavorable weather conditions Mr. Blain completed the field work in connection with this survey by August 31.

MISSISSIPPI RIVER COMMISSION.

H. L. MARINDIN.
H. P. RITTER.

Assistant Marindin continued his service as a member of the Mississippi River Commission, from July 1 to March 25, the date of his death. During this period he performed all the duties required of a member and devoted a considerable portion of his time to the work.

He left Washington on November 5 and attended a meeting of the Commission at St. Louis, Mo., and from November 7 to 17 he was with the Commission on a trip of inspection down the river to New Orleans, La. In March he again attended a meeting of the Commission in St. Louis and made a trip of inspection down the river, and his death occurred a few days after his return to the Office. A short biographical notice of this distinguished officer appears in the proper place in this Report, under the head of Necrology.

Assistant H. P. Ritter was appointed by the President to succeed Assistant Marindin as a member of the Commission, and this appointment was confirmed by the Senate on April 14, 1904. His absence on duty in Alaska prevented his active participation in the work of the Commission during the remainder of the fiscal year.

TRIANGULATION OF THE CITY OF NEW YORK.

A. T. MOSMAN.

SUMMARY OF RESULTS.

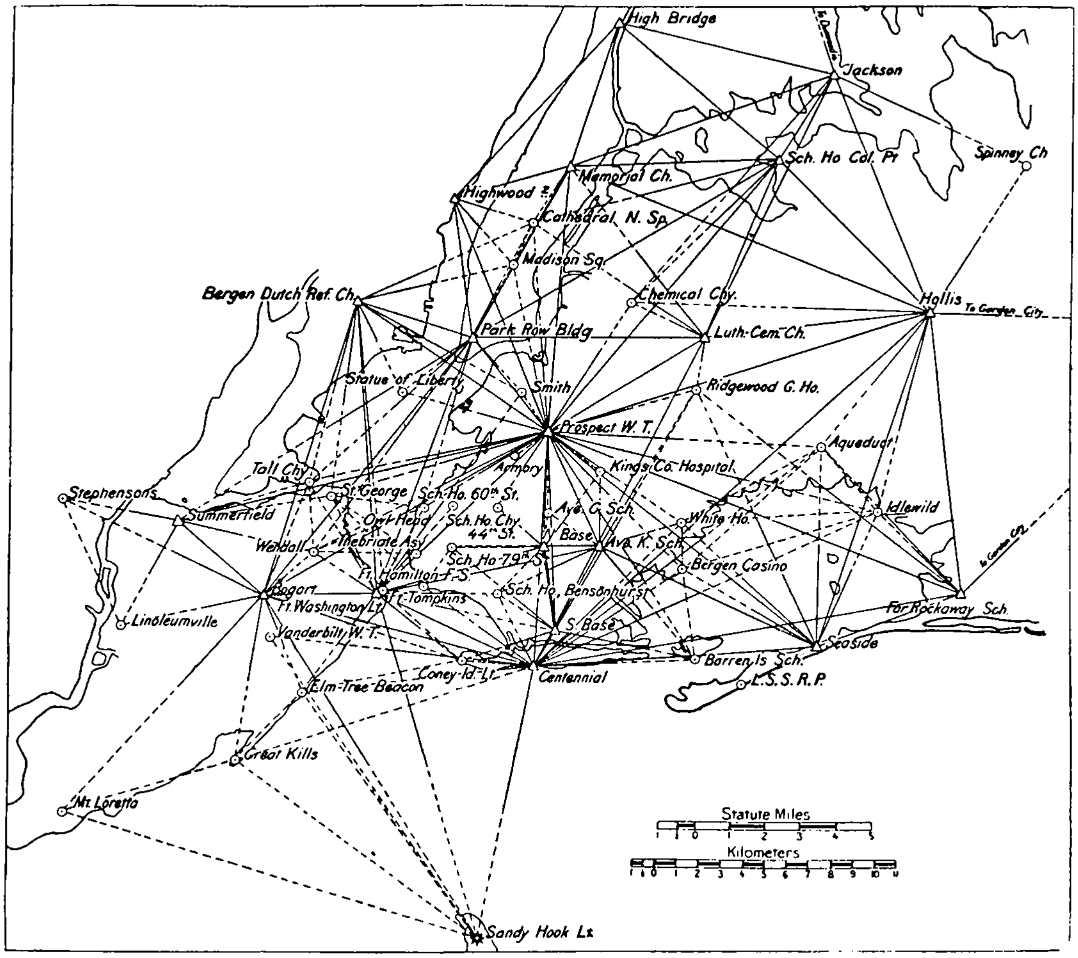
Reconnaissance:
- 379 square miles area covered.
- 56 triangulation stations selected.

Triangulation:
- 319 square miles area covered.
- 19 stations occupied.
- 56 geographic positions determined.

The triangulation of the city of New York was in progress by the city authorities, under the direction of Assistant Mosman, at the close of the last fiscal year, as stated in the previous annual report.

Messrs. George Wood and Camille Mazeau continued the work of observing until Mr. Mazeau resigned in July. No other observer was available until November, when Mr. F. W. Koop was appointed. The work progressed throughout the year whenever the conditions permitted. During a large portion of the time the weather was unfavorable for making observations, and many of the lines passed over the manufacturing section of the city and were obscured by smoke, even when heliotropes were used, except during strong winds in certain directions. The work was in progress on June 30.

No. 47.



Triangulation, New York City.

PATROL DUTY. NEW JERSEY. JOHN ROSS, Commanding,
Steamer *Hydrographer*.

By direction of the Secretary of Commerce and Labor, officers were detailed to patrol the course of the regatta of the New York Bay Regatta Association, to be held on the Kill von Kull on August 29, 1903, and Nautical Expert John Ross was designated as the commanding officer by the Secretary.

He reached Tompkinsville, N. Y., on August 27, and communicated with Capt. W. M. Folger, U. S. Navy, Inspector of the Third Light-House District, who furnished an electric launch to aid in the work. Aid Quillian, with the launch *Inspector*, reported on the 28th, and Assistant Boutelle, with the steamer *Bache*, early on the 29th. The patrol fleet was arranged as follows, viz:

Vessel.	Commanding officer.
Hydrographer	John Ross, Nautical Expert.
Bache	J. B. Boutelle, Assistant.
Launch Inspector	C. L. Green, First Watch Officer.
Launch (steam)	W. M. Atkinson, First Watch Officer.
Launch (oil No. 31)	C. E. Marchand, Surgeon.
Launch (electric)	Wm. Sanger, Captain's Clerk.
Launch (gasoline)	C. G. Quillian, Aid.
Whaleboat, No. 1	E. V. Miller, Junior Captain's Clerk.
Whaleboat, No. 2	E. C. Sassnett, Aid.

Copies of the rules governing the race were distributed to the commanding officers, who had authority to enforce them.

In spite of very unfavorable weather, rainy and with the wind blowing at a velocity of 20 to 25 miles an hour, the regatta was held, but many of the races failed.

The *Hydrographer* was anchored at the starting line and the *Bache* at the finish line, while the boats were distributed along the course. Each boat of the patrol flotilla performed the duty assigned in a most satisfactory manner. The two whaleboats were ordered back to the *Bache* after being on duty one and a half hours, as the water was too rough for their effective use. Thirteen men were taken on board from swamped boats, and nine boats were recovered and taken to the clubhouse. The assistance rendered by the light-house officer in charge of the electric launch and her crew deserves high commendation. At 6 o'clock further attempts to race were abandoned, and the vessels of the patrol fleet returned to their respective duties. It was afterwards determined to have the unfinished races on September 12, and Mr. Ross was again placed in charge of the work of patrolling the course.

The Light-House Service furnished the tender *Daisy*, the *Hydrographer* was used as before, and six power launches were hired for the occasion. The patrol fleet was as follows, viz:

Vessel.	Commanding officer.
Hydrographer	John Ross, Nautical Expert.
Daisy	Capt. E. M. Trott.
Launch No. 1	C. L. Green, First Watch Officer.
Launch No. 2	C. G. Quillian, Aid.
Launch No. 3	J. C. Landers, Aid.
Launch No. 4	G. F. Rude, Deck Officer.
Launch No. 5	B. D. Barker, Aid.
Launch No. 6	H. C. Graves, Nautical Expert.

The *Hydrographer* was placed at the starting line, the *Daisy* at the finish, and the launches along the course. The officers in charge of the boats all performed their duties in a most creditable manner, the course was kept clear, and there were no accidents. Captain Trott was especially active in enforcing the regulations and assisted in every possible way in making the patrol duty successful.

The regatta closed at 7 o'clock and all officers were instructed to return to their respective duties.

NORTHWEST BOUNDARY. O. H. TITTMANN.

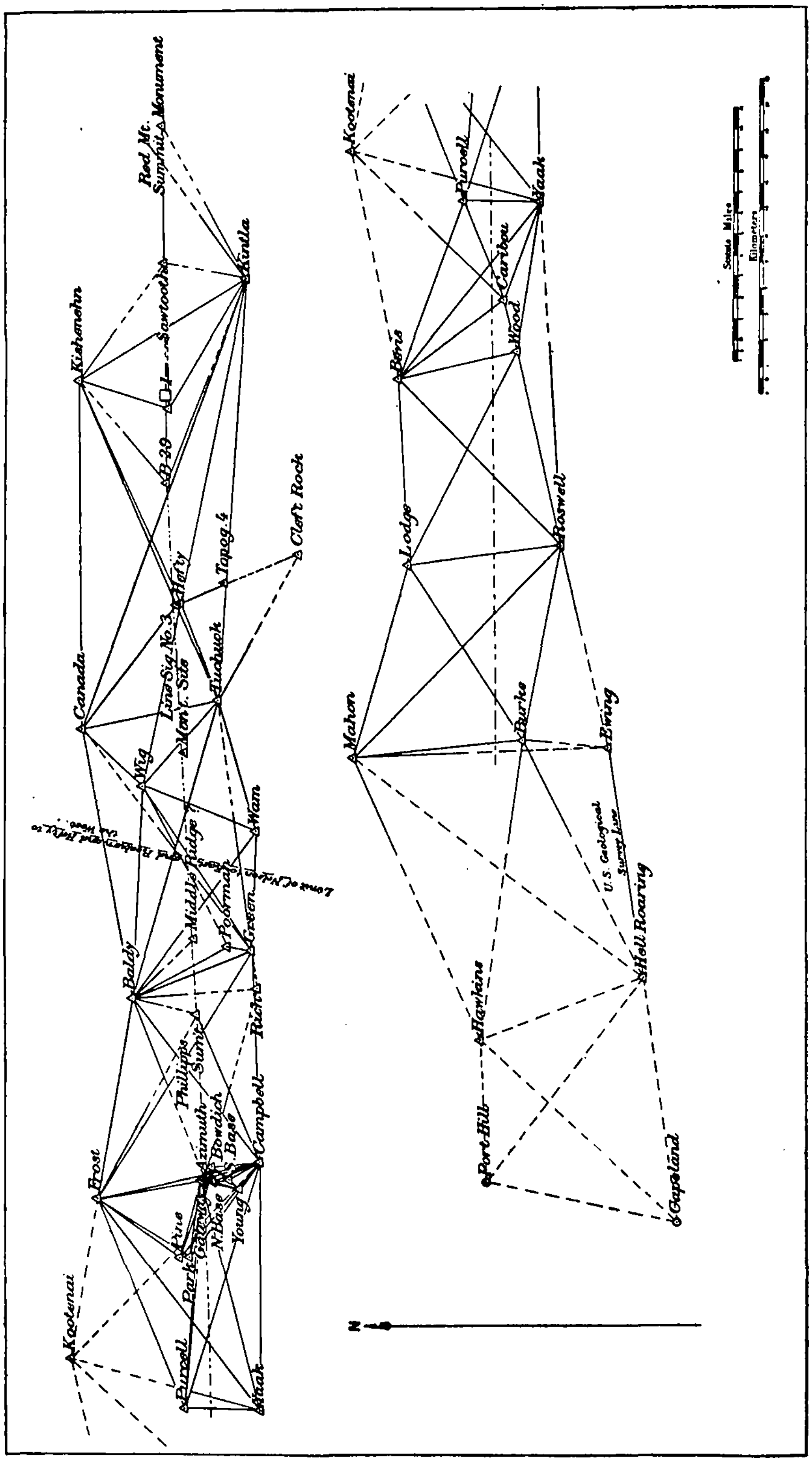
C. H. SINCLAIR, *Assistant.*

On July 1 the work of re-marking the boundary line between the United States and Canada was in progress under the Department of State, with Messrs. O. H. Tittmann, Superintendent Coast and Geodetic Survey, and C. D. Walcott, Director United States Geological Survey, as Commissioners representing the United States. Mr. W. F. King, Chief Astronomer of the Canadian Department of Interior, represents the British Government on this Commission.

The Commissioners had each assigned officers of their Bureaus to have charge of the work in the field, and Assistant C. H. Sinclair was detailed for this purpose from the Coast and Geodetic Survey. Three parties continued the work under Mr. Sinclair's direction, as follows:

Assistant John Nelson, in charge of a triangulation party, began work on the east side of the Wigwam River, in Montana, in July, and extended the work toward Gateway. A base line was measured on the railroad track south of Gateway with a steel tape laid along the top of the rail. From this base line the triangulation was extended to the mountains east of Gateway and the work was transferred to the west of the Purcell Range beyond the Kootenai River. By the end of October the work had been extended nearly to Porthill, at the west crossing of the Kootenai, and the party returned to occupy a station northwest of Gateway to strengthen the triangulation in this vicinity. Before the station could be cleared a prolonged storm early in November forced the suspension of the work, and the party was disbanded on November 20. To the east of Porthill the work joined the triangulation of the United States Geological Survey extending north from Spokane.

No. 48.



Triangulation, Northwest Boundary.

SUMMARY OF RESULTS.

74 miles of triangulation completed.
592 square miles area covered.
21 stations occupied.

A line party in charge of Mr. Reinert Hanssen was at work on the line between boundary monuments Nos. 7 and 8, a distance of 13 miles, at the beginning of the fiscal year. The line clearing was completed on September 5, a great deal of this time having been spent in building 18 miles of main and side trails, to make it possible to get the pack animals with supplies near the field of work. The party was then moved to the Yaak River and began work on September 16 on the line between boundary monuments Nos. 6 and 18, a distance of 24 miles.

On September 18 Mr. F. A. Camp succeeded Mr. Hanssen as chief of the party, and continued in charge until the close of the season. The work of clearing the vista and of building trails continued whenever the conditions permitted until the first week in November, when the snow began to fall and continued to fall from day to day until it was 2 feet deep on the 18th, compelling the return of the party to Gateway, where it was disbanded on the 21st.

SUMMARY OF RESULTS.

24 miles of vista cleared.
31 miles of trail built.
11 miles of stadia line completed.

A second line party under charge of Mr. E. R. Martin continued the work of running a trial line and building trails along the boundary between monuments Nos. 11 and 13, a distance of 17 miles. This work was completed to the Yaak River, and the offset south of monument No. 13 was determined. The proper offsets were then laid off on the different summits along the trial line and the boundary line was cleared. The vista clearing and stadia work were completed in the latter part of October and the party was then moved to the line between monuments Nos. 16 and 18, but after a few days' work was forced by the November snow storm to close work for the season and was disbanded at Yaak Siding on November 17.

SUMMARY OF RESULTS.

18 miles of vista cleared.
31 miles of trail built.
20 miles of stadia line completed.

Twenty-one miles of trail were built by Messrs. Sinclair and Nelson in addition to the mileage stated above.

Magnetic observations were by Mr. A. E. Franklin in October and November, under Mr. Sinclair's direction, at Gateway, on the east side of the Flathead River in line between monuments Nos. 4 and 5, at monument No. 8, near Phillips, and at monument No. 11, 4 miles east of Gateway.

All field work for the season closed on November 28.

Field work was resumed on the Northwest Boundary early in May. Mr. Sinclair left Washington on May 5, accompanied by John Nelson, Assistant, and A. M. Miller, transitman, and proceeded to Kalispeel, Mont., where the parties were organized and arrangements for the work were completed.

Mr. Nelson began the work of reconnaissance on May 17 in the vicinity of Laurier, Wash., and extended it to Midway, British Columbia. Signals were erected at the stations covering a distance of 30 miles, and the triangulation was completed for a distance of 20 miles. A base line was measured on the railroad track south of Grand Forks. Mr. Nelson was assisted in this work by Mr. E. R. Martin, who made nearly all of the observations at the triangulation stations. Before joining Mr. Nelson on May 25 Mr. Martin traced the line between monuments 10 and 11, a distance of 3.6 miles, and located the positions for two intermediate monuments. He also extended a stadia line from monument 11, 3 miles toward monument 13, and then joined Mr. Nelson's party. Mr. F. A. Camp, transitman, traced the line between monuments 8 and 9 and located the position of three intermediate monuments. He also located the position for an intermediate monument 1 mile east of monument 8 and then completed the stadia line between monuments 11 and 13 as far as Purcell summit, in spite of the deep snow. The lines leading from Kootenai Mountain were cleared and the observations were made at this station and at several other stations near Gateway which were necessary to connect Kootenai Mountain with the triangulation along the boundary. The trails between monuments 7 and 8 were then cleared and the work of verifying the line between these monuments was in progress at the end of the fiscal year.

ALASKA BOUNDARY.

O. H. TITTMANN.
W. C. HODGKINS.

My detail and that of Assistant Hodgkins to the State Department for duty in connection with the preparation and presentation of the United States case before the Alaska Boundary Tribunal at such times as our services were required, referred to in the previous Annual Report, were continued after July 1 by the Secretary of Commerce and Labor.

The preparations were made in Washington under the direction of Gen. John W. Foster, Agent of the United States, and we proceeded to London, England, and reported to General Foster in the latter part of August. We remained in London during the sessions of the tribunal, September 1 to October 24, and our service in connection with the tribunal terminated on the latter date.

On February 11, 1904, at the request of the Secretary of State, I was designated as Commissioner to represent the United States on the Delimitation Commission to trace and mark the boundary between Alaska and Canada as laid down in the award of the Alaska Boundary Tribunal at London in 1904. Mr. W. F. King, Chief Astronomer of the Canadian Department of the Interior, was appointed Commissioner to represent the British Government on this Commission. The Commissioners were further empowered by their respective Governments to make recommendations in regard to the marking of the whole line, and the actual work in the field was begun by officers appointed by the Commissioners for this purpose.

On May 4 Assistant Fremont Morse was assigned to the charge of one of the United States parties, to cooperate with a similar party representing the British Commissioner on the Alaskan boundary work in the field between Mount Whipple and Castle Peak.

He made the necessary preparations in San Francisco and Seattle, and sailed for Alaska from the latter place on June 12, accompanied by L. Netland and Adolf Mosheim, Surveyors, and a party of 12 men.

The Canadian party, under direction of Mr. White-Fraser, was found at Wrangell, and on the 16th both parties proceeded to the working ground on the Stikine River. The preliminary work to be done was divided by mutual agreement, and progress was made whenever the favorable weather conditions permitted. It was found to be impracticable to climb the mountains from the lower camp in time to do any work and return the same day, and consequently a light camp was established about 2 500 feet above the river, near the timber and snow line, and the remainder of the month was spent in opening a trail and packing outfit and provisions to this upper camp. The work was in progress at the close of the fiscal year.

Early in May Mr. J. A. Flemer, formerly an Assistant in the Coast and Geodetic Survey, was engaged as surveyor to the Commissioner and assigned to the charge of one of the United States parties, to be engaged in locating and marking the boundary at the headwaters of the Chilkat River. He made preparations in Washington, and on May 16 proceeded to Seattle, Wash., where he had a consultation with Mr. C. A. Bigger, Engineer to the British Commissioner. At Seattle Mr. Flemer completed his preparations, and on May 31 sailed for Haines, Alaska, accompanied by Messrs. J. M. Donn, Edmund Polk, and D. W. Eaton, Surveyors, and the necessary party employees. The party reached Haines on June 8 and went into camp at a point near the provisional boundary at the junction of the Tlehini and Chilkat rivers. Stations were selected and signals erected for the purpose of extending triangulation up these rivers to the peaks defining the boundary in this locality. Observations began on the 28th, and the work was in progress on June 30.

The cooperating Canadian party under direction of Mr. Bigger was at Pleasant Camp in this vicinity, and the peaks defining the boundary were identified by the joint action of chiefs of the two parties as the representatives of the Commissioners.

INTERNATIONAL GEODETIC ASSOCIATION. O. H. TITTMANN.

The duty of representing the United States, as delegate to the Fourteenth General Conference of the International Geodetic Association, at Copenhagen, Denmark, was performed by me. I reached Copenhagen on August 3, and the opening session of the Conference was held the next day.

I attended all the sessions of the Conference, covering the period from August 4 to 13, and presented a printed report on the geodetic operations of the United States, 1900–1903. The proceedings of the Conference have been printed at Leyden, under the title, "Comptes Rendus des Séances de la Quatorzième Conférence Général de l'Association Géodésique Internationale, reunie a Copenhague du 4 aux 13 Août, 1903."

I desire to make special acknowledgment of the many courtesies extended to me as the delegate of the United States by the Director in charge of Geodetic Operations in Denmark and his officers, as well as by the Ministers of War and State.

LOUISIANA PURCHASE EXPOSITION. D. B. WAINWRIGHT.

The preparation and installation of the exhibit of the Coast and Geodetic Survey for the Louisiana Purchase Exposition was assigned to Assistant Wainwright. All the preliminary preparations were made at the Office in Washington at intervals when he was not engaged on other duty, and on April 9 he proceeded to St. Louis and installed the exhibit. After May 1 he remained in charge until the close of the fiscal year.

PATROL DUTY. D. B. WAINWRIGHT.

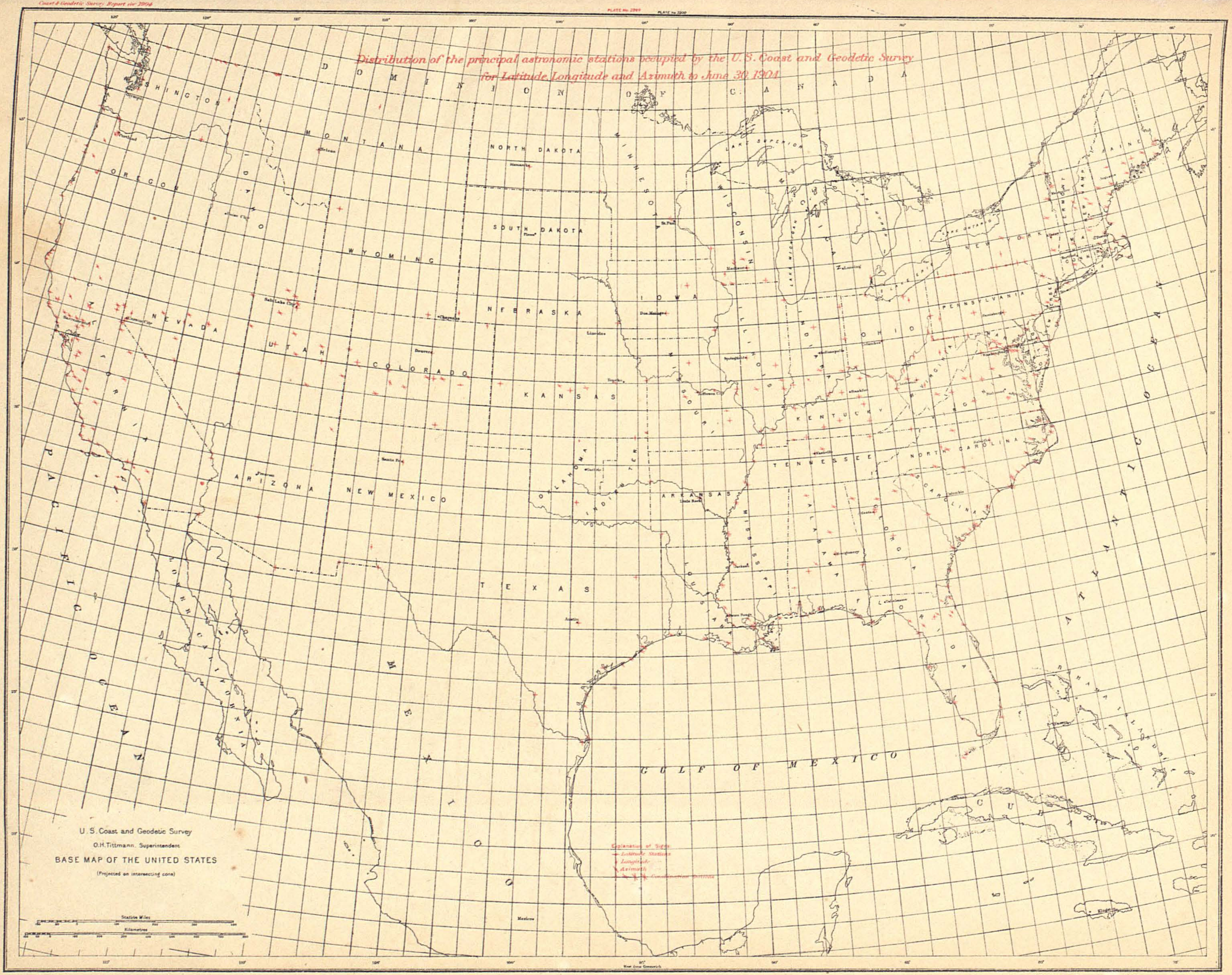
By direction of the Secretary of Commerce and Labor officers were detailed to patrol the course of the Middle States Regatta Association on the Potomac River at Washington on September 7, 1903. Assistant Wainwright was placed in charge of this work, and was authorized by the Secretary to enforce the regulations of the Department adopted for the prevention of accidents. The steamer *Endeavor* and launch No. 515 were assigned to duty under Mr. Wainwright's direction. Assistant F. A. Young, commanding the *Endeavor*, and R. McD. Moser, Watch Officer, and B. D. Barker, Aid, officers of the *Endeavor*, were placed in charge of two rowboats and the launch for patrol duty, and the police patrol boat *Vigilant* also cooperated in the work in a most effective manner. Mr. Wainwright was on board the *Vigilant* during the time when the patrol work was most troublesome, and reports his appreciation of the courtesy extended to him by the superintendent of police and by the harbor master, who were on board.

The patrol duty was performed to the satisfaction of all concerned.

CABLE TO ALASKA. F. WESTDAHL.

In response to a request from the Chief Signal Officer, United States Army, for an officer of the Survey to be detailed to accompany the cable ship *Burnside* while laying the military cable in Alaska, Assistant Westdahl was assigned to this duty. He proceeded to Sitka, Alaska, and on July 6 reported to the signal officer in charge of the *Burnside* upon the arrival of the ship at Sitka. He remained on the ship until December 31, and during this period aided in every way in his power in facilitating the work of laying the cable. His services were especially valuable in consequence of his local knowledge of Alaskan waters, acquired while in command of one of the surveying vessels of the Survey engaged in charting these waters.

Distribution of the principal astronomic stations occupied by the U.S. Coast and Geodetic Survey for Latitude, Longitude and Azimuth to June 30, 1904



Explanation of Signs
- + Latitude Stations
- Longitude
- Azimuth
- Combination Stations

U. S. Coast and Geodetic Survey

O. H. Tittmann, Superintendent

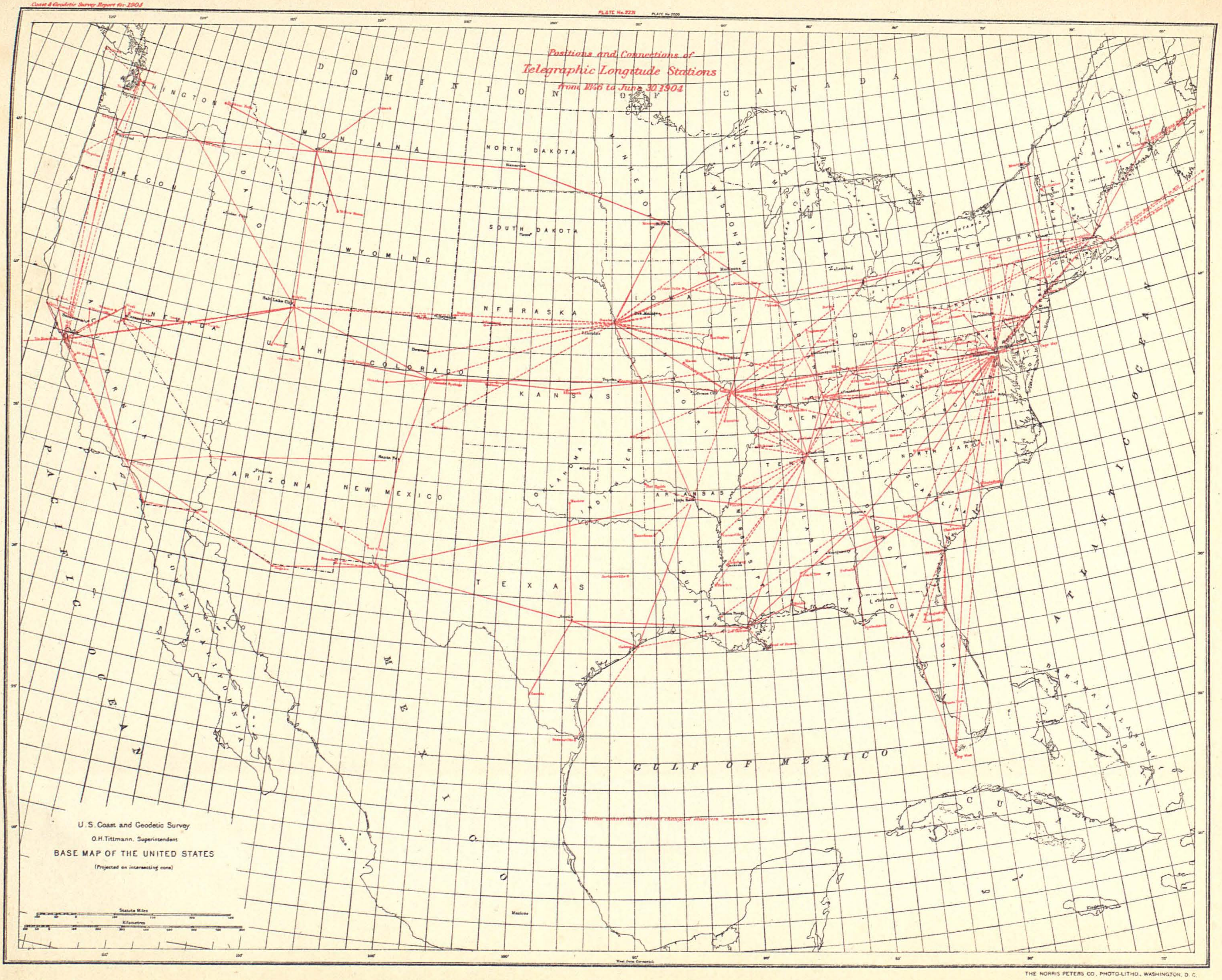
BASE MAP OF THE UNITED STATES

(Projected on intersecting cone)

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

Coast & Geodetic Survey Report for 1904

PLATE No. 2231 PLATE No. 2200

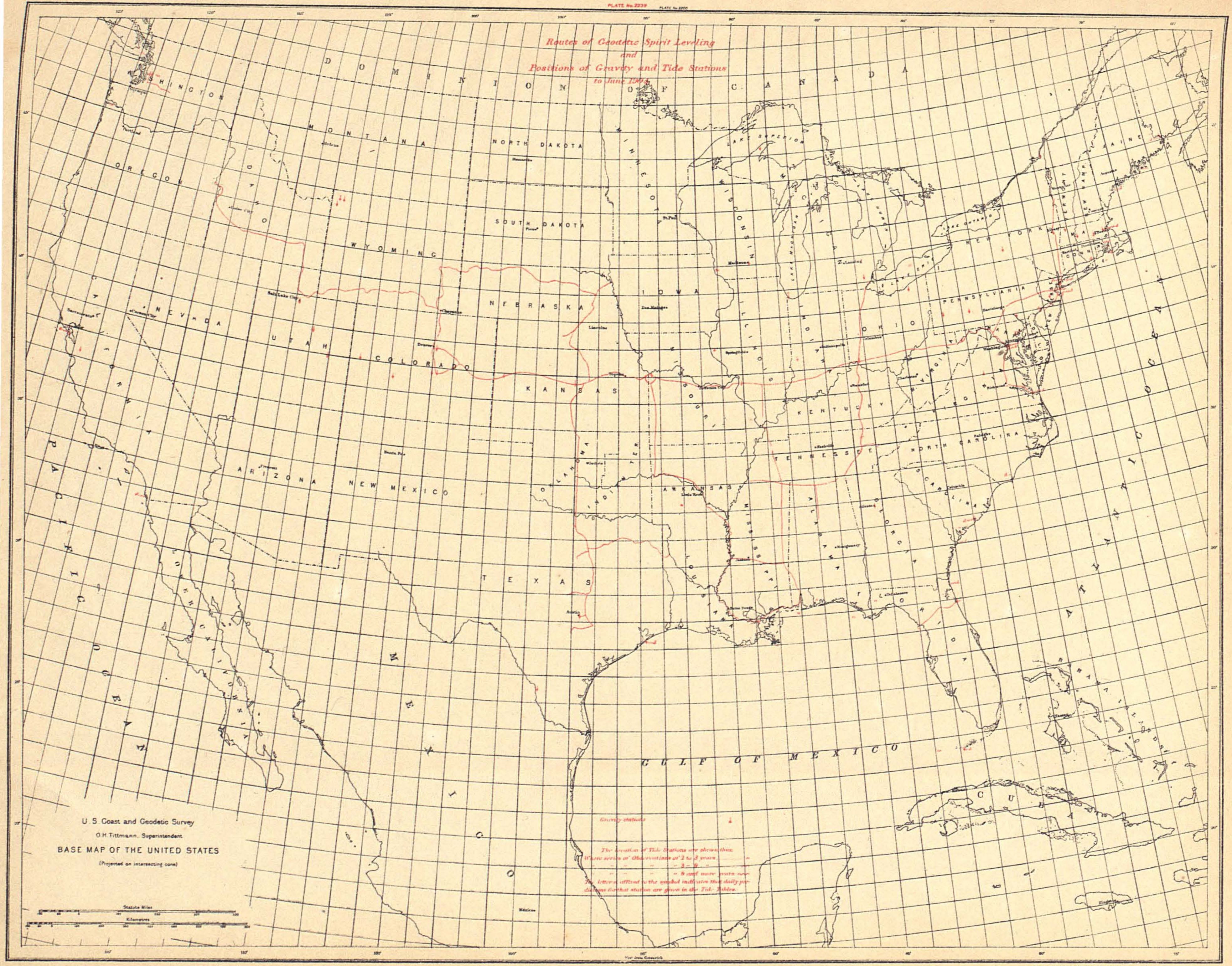


Positions and Connections of Telegraphic Longitude Stations from 1846 to June 30, 1904

U. S. Coast and Geodetic Survey
O. H. Tittmann, Superintendent
BASE MAP OF THE UNITED STATES
(Projected on intersecting cone)

Station connection without change of observers - - - - - - - -

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.



Routes of Geodetic Spirit Leveling
and
Positions of Gravity and Tide Stations
to June 1904

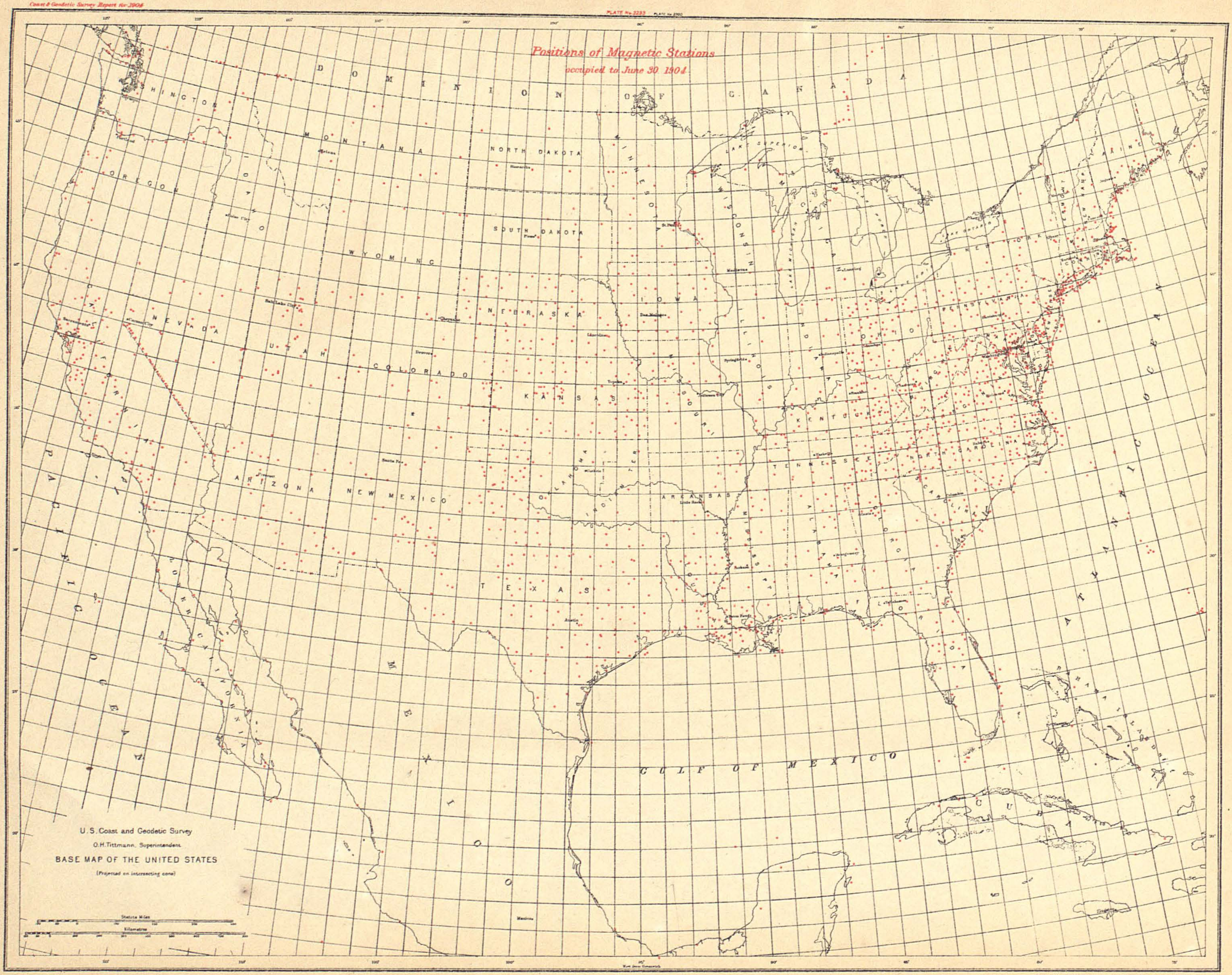
U. S. Coast and Geodetic Survey
O. H. Tittmann, Superintendent
BASE MAP OF THE UNITED STATES
(Projected on intersecting cone)

Gravity stations

The location of Tide Stations are shown thus;
Where series of Observations of 1 to 3 years
" " " " " 3 – 9 "
" " " " " 9 and more years over
The letter a affixed to the symbol indicates that daily predictions for that station are given in the Tide Tables.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

PLATE No. 2233 PLATE No. 2300



Positions of Magnetic Stations
occupied to June 30 1904

U. S. Coast and Geodetic Survey
O. H. Tittmann, Superintendent.
BASE MAP OF THE UNITED STATES
(Projected on intersecting cone)

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

APPENDIX 2

REPORT 1904

DETAILS OF OFFICE OPERATIONS.

CONTENTS.

DETAILS OF OFFICE OPERATIONS.

OFFICE OF THE ASSISTANT IN CHARGE.

ANDREW BRAID, *Assistant in Charge.*

The Assistant in Charge of the Office has direct supervision of the work of the different divisions of the Office.

The following persons were employed under his immediate direction:

Name.	Occupation.
George A. Fairfield	Clerk; July 1 to July 17.
A. B. Simons	Clerk.
E. B. Wills	Do.
Miss Kate Lawn	Do.
John S. Collins	Stenographer and typewriter.
David Parker	Watchman.
John W. Drum	Do.
J. A. McDowell	Do.
W. R. McLane	Messenger.
Attrell Richardson	Do.
William B. Little	Do.
John W. Hunter	Do.
Horace Dyer	Fireman.
C. H. Strother	Laborer.
Ransom Smart	Do.
William S. Pugh	Do.
Miss Virginia McGlincey	Do.
J. W. Brown	Do.
John H. Neal	Do.
William F. Evans	Extra laborer.
Josephine Reed	Do.

The Miscellaneous Section is a part of the immediate Office of the Assistant in Charge, and the manifold and arduous duties pertaining to it were performed by Messrs. H. C. Allen and C. W. Jones. The details of the work in this section are given under the heading "Miscellaneous Section" in this Appendix. The duties of the other members of the personnel mentioned above were of the usual routine character. Mr. George A. Fairfield died on July 17, 1903. A biographical notice of this officer is given under the head of Necrology.

The following extracts are taken from the report of the Assistant in Charge:

> I have the honor to submit the Annual Report of the Office for the fiscal year ended June 30, 1904, accompanied by the annual reports of the various divisions, namely: Computing Division, Division of Terrestrial Magnetism, Tidal Division, Drawing and Engraving Division, Chart Division, Instrument Division, Library and Archives Division, and Miscellaneous Section.

The Computing Division continued under the charge of Assistant J. F. Hayford, whose report gives in considerable detail a statement of the work accomplished during the year. The force of the Division, as heretofore, has been augmented from time to time as opportunity offered by the temporary detail of Assistants and Aids, and Deck Officers who were available between the field seasons.

Among the special works accomplished during the year the following may be mentioned:

1. The computation of the primary triangulation along the ninety-eighth meridian has made considerable progress.

2. The computation of precise leveling work has been kept up to date, or nearly so, continuously.

3. The reduction of the triangulation of California to the United States Standard Datum has made excellent progress, and is now nearly completed from the Mexican boundary to about latitude 37° in the vicinity of Monterey Bay. These computations were begun in August, 1902, and at the end of the last fiscal year were completed as far north as Point Conception.

4. The computations connected with the new computation of the form of the geoid have progressed steadily during the year. The revision of the general formulæ for the treatment of very large areas has been a slow process, but is now nearly completed. The topographic corrections to observed deflections of the vertical to take account of the topography for a radius of more than 4 000 kilometers around each station has been completed for about 180 astronomic stations. About 300 additional stations are now available for similar treatment.

5. The computations of determinations of gravity at the surface and at stations 1 200 to 4 600 feet, respectively, below the surface at the North Tamarack mine near Columbia, Mich., has been completed and a special report relative thereto has been prepared.

6. The computation of the tests made in March, April, and May of the transit micrometer fitted on one of our portable transits, and proposed to be used in telegraphic longitude work hereafter, have been completed and a report relative thereto submitted to the Superintendent.

The routine work of the Division has received, as usual, prompt attention. The demands upon the Division in this respect have been very great, both for the field parties of the Survey and for outside persons desiring special information, particularly in regard to geographic positions and descriptions of stations.

During the year the manuscript for two appendices entitled, respectively, "Precise Leveling in the United States, 1900–1903" and "Triangulation Southward along the Ninety-eighth Meridian in 1902" were completed and the proofs read in cooperation with the Editor. The proof of "Report of Geodetic Operations in the United States," which was presented to the International Geodetic Association, was also read.

Mr. Hayford commends highly the skill and efficiency of the various computers under his charge.

The Division of Terrestrial Magnetism continued under the charge of Assistant L. A. Bauer, who, as Inspector of Magnetic Work, is also charged with the supervision of the field parties engaged on magnetic work.

Much of his time while at the Office was necessarily occupied with his duties in the latter capacity, involving the planning of field work, preparation of estimates and instructions, testing instruments, and the preparation of the necessary reports, etc. The Cheltenham Observatory required his presence for one or two days each month. Mr. D. L. Hazard acted as chief of the Division during Mr. Bauer's absence, and had immediate charge of the Office computations throughout the year.

The routine work, correspondence, and the furnishing of magnetic information in response to numerous demands have received prompt attention.

The revision of the field magnetic computations has been kept nearly up to date; progress has also been made in the tabulation of the absolute observations at the various magnetic observatories; the results of the magnetic observations for the previous year were completed and submitted for publication in the Annual Report for 1903; the magnetic observations of the Bahama Expedition of the Baltimore Geographic Society were discussed and a report thereon submitted; a report was made on the magnetic survey of Louisiana, carried on under the joint auspices of the Coast and Geodetic Survey and the State Geological Survey; good progress was made in the tabulation of results at repeat stations, for use in future secular change discussions; and a discussion was made of magnetic observations at sea, etc.

Observations for standardizing various instruments were made as occasion required, and newly appointed magnetic observers received necessary instructions in the use of instruments and methods of computing results.

The Tidal Division continued, as heretofore, under the charge of Mr. L. P. Shidy, whose report gives the usual detailed information in regard to the work accomplished during the year, the tidal observations and data received from the field parties and from outside sources, and the information and data furnished to field parties and the public. Mr. R. A. Harris has continued the study of tidal phenomena, and has prepared an appendix on the subject of cotidal lines for the Superintendent's Annual Report, illustrated by cotidal maps for the world.

The Drawing and Engraving Division, continued under the charge of Assistant W. W. Duffield, whose report shows in detail the work accomplished by each of the five sections of the Division and gives other statistical information.

In the Engraving Section, 8 copper plates were completed, 5 were begun, and 20 remain unfinished; 19 copper plates were completed for new editions, 22 were begun and 17 others remain unfinished; also 4 heliogravure plates were completed ready for electrotyping, and 663 plates had corrections of more or less magnitude applied.

In the Drawing Section, under the immediate direction of Mr. E. H. Fowler until March 11 and subsequently under Mr. George L. Flower, the usual amount of work has been accomplished during the year.

Fourteen drawings have been completed for photolithographing or engraving and 10 others are in progress. In addition to the above 658 charts were revised, corrected, and verified for new editions or new prints. This number, however, in some cases includes the second and third revisions of the same chart. Fourteen topographic and 40 hydrographic projections for use of the Office or field parties and 13 projections were made on copper plates. Two hundred and ninety-one topographic and hydrographic sheets were inked, lettered, plotted, revised, and made ready for the approval of the Office.

A large number of illustrations for the Annual Report were prepared, and miscellaneous work of various kinds has received due attention. A large commercial map of the world prepared for the use of the honorable Secretary of Commerce and Labor, and a bromide copy of the same for the use of the President, were completed.

Considerable work in connection with the Alaskan boundary maps has also been done and the increasing work necessary for keeping up the Philippine charts, which in number are increasing rapidly, has added much detail work to the section.

The Drawing Section suffered a heavy loss by the death of two of its chief members, Mr. Edwin H. Fowler and Mr. Adolph Lindenkohl, the former on the 11th of March and the latter on June 22.

In the Printing Section, under the immediate direction of Mr. D. N. Hoover, the usual large amount of work has been accomplished, over 79 000 impressions having been printed from copper plate and 14 500 from stone. The new lithographic plant was not in operation until the second half of the fiscal year and some difficulty was experienced in having the proper adjustment made of the electric motive power, but it is now working very satisfactorily.

Sixteen new charts, 8 new editions of charts, and 13 new prints have been issued, a total of 37 charts, the editions averaging from 300 to 600 copies. The work done compares favorably with any we have had performed by contract. The contract work during the year amounted to 53 charts, of which 8 were new charts, 8 new editions of charts, and 37 were new prints.

In the Photograph Section a large amount of work was done and it was found necessary to detail an assistant to the photographer on account of the increasing demands upon the section. Mr. C. F. Blacklidge has been in immediate charge of the photograph section, as heretofore.

The Chart Division, composed of the Chart and Hydrographic sections, continued under the charge of Assistant Gershom Bradford, Inspector of Charts.

In the Chart Section, under the immediate direction of Miss L. A. Mapes, the work of coloring lights and buoys, the application of hand corrections to charts, from recent information, the general issue of charts, etc., to the public and to the Navy and other Departments, received due attention, as did also the voluminous correspondence relating thereto, and the keeping of the accounts of 190 chart agencies. The sales of charts during the year have been greater than for any previous year.

In the Hydrographic Section duties in connection with the preparation of the monthly Notice to Mariners, the verification of original hydrographic sheets and of charts and drawings, and the indicating of chart corrections have been promptly and efficiently performed.

Mr. Bradford has also prepared proof for a new edition of the Chart Catalogue, and during the absence of the Inspector of Hydrography and Topography, April 11 to June 20, performed the duties of that office.

The Instrument Division continued under the charge of Mr. E. G. Fischer, except during his absence in Europe, from July 1 to September 16, when he was relieved by Assistants William Eimbeck and J. B. Baylor, the former serving from July 1 to September 4, and the latter from September 5 to September 16.

The usual amount of work has been accomplished during the year, consisting of repairs of instruments, the construction of such new instruments as are not obtainable on the market, the issue of instruments, camp outfit, and general property to field parties, the keeping of the accounts relative to issue and receipt of instruments and general property and the miscellaneous correspondence relative thereto, etc.

Mr. Fischer's report gives in complete detail the work of each class accomplished during the year. Among the special items mentioned in his report are the construction of two vertical collimators, the remodeling of an electric tide indicator and an astronomical transit, the progress made in the construction of the new tide-predicting machine, the further use of aluminum alloys to obtain greater lightness in portable instruments, and the efforts and experiments made to secure the most suitable aluminum alloy for this purpose.

The preparation and shipment of the Coast and Geodetic Survey contribution to the St. Louis Exposition added largely to the regular labors of the Division.

The Library and Archives Division remained nominally under the charge of Mr. E. L. Burchard, who was actually engaged in the work of organizing the Library of the Department of Commerce and Labor, having been detailed for that purpose until December 30, when he resigned to accept a position in the Library of Congress. Since that date, and pending the appointment of a Librarian, Assistant William Eimbeck has performed the duties of Chief of the Division and has prepared and submitted its annual report.

This report gives the usual statistical information in regard to the acquisition of books, maps, periodicals, and charts, donated, purchased, or received in exchange, and the original topographic and hydrographic sheets and field records of every description received from field parties.

The Miscellaneous Section, under the immediate direction of Mr. H. C. Allen, has, as heretofore, attended to the ordering and distribution of supplies required for the Office, the keeping of the accounts relating thereto, the making of requisitions for printing and binding, the issue of stationery to field parties and office divisions, the custody and general domestic and foreign distribution of publications of the Survey (other than charts), and the keeping of the records relating thereto. The report is submitted in the usual statistical form. He was assisted by Mr. C. W. Jones.

The preparation of the Coast and Geodetic Survey exhibit for the St. Louis Exposition has already been mentioned under the head of Instrument Division, but it may be stated here that other divisions also contributed to the general results. The heaviest demands were, however, made upon the Instrument Division and the Drawing and Engraving Division, both of which were also required to detail members of their force to assist in the installation or to aid in the running of the exhibit. The details made up to the close of the fiscal year were as follows: D. N. Hoover, April 26 to May 18; G. W. Clarvoe, April 11 to May 14; C. J. Harlow and E. M. Kline, each from April 21 to June 30.

Computing Division.

Personnel.

Name.	Occupation.
J. F. Hayford	Chief of Division.
A. L. Baldwin	Computer.
Miss S. Beall	Do.
W. H. Dennis	Do.
M. H. Doolittle	Do.
C. R. Duvall	Do.
Miss L. J. Harvie	Do.
H. C. Mitchell	Do.
R. M. Packard	Computer; Feb. 12 to June 30.
Miss L. Pike	Computer.
J. H. Millsaps	Writer; July 1 to July 8.
W. S. Stackpole	Writer; Sept. 14 to Dec. 11.
F. A. Techtman	Writer; Jan. 11 to June 30.
J. V. S. Fisher	Computer (temporary).

Temporarily detailed.

Assistants.

F. D. Granger.
John Nelson.
G. W. Ferguson.
W. H. Burger.

Aids.

J. B. Miller.
B. D. Barker.
F. T. Lawton.
B. C. Lillis.
H. M. Trueblood.
W. T. Carpenter.
F. H. Sewall.
T. T. Fitch.
C. E. Morford.
G. C. Baldwin.
D. R. Jewell.
E. Mueller.
R. L. Libby.
E. H. Pagenhart.
J. W. Maupin.
W. A. Kemper.
L. J. Arbuckle.
G. T. Thompson.
W. G. Emory.
W. R. Johnson.

Deck Officers.

R. McD. Moser.
J. W. Yates.
N. Heck.
J. H. Wood.
P. A. Staples.

The work of furnishing information to the field parties of the Survey and to persons outside the Survey occupied about 10 per cent of the time of the regular force of the Division.

The manuscript of Appendix No. 3, Report for 1903, "Precise Leveling in the United States, 1900–1903" (623 pp.), and of Appendix No. 4, Report for 1903, "Triangulation Southward along the Ninety-eighth Meridian in 1902" (120 pp.), was completed and the proof was read.

The computation of the precise leveling work was kept up to date and the results were prepared for publication. Considerable progress was made in computing the triangulation along the ninety-eighth meridian. The recomputation and reduction of the triangulation in California, from the southern boundary to Monterey Bay, to the United States Standard Datum was nearly completed and much of the resulting material was prepared for publication. The computations connected with a new investigation of the form of the geoid made steady progress during the year. The reduction of the observations made to determine the force of gravity at the North Tamarack copper mine, near Calumet, Mich., at stations on the surface and at points 1 200 and 4 600 feet below the surface was completed, and also the discussion of the tests made with a transit micrometer fitted to a portable instrument.

Mr. A. L. Baldwin acted as Chief of the Division October 22 to 24, and Mr. Duvall July 17 to August 12. Mr. Baldwin was absent on special duty under the State Department in connection with the Alaskan boundary for about one month in July and August.

A considerable number of the aids mentioned above were appointed during the year, and were assigned to the Division for instruction in the methods of making computations before being sent on field duty. In addition to the persons named in the personnel, various typewriters were assigned to the Division from time to time for short periods to assist in handling the routine work.

The average effective force of the Division engaged in making computations during the year was 12, in addition to the chief, and varied from 8 in September to 15 in March.

In his report Mr. Hayford makes special mention of the work of the members of the Division, as follows:

> Much of Mr. Baldwin's work required the use of rare good judgment and it was done in an excellent manner.
>
> Mr. Doolittle rendered very valuable service in solving the difficult theoretical questions encountered in the revision of the formulæ concerned in the determination of the figure of the earth.
>
> Miss Pike had charge of the computations relating to precise levels, the preparation of manuscript for the printer, and the proof reading done in the Division. Her work was handled with rare and increasing skill.
>
> Miss Harvie assisted in revising the fundamental formulæ involved in the determination of the figure of the earth from astronomic observations scattered irregularly over a large area. She showed great ability and efficiency in verifying the theory involved and in the orignal investigations necessary to correct certain inaccuracies in the published theory and formulæ, which have apparently been accepted heretofore without question.
>
> Mr. Mitchell spent much of his time in the computation of corrections to observed deflections of the vertical to take account of the known features of the topography within 4 000 kilometers of each astronomic station. The rapid progress made in this work was due to his skill and good judgment.

Division of Terrestrial Magnetism.

Personnel.

Name.	Occupation.
L. A. Bauer	Chief of Division.
D. L. Hazard	Computer; absent Mar. 4 to May 27.
C. J. Houston	Computer.
Miss J. E. Haslup	Writer.
Temporarily detailed.	
Jose Vano Reyes	Aid; July 1 to June 30.
L. B. Smith	Magnetic observer; July 1 to 3 and July 11 to 16.
R. E. Nyswander	Magnetic observer; July 9 to Aug. 29 and Jan. 15 to Feb. 29.
G. B. Pegram	Magnetic observer; July 1 to 3.
W. B. Keeling	Magnetic observer; Aug. 1 to 5.
J. E. Burbank	Magnetic observer; Dec. 21 to Jan. 4 and Mar. 24 to June 30.
W. M. Hill	Magnetic observer; Apr. 11 to June 6.
P. H. Dike	Magnetic observer; Mar. 15 to Apr. 9.
J. W. Green	Magnetic observer; June 15 to 30.
S. G. Townshend, jr	Magnetic observer; June 28 to 30.
T. L. Jenkins	Watch officer; Aug. 1 to Oct. 31.
P. A. Staples	Aid; Oct. 15 to Nov. 11.

The revision of the field computation of the current magnetic determinations was kept as nearly as practicable up to date, and the results for the fiscal year are published as Appendix 3. Progress was made in the tabulation of the observations for absolute values at the magnetic observatories. The results from magnetic observations, July 1, 1902, to June 30, 1903, were prepared for publication as an appendix to the Annual Report for 1903, and the proof of this appendix was read. The computation of the magnetic observations made by the Bahama expedition of the Baltimore Geographical Society was completed and a discussion of the results was furnished to the society.

A report was made on the magnetic survey of Louisiana, made in cooperation with the State Geological Survey. This involved a new discussion of the secular change of the magnetic declination in the State and in the adjoining States. The results were reduced to January 1, 1904, and an isomagnetic chart for that date was prepared.

The discussion of the record obtained at the Cheltenham Observatory with the Eschenhagen magnetograph for a month was made and it shows in a most satisfactory manner the characteristic features of the lunar diurnal variation of the declination and horizontal intensity. In connection with the discussion of the magnetic observations at sea on board the vessels of the Survey a summary of all available results of magnetic work at sea was prepared. Good progress was made in the work of tabulating results of observations at stations where the observations have been repeated from time to time for use in the discussion of the secular change. Observations were made as required to standardize various magnetic instruments and the recent additions to the force of magnetic observers were instructed in the use of the instruments and in the methods of computing. Most of the men assigned to the Division for short periods required instruction and consequently did not aid materially in advancing the progress of the regular work of the Division.

In his report the Chief of the Division testifies to the faithfulness, industry, and devotion to duty shown by the members of the Division.

The duties assigned to Assistant Bauer as Inspector of Magnetic Work occupied much of his time in the office and required his presence in the field from time to time for short periods. In his absence the duties of Chief of Division were performed by Mr. D. L. Hazard, Computer.

Tidal Division.

Personnel.

Name.	Occupation.
L. P. Shidy	Chief of Division.
R. A. Harris	Computer.
Artemas Martin	Do.
Miss C. C. Barnum	Do.
Paul Schureman	Do.
W. D. Lambert	Computer; Mar. 5 to June 30.
M. J. Waul	Computer; July 1 to 20.
Miss A. G. Reville	Clerk.
Miss E. V. Campbell	Writer.
L. A. Cole	Do.
Temporarily detailed.	
T. T. Fitch	Computer; Aug. 26 to Oct. 22.
W. K. West	Computer; Oct. 23 to Nov. 30.
G. F. Thompson	Computer; Dec. 9 to Mar. 4.
C. E. Forrest	Writer; Feb. 15 to May 8.
B. W. Payne	Writer; May 9 to June 20.

Harmonic analyses were computed for 11 stations, with an aggregate length of 2 years and 4 months. Nonharmonic reductions were made for 272 stations, with a total length of 58 years. The plane of reference for reduction of soundings was determined for 57 stations. Tide notes were prepared for 370 stations upon 100 charts and 43 original hydrographic sheets. Tidal information was furnished to the field parties, and in response to requests from individuals not connected with the Survey in 286 instances, involving the preparation of 451 descriptions of bench marks, tidal data for 705 stations, and current data for 86 stations. About 18 years of self-registering tide gauge records, from 37 stations, were tabulated as high and low waters, and also as hourly heights of the sea. There were received, examined, and registered in this Division an aggregate of about 20 years of record from self-registering gauges at 38 stations, together with about 7 years of record from box and staff gauges. Tidal records from outside sources were received as follows:

(1) The Navy Department loaned to the Survey about 4½ years of records from self-registering tide gauges at 23 stations, and 1½ years of staff observations at 20 stations, or a total of about 6 years of record at 43 stations. These stations were distributed as follows: 18 in Cuba, 2 in Panama, 7 in Mexico, 8 in the Philippines, 2 in China, and 1 each in Haiti, Porto Rico, Venezuela, Nicaragua, Midway Island, and Guam Island.

(2) About a year of self-registering gauge record has been received from Nassau, New Providence Island, Bahamas. The gauge and paper were furnished by the Survey, but the station was established and maintained by the Bahama Expedition of the Baltimore Geographical Society, under the direction of Mr. George B. Shattuck.

(3) From various publications received in the library the following tidal information has been obtained: About 5½ years of record at 64 European ports, 3½ years at 14 Arctic stations, 1 year at Cape Horn, and nearly 2 years at 16 scattered stations, chiefly oceanic islands, making a total of about 12 years of record at 95 stations.

Copies of the predicted tides for Wellington and Port Russell, New Zealand, with tidal differences for 80 ports, were prepared and furnished in response to a request from the Secretary of the Marine Department of New Zealand.

Cotidal maps of the world were constructed and are published in Appendix 5 to this report.

The tide tables for the year 1905 were prepared for printing and the proof of the first 80 pages was read before June 30. A current diagram for Georges Bank, Gulf of Maine, and twilight tables were added to the volume.

In closing his report Mr. Shidy states his pleasure in testifying to the general industry, faithfulness, and efficiency of the members of the Division.

Drawing and Engraving Division.

Personnel.

Name.	Occupation.
W. W. Duffield	Chief of Division.
E. Meads	Clerk.
Edwin H. Fowler*	Chief draftsman; July 1 to Mar. 11.
G. L. Flower	Acting chief draftsman; Mar. 12 to June 30.
Harlow Bacon	Draftsman.
P. B. Castles	Draftsman; Mar. 29 to June 30.
Chas. H. Deetz	Draftsman.
F. C. Donn	Do.
E. P. Ellis	Do.
P. Von Erichson	Do.
H. S. Gamble	Draftsman; Oct. 12 to June 30.
C. M. Hahn	Draftsman; July 1 to July 17.
E. W. Hart	Draftsman; Aug. 26 to Oct. 15.
F. M. Hart	Draftsman; July 2 to June 30.
D. M. Hildreth	Draftsman.
W. H. Huntington	Draftsman; Dec. 22 to June 30.
A. Lindenkohl*	Draftsman; July 1 to June 22.
H. Lindenkohl	Draftsman.
J. W. McGuire	Do.
S. B. Maize	Do.
H. S. Ober	Draftsman; Oct. 26 to Dec. 20.
H. L. Simons	Draftsman.
E. J. Sommer	Do.
W. H. Davis	Engraver.
H. E. Franke	Do.
R. H. Ford	Do.
P. H. Geddes	Do.
F. Geoghegan	Do.
Geo. Hergesheimer	Do.
W. H. Holmes	Do.

* Died. See Necrology.

Drawing and Engraving Division—Continued.

Personnel—Continued.

Name.	Occupation.
H. M. Knight	Engraver.
Wm. Mackenzie	Do.
W. F. Peabody	Do.
A. H. Sefton	Do.
E. H. Sipe	Do.
H. L. Thompson	Do.
J. W. Thompson	Do.
W. A. Van Doren	Do.
Theo. Wasserbach	Do.
F. G. Wurdemann	Do.
D. N. Hoover	Foreman of printing.
C. M. Hahn	Lithographer; July 18 to June 30.
F. Hahn	Lithographer; Aug. 31 to June 30.
E. F. Campbell	Plate printer.
R. J. Fondren	Do.
Eberhard Fordan	Do.
C. J. Harlow	Do.
C. J. Locraft	Do.
R. V. H. Jama	Printer's helper.
W. W. Kirby	Do.
E. M. Kline	Do.
W. B. Mehler	Printer's helper; July 1 to Jan. 30
E. B. Tiller	Printer's helper; Nov. 9 to June 30
V. E. Torney	Printer's helper
C. F. Blacklidge	Photographer and electrotyper
L. P. Keyser	Assistant photographer
F. G. Robinette	Assistant electrotyper; July 20 to June 30
H. Thomas	Assistant electrotyper; Mar. 9 to Apr. 25
Roy Thomas	Assistant electrotyper; July 1 to Feb. 17
W. B. Little	Messenger; Aug. 10 to June 30
George Newman	Messenger
J. M. Brown	Laborer; July 1 to Mar. 28
C. W. Hawkins	Laborer; absent Nov. 30 to Mar. 28
H. Murray	Laborer
Frank Thomas	Do.
W. Hammer	Extra laborer; Aug. 17 to June 30
J. M. Kline, jr	Extra laborer; May 21 to June 30
Temporarily detailed.	
J. B. Boutelle	Assistant; June 6 to June 10
J. C. Landers	Aid; June 20 to June 30

The Division is divided into five sections—the Drawing, the Engraving, the Printing, the Photographing, and the Electrotyping sections. Each section executes the work indicated by its title, and the combined result is shown by the charts published and issued by the Survey.

During the year 353 requests for information were received and answered in the Division. These involved the measurement of areas and shore line and distances between various points, the preparation of tracings from original topographic and hydrographic sheets, copies of old and canceled charts, and the construction of special maps.

Drawing Section.

During the year the following drawings were completed for photolithographing or engraving:

Chart No.	Title.	Scale.
(*)	Chilkat River Valley	1-80 000
(†)	Lake Borgne and Mississippi Sound	1-80 000
193	Lakes Pontchartrain and Maurepas	1-80 000
251	Buzzards Bay, Mass	1-20 000
4108	Hanapepe Bay, Hawaii	1-5 000
5533	San Pablo Bay, Cal	1-40 000
6023	Suislaw River, Oreg	1-10 000
6112	Tillamook Bay, Oreg	1-20 000
8304	Icy Strait and Cross Sound	1-80 000
8513	Controller Bay, Alaska	1-100 000
8520	Prince William Sound	1-80 000
8841	Sannak Islands and Ikatan Peninsula	Varying.
9192	Harbor and anchorages in southwestern Alaska	Varying.

* Prepared for State Department. † Prepared for the States of Louisiana and Mississippi.

In addition to the foregoing, 658 charts were revised (including second and third editions of the same chart), corrected, and verified for new editions or new prints. Fourteen projections for topographic sheets and 44 hydrographic sheets were constructed for the use of field parties or the Office. Two hundred and ninety-one topographic and hydrographic sheets were inked, plotted, revised, or made ready for the approval of the Office. The illustrations required for the Annual Report of the Superintendent for the year 1903 were completed and the usual number for the Report for 1904 were prepared.

A very large commercial map of the world (colored) was prepared for the use of the Secretary of Commerce and Labor, and a smaller one was completed for the use of the President.

A large amount of work was done for the Department of State in preparing maps relating to the Alaska boundary for publication.

The work in the Drawing Section continued under the immediate direction of Mr. E. H. Fowler, Chief Draftsman, until March 11, 1904, when he died. (See "Necrology" for biographical notice.) On March 12, Assistant G. L. Flower was assigned to duty as Acting Chief Draftsman, and as such performed the duties of that position during the remainder of the year.

On June 22, 1904, the senior draftsman, Mr. Adolph Lindenkohl, died. (See "Necrology" for biographical notice.)

The Chief of the Division in his report commends the efficient service rendered by all the members of the section.

Engraving Section.

The following original plates were completed:

Chart No.	Title.	Scale.
471a	Tortugas Harbor and Approaches	1-40 000
908	San Juan Harbor	1-10 000
916	Port Mulas and Approaches	1-10 000
920	Porto Rico	Mercator.
922	Ensenada Honda	1-10 000
927	Ponce Harbor	1-10 000
928	Guayanilla Harbor	1-20 000
929	Guanica Harbor	1-10 000

The following plates were corrected for new editions of charts:

Chart No.	Title.	Scale.
113	Cuttyhunk to Block Island	1-80 000
170	Key West to Rebecca Shoals	1-80 000
171	Rebecca Shoals to Dry Tortugas	1-80 000
177	Tampa Bay	1-80 000
183	Apalachicola Bay to Cape San Blas	1-80 000
246	Boston Harbor	1-20 000
250	Eastern Entrance to Nantucket Sound	1-40 000
273	Throgs Neck to Randall Island	1-10 000
337	Boston Harbor	1-40 000
343	Nantucket Harbor	1-10 000
376	Delaware and Chesapeake bays	1-400 000
436	St. Helena Sound	1-40 000
469	Key West Harbor	1-50 000
477	Entrance to Tampa Bay	1-20 000
542	St. Simon Sound, Brunswick Harbor, and Turtle River	1-20 000
913	Great Harbor, Culebra Island	1-6 500
5800	Cape Mendocino to Point St. George	1-200 000
6140	Columbia River, entrance to Upper Astoria	1-40 000
6145	Columbia River, Fales Landing to Portland	1-40 000

The following new bassos were completed:

Chart No.	Title.	Scale.
107	Seguin Island to Kennebunkport	1-80 000
165	Hillsboro Inlet to Fowey Rocks	1-80 000
194	Missississi River, Passes to Grand Prairie	1-80 000
204	Galveston Bay	1-80 000
292	Mount Desert Island	1-40 000
310	West Penobscot Bay	1-40 000

Recapitulation.

Recapitulation of the work done in the Engraving Section.

	Number.
Original plates commenced	5
Original plates completed	8
Original plates unfinished	20
New editions commenced	22
New editions completed	19
New editions unfinished	17
New bassos commenced	11
New bassos completed	6
New bassos unfinished	5
Plates corrected for printing	663

Printing Section.

	Number.
Impressions made for the Chart Section (plates)	73 077
Impressions made for the Chart Section (stones)	11 997
Impressions made for the Office from stones	1 198
Impressions made for proofs from plates	4 439
Impressions made for proofs from stones	1 743
Impressions made for standards from plates	151
Impressions made for transfers, lithograph (plates)	273
Impressions made for transfers, lithograph (stones)	26
Impressions made for transfers, Drawing Section (plates)	121
Impressions made for transfers, Drawing Section (stones)	39
Impressions made on bond from plates	1 217
Impressions made on bond from stones	221
Number of impressions (plate)	79 278
Number of impressions (stones)	14 524
Total number of impressions	93 802

Of the charts printed for the Chart Section, 1 355, namely, Nos. 369, 380 and 381, required two impressions, and 717 District of Columbia charts required four impressions, leaving 69 571 charts delivered to the Chart Section.

In addition to the number of charts printed from plates in the Printing Section, the following have been published by photolithography and sent to the Chart Section for distribution:

New charts.

Chart No.	Title.	Scale.
(*)	Alaska Boundary Award	1-1 200 000
(*)	Chilcat River Valley	1-80 000
(*)	....do	1-80 000
(†)	International Metric System	
251	Head of Buzzards Bay, Mass	1-20 000
901	West Coast of Porto Rico	1-100 000
914	Culebra Island and Approaches	1-20 000
4108	Hanapepe Bay, Hawaii	1-5 000
4241	Albay Gulf and Lagonoy Gulf	1-100 000
4344	Port Galera and Varadero Bay	1-10 000
4426	Southwest Coast of Leyte	1-100 000
4450	San Juanico Strait and Tacloban Harbor	1-50 000
4451	Approaches to Catbalogan	1-50 000
4454	Harbors on Burias and Ticao islands and Ragay Gulf	Varying.
4718	Panay, Negros, and Cebu	Mercator.
5531	San Francisco Bay, Southern Part	1-50 000
6023	Suislaw River, Oreg	1-20 000
6112	Tillamook Bay, Oreg	1-20 000
6443	Port Orchard, Wash	1-20 000
8105	Behm Canal, Alaska	Varying.
8304	Icy Strait and Cross Sound	1-80 000
8513	Controller Bay, Alaska	1-100 000
8841	Sannak Islands and Ikatan Peninsula	Varying.
9192	Harbors and Anchorages in Southwest Alaska	Varying.
9382	Golofnin Bay, Alaska	1-40 000

New editions.

Chart No.	Title.	Scale.
79	Chesapeake Bay	1-200 000
113	Cuttyhunk to Block Island	1-80 000
248	Boston Inner Harbor	1-10 000
422	New River Inlet	1-10 000
904	Virgin Passage and Vieques Sound	1-10 000
914	Culebra Island and Approaches	1-20 000
915	Target Bay and Approaches	1-10 000
920	Porto Rico	Mercator.
4100	Hawaiian Islands	Mercator.
4711	Northern Part of Mindoro	Mercator.
4714	Mindoro and Adjacent Coasts	Mercator.
5534	Suisun Bay, Cal	1-40 000
6003	Umpqua River Entrance	1-20 000
8520	Prince William Sound	1-80 000
9100	Aleutian Islands	1-1 200 000

* Printed for State Department.

† Printed for Bureau of Standards.

New prints.

Chart No.	Title.	Scale.
109	Boston Bay and Approaches	1-80 000
113	Cuttyhunk to Block Island	1-80 000
244	Salem Harbor and Approaches	1-20 000
257	Cornfield Point to Duck Island	1-10 000
264	Milford to Bridgeport	1-10 000
266	Fairfield to Georges Rock	1-10 000
268	Sheffield Island to Westcott Cove	1-10 000
316a	Kennebec River, Abagadassett Point to Court-House Point	1-10 000
369[8]	Hudson River, 53d Street to Fort Washington	1-10 000
376	Delaware and Chesapeake bays	1-400 000
517	Sabine Pass and Lake	1-40 000
549	Approaches to Baltimore Harbor	1-40 000
577	Fernandina to Jacksonville	1-40 000
920	Porto Rico	Mercator.
1000	Cape Sable to Cape Hatteras	Mercator.
1001	Chesapeake Bay to Jupiter Inlet	Mercator.
1007	Gulf of Mexico	Mercator.
3035a	City of Washington, D. C	1-15 840
3089	Olympia, Wash., to Mount St. Elias	1-1 200 000
4104	Maalaea Bay, Mauai, Hawaii	1-10 000
4231	Port of Manila	1-10 000
4244	Balayan Anchorage	1-5 000
4247	Barigayos Inlet	1-5 000
4249	Port Mariveles	1-15 000
4253	Tabaco Bay Entrance	1-30 000
4256	San Bernardino Straits and Approaches	1-100 000
4444	Ormoc Bay, P. I	1-30 000
4447	Cebu Harbor and Approaches	1-30 000
4448	Iloilo Straits and Harbor	1-50 000
4642	Anchorages off North Coast of Mindanao Island	Varying.
5002	San Diego to Point St. George	Mercator.
5052	San Francisco to Cape Flattery	Mercator.
5532	San Francisco Entrance	1-40 000
5534	Suisun Bay, Cal	1-40 000
5832	Humboldt Bay, Cal	1-30 000
5984	Coos Bay, Oreg	1-20 000
6195	Grays Harbor, Wash	1-40 000
6400	Seacoast and Interior Waters of Washington	1-300 000
7000	Cape Flattery to Dixon Entrance	1-1 200 000
8176	Shaken Strait, Alaska	1-20 000
8283	Peril Strait, Hooniah Sound to Chatham Strait	1-40 000
8500	Icy Cape to Semidi Islands	1-1 200 000
8881	Islands and Harbors off Alaska Peninsula	Varying.
9008	Dutch Harbor, Alaska	1-10 000

Of the above lithographs, the following were printed in the Printing Section:

New charts.

Chart No.	Title.	Scale.
(*)	Alaska Boundary Award	1–1 200 000
(*)	Alaska Boundary Award	1–1 200 000
(*)	Chilkat River Valley	1–80 000
(†)	Lake Borgne and Mississippi Sound	1–80 000
251	Head of Buzzards Bay, Mass	1–20 000
4108	Hanapepe Bay, Hawaii	1–5 000
4344	Port Galera and Varadero Bay	1–10 000
4426	Southwest Coast of Leyte	1–100 000
4451	Approaches to Catbalogan	1–50 000
6023	Suislaw River, Oreg	1–20 000
6112	Tillamook Bay, Oreg	1–20 000
8304	Icy Strait and Cross Sound	1–80 000
8513	Controller Bay, Alaska	1–100 000
8841	Sannak Island and Ikatan Peninsula	Varying.
9192	Harbors and Anchorages in Southwestern Alaska	Varying.

New editions.

Chart No.	Title.	Scale.
(†)	Lake Borgne and Mississippi Sound	1–80 000
422	New River Inlet	1–10 000
920	Porto Rico	Mercator.
4100	Hawaiian Islands	Mercator.
5534	Suisun Bay, Cal	1–40 000
6003	Umpqua River Entrance	1–20 000
8520	Prince William Sound	1–80 000
9100	Aleutian Islands	1–1 200 000

New prints.

Chart No.	Title.	Scale.
369^{8}	Hudson River, 53d Street to Fort Washington	1–10 000
549	Approaches to Baltimore Harbor	1–40 000
920	Porto Rico	Mercator.
4231	Port of Manila	1–10 000
4244	Balayan Anchorage	1–5 000
4247	Darigayos Inlet	1–5 000
4249	Port Mariveles	1–15 000
4444	Ormoc Bay, P. I	1–30 000
4642	Anchorages off North Coast of Mindanao Island	Varying.
6195	Grays Harbor, Wash	1–40 000
6400	Seacoast and Interior Waters of Washington	1–300 000
8176	Shakan Strait, Alaska	1–20 000
9008	Dutch Harbor, Alaska	1–10 000

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* Printed for State Department.

† Printed for the States of Louisiana and Mississippi.

Recapitulation of lithograph work.

	Number.
New charts published	24
New editions published	16
New prints published	50
Total	90

Of the above the following were published in the Printing Section:

	Number.
New charts	16
New editions	8
New prints	13
Total	37

The total number of impressions printed from copper plates was somewhat less than during the previous year, but the number of charts (including new charts, new editions, and new prints) published by photolithography during the year was 50 per cent greater.

Proofs on bond paper were made of all new charts, of new editions, and of all charts that were extensively corrected.

A new lithographic press was installed before the close of the calendar year and worked successfully during the remainder of the year. The prints from this press already compare favorably with those obtained by public contract. The Chief of the Division commends Mr. D. N. Hoover for his successful management of this branch of his work.

Photographic Section.

	Number.
Glass negatives made	695
Paper negatives made	106
Velox prints made	1 860
Vandyke prints made	99
Bromide prints made	218
Blue prints made	770
Silver prints made	98
Lantern slides made	53
Negatives developed	353
Prints mounted	306

The output of the Photograph Section was larger than that of the previous fiscal year, which was much larger than usual.

Electrotyping Section.

	Number.
Kilograms of copper deposited	1 294
Square decimeters on which deposited	7 917
Alto plates made	35
Basso plates made	43

Chart Division.

Personnel.

Name.	Occupation.
Gershom Bradford	Inspector of Charts and Chief of Division.
Miss L. A. Mapes	Chief of Chart Section.
J. T. Watkins	Draftsman.
E. H. Wyvill	Chart corrector.
H. R. Garland	Do.
J. B. Quinlan	Clerk; July 1 to Oct. 14.
A. B. Simons, jr	Buoy colorist.
Frank Sanford	Buoy colorist; July 8 to June 30.
P. R. Terry	Buoy colorist; Aug. 4 to June 30.
Miss C. Willenbucher	Buoy colorist; July 1 to July 16, Aug. 21 to Sept. 14, Nov. 3 to Jan. 15, and Apr. 25 to May 8.
F. M. Hart	Buoy colorist; July 3 to July 17.
W. A. Naghten	Buoy colorist; July 16 to Aug. 3.
Miss Bert Williams	Buoy colorist; Sept. 1 to Sept. 12.
E. F. Springer	Buoy colorist; Sept. 15 to Nov. 3.
C. E. Forrest	Buoy colorist; May 9 to June 30.
Archie Upperman	Map mounter.
J. H. Mason	Messenger.
Temporarily detailed.	
Swepson Earle	Draftsman; July 1 to Sept. 3.
W. B. Proctor	Watch officer; Nov. 10 to Nov. 30.

The Chief of Division supervised the work of the two sections in which this Division is divided, and gave personal attention to the inspection of the work on new charts and on new editions of charts in its various stages of progress. Progress was made in the preparation of a new edition of the Chart Catalogue, and Mr. Bradford served as Acting Inspector of Hydrography and Topography from April 11 to June 20.

Chart Section.

In this section all letters relating to the sale of charts, tide tables, and coast pilots were prepared; the accounts with the sales agents were kept; the buoys on the charts were colored, and other routine work was done. Editions of 20 new charts, 18 printed by photolithography and 2 from copper plates were issued during the year. Forty new editions, 19 printed from copper plates and 21 by photolithography, were also issued. Charts were received as follows:

	Number.
From Drawing and Engraving Division, prints from plates	69 571
From Drawing and Engraving Division, prints from stone	11 297
From lithographers	19 551
From Manila suboffice	2 400
	102819

The following table contains a list of charts which were prepared, published, and issued from the suboffice of the Survey at Manila, P. I., copies of which were received for issue at the Washington Office during the year:

No. 4261. Legaspi Anchorage and West Part of Albay Gulf, P. I.
No. 4449. Port Palapag and Laguan Bay, P. I.
No. 4541. Anchorages on the Coast of Jolo Island, P. I.
No. 4542. Jolo Island and Vicinity, P. I.
No. 4343. Puerto Princesa, Paragua Island, P. I.
No. 4263. Port San Vincente and Vicinity, P. I.
No. 4264. Salomague Harbor, P. I.
No. 4262. Cagayan River, P. I.

Charts were issued as follows:

	Number.
Sales agents	39 566
Sales at the Office	1 681
Congressional account	2 429
Hydrographic Office, United States Navy	23 098
Light-House Board	2 893
Coast and Geodetic Survey Office	6 232
Coast and Geodetic Survey suboffice	4 955
Executive Departments	5 016
Foreign governments	607
Libraries	117
Miscellaneous	495
Total	87 089

A comparison of the total issue of charts for the fiscal year with the issue in previous years shows the total to be 32 per cent larger than the average and 19 per cent less than during the previous fiscal year, this falling off being accounted for in the decrease in the demand from the Navy Department and others to whom the charts are furnished free of cost.

The Chief of Division particularly commends the efficient service rendered by Miss Mapes and Mr. Garland.

Hydrographic Section.

The work of indicating the chart corrections and preparing the monthly Notice to Mariners was efficiently performed by Mr. Wyvill, and he also performed a portion of the duties of the Chief of Division during the time Mr. Bradford had additional duty assigned him, so that the current work was kept up to date.

Mr. Watkins, assisted by Mr. Earle and Mr. Proctor during their temporary detail to the Division, did the other work assigned to this section, as shown in the following table:

32 charts reviewed for publication.
234 charts, corrections on Office Standards verified.
107 charts, corrections on proofs verified.
13 hydrographic sheets verified; 40 025 angles; 115 292 soundings; 3 000 miles of sounding lines; 240 square miles area covered.
1 hydrographic sheet verified and inked; 8 403 angles; 34 346 soundings; 846 miles of sounding lines; 90 square miles area covered.
1 hydrographic sheet plotted; 1 493 angles; 4 050 soundings; 96 miles of sounding lines; 5 square miles area covered.

Instrument Division.

Personnel.

Name.	Occupation.
E. G. Fischer	Chief of Division.
W. C. Maupin	Clerk.
Otto Storm	Instrument maker.
C. Jacomini	Instrument maker; July 1 to Aug. 23.
M. Lauxman	Instrument maker.
W. R. Whitman	Instrument maker; July 1 to Sept. 2.
H. G. Fischer	Instrument maker.
J. D. Morrison	Do.
C. F. Zimmisch	Do.
L. F. Senior	Instrument maker; Nov. 4 to June 30.
J. R. Aufente	Nov. 4 to June 30.
H. O. French	Carpenter.
G. W. Clarvoe	Do.
C. N. Darnall	Do.
Jere Hawkins	Messenger.

In this Division an account was kept of all instruments and general property owned by the Survey or purchased during the year; 1 165 instruments of various classes were put in order, adjusted, and sent to the field. Minor repairs were made to the Office buildings and furniture, and considerable progress was made in constructing a new tide-predicting machine. A suitable alloy of aluminum for use in construction of instruments not being on the market, Mr. George T. Ennis, of Washington, D. C., made a number of experiments, at the suggestion of Mr. Fischer, and succeeded in obtaining an alloy combining a low degree of density with great rigidity and toughness, and this alloy is being used in constructing all portions of instruments for which it is adapted. A tape-stretching apparatus and two 50-meter tapes made for the Brazilian Government were inspected and accepted at the request of that Government.

Two vertical collimators were constructed and sent to the field. An electric tide indicator was purchased, modified, and installed in the hall of the Maritime Association of New York. In connection with the tide gauge at Philadelphia, a tide staff was constructed with a device which is very useful in places where it is difficult to read the staff correctly on account of its position or where the water is rough. A glass tube was mounted on the face of the staff, with the lower end cemented in one end of a U-shaped brass tubular fitting with a valve at the other end. When the staff is lowered into position, resting by a shoulder on a fixed point, the valve can be opened to admit the water into the tube unaffected by wave action. By closing the valve the staff can be removed and the height of the water in the glass tube accurately read.

From a description and illustration of the Repsold & Sons' transit micrometer, one was made with certain modifications adapted for use on the portable transits in use in the Survey, which has proven satisfactory in every respect when tested by numerous observers by observations made in the small observatory at the Office.

From a design furnished by Assistant J. F. Pratt, an instrument called a dip sector was constructed to enable the mariner to determine with accuracy the actual dip on board a vessel whenever observations are made with a sextant, and this instrument is in use at present.

A number of instruments were selected and purchased for use in surveying and marking the boundary between the United States and Canada west of the Rocky Mountains, and the Alaska boundary.

In his report Mr. Fischer commends the conduct and efficiency of the employees in the Division.

Library and Archives.

Personnel.

Name.	Occupation.
Edward L. Burchard	Librarian; July 1 to Dec. 31.
Wm. Eimbeck	Acting Librarian; Dec. 7 to June 30.
A. F. Zust	Writer.
J. P. Maupin	Writer; July 1 to July 23.
Miss Blanche Love	Writer; Nov. 23 to June 30.
Mrs. M. A. Grant	Writer; July 1 to Dec. 19.
Miss M. L. Handlan	Writer; July 1 to Oct. 5.
L. H. White	Writer; July 1 to Aug. 10.
J. R. Johnson	Writer; Sept. 1 to June 30.
W. H. Butler	Messenger.

The routine work in the library was kept up to date. The records of the observations made in the field were indexed as they were received. The detail of the librarian to duty in the library of the Department of Commerce and Labor was continued from July 1 to December 31, when he resigned from the Service. During his absence Mr. Zust performed the duties of librarian until December 7, when Assistant Eimbeck was assigned to the Division as Acting Librarian, and continued in this position during the remainder of the year.

Accessions.

Items.	Purchased.	Donated.	Exchanged.	Total.
Books	167	24	112	303
Pamphlets	7	126	111	244
Serials	85	60	704	849
Maps and charts	131	431	2 310	2 872

Issued for temporary use.

	Number.
Books and pamphlets	2 020
Serials	604
Records	2 843
Original sheets	2 943
Maps and charts	3 516

The following list shows the original records received:

Subject.	Volumes.	Cahiers.	Sheets or rolls.
Astronomy	15	2	93
Geodesy	165	124	....
Hydrography	380	41	46
Hypsometry	130	24	....
Magnetism	....	516	....
Tides	122	6	119
Topography	....	....	....
Totals	812	713	258
Photographic prints	....	....	71
Photographic negatives	....	....	57

Miscellaneous Section.

Personnel.

Name.	Occupation.
H. C. Allen	Clerk and Chief of Section.
C. W. Jones	Clerk.
Thomas McGoines	Messenger.

The increased amount of work done in this section, reported in the previous fiscal year, was maintained during the year without increase in the personnel by means of better working facilities and some slight changes in the methods of work. The publications received were issued promptly and all current business was kept up to date. A card record was kept of the receipt and issue of all stationery, which renders it possible to see at a glance the total issue from month to month and for the year. This record has already been of value in estimating the amounts required for future use.

The following publications were received from the Public Printer:

	Number.
Report of the Superintendent of the Coast and Geodetic Survey showing the progress of the work from July 1, 1902, to June 30, 1903 (1 032 pp.)	2 000
Appendices to Report for 1903 as separates:	
No. 3. Precise Leveling in the United States, 1900–1903, with a readjustment of the level net and resulting elevations (623 pp.)	1 500
No. 4. Triangulation southward along the ninety-eighth Meridian in 1902 (120 pp.)	500
No. 5. Results of Magnetic Observations made by the Coast and Geodetic Survey between July 1, 1902, and June 30, 1903 (74 pp.)	1 000
No. 6. Channel and Harbor Sweep (6 pp.)	200
United States Magnetic Declination Tables and isogonic Charts for 1902 and principal facts relating to the earth's magnetism (second edition, 405 pp.)	1 500
Report on geodetic operations in the United States to the Fourteenth General Conference of the International Geodetic Association (28 pp.)	500
United States Coast Pilot, Atlantic Coast, Parts I–II, from the St. Croix River to Cape Ann (second edition, 243 pp.)	2 500

	Number.
United States Coast Pilot, Atlantic Coast, Part III, from Cape Ann to Point Judith (second edition, 199 pp.)	2 491
United States Coast Pilot, Pacific Coast, California, Oregon and, Washington	2 512
Supplement to United States Coast Pilot, Atlantic Coast, Part IV (second edition, 10 pp.)	500
Supplement to United States Coast Pilot, Atlantic Coast, Part VII (second edition, 18 pp.)	600
Supplement to United States Coast Pilot, Atlantic Coast, Part VIII (second edition, 26 pp.)	500
Supplement to United States Coast Pilot, Pacific Coast, Alaska, Part I (fourth edition, 14 pp.)	500
Coast Pilot Notes on Warren Channel and Davidson Inlet, Alaska (4 pp.)	500
Catalogue of Charts, 1903 (174 pp.)	1 972
Tide Tables, Atlantic Coast, 1904 (reprint, 177 pp.)	1 024
Tide Tables, Pacific Coast, 1904 (reprint, 161 pp.)	7 504
Leaflets for distribution at the Louisiana Purchase Exposition at St. Louis, Mo	70 000
Notices to Mariners, Nos. 299 to 312	62 115

The following publications were received from the Manila suboffice:

Sailing Directions, P. I., Section I, second edition	200
Sailing Directions, P. I., Section II, second edition	200
Sailing Directions, P. I., Section VI	198
Sailing Directions, P. I., Section VII	200
Notices to Mariners, P. I., Nos. 6 to 12 of 1903 and Nos. 1 to 5 of 1904	1 203

The following publications were issued by the Office:

Annual Reports covering the years 1851 to 1903	2 567
Appendices to Annual Reports	8 735
Bulletins, Nos. 1 to 41	620
Special Publications, Nos. 1 to 7	263
United States Declination Tables and isogonic Charts for 1902, and principal facts relating to the earth's magnetism (second edition)	669
Report on Geodetic Operations in the United States to the Fourteenth General Conference of the International Geodetic Association	255
United States Coast Pilots, Atlantic Coast	2 410
United States Coast Pilots, Pacific Coast	585
Supplements to United States Coast Pilots, Atlantic Coast	2 376
Supplements to United States Coast Pilots, Pacific Coast	220
Coast Pilot Notes on Warren Channel and Davidson Inlet, Alaska	298
List and Catalogue of Publications	211
Catalogue of Charts 1899–1903	1 724
Leaflets for distribution at Louisiana Purchase Exposition at St. Louis, Mo	43 070
Tide Tables, complete, for years 1898–1904	1 729
Tide Tables, Atlantic Coast (reprint), for years 1890 to 1904	1 267
Tide Tables, Pacific Coast (reprint), for years 1890 to 1904	7 733
Notices to Mariners, Nos. 299 to 312	59 919
Notices to Mariners, Philippine Islands, Nos. 1 to 12 of 1903 and Nos. 1 to 5 of 1904	271
Sailing Directions, Philippine Islands, Sections I to VII	345

APPENDIX 3.

REPORT 1904.

RESULTS OF MAGNETIC OBSERVATIONS MADE BY THE COAST AND GEODETIC SURVEY BETWEEN JULY 1, 1903, AND JUNE 30, 1904.

By L. A. BAUER,
Inspector of Magnetic Work and Chief of Division of
Terrestrial Magnetism,
Assistant, Coast and Geodetic Survey.

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ILLUSTRATIONS.

RESULTS OF MAGNETIC OBSERVATIONS MADE BY THE COAST AND GEODETIC SURVEY BETWEEN JULY 1, 1903, AND JUNE 30, 1904.

By L. A. Bauer,
Inspector of Magnetic Work and Chief of Division Terrestrial Magnetism, Assistant, Coast and Geodetic Survey.

INTRODUCTION.

The present publication contains the results of the magnetic observations made on land and at sea by members of the Coast and Geodetic Survey in the prosecution of the magnetic survey of the United States and outlying territories during the period July 1, 1903, to June 30, 1904,* including some results obtained at sea during the period January 1, 1903, to June 30, 1903.

The detailed results of the observations made at the five magnetic observatories,† at present in operation, will be contained in a separate publication now in preparation.

The new feature in the present paper is the inclusion of the results thus far obtained at sea by the Coast and Geodetic Survey vessels in the course of their regular surveying duties.

OBSERVATIONS ON LAND AND THEIR DISTRIBUTION.

In continuance of the general plan of the magnetic survey, as published in Appendix 10, Report for 1889, the work as mapped out provided for stations averaging about 25 to 30 miles distant from one another. Such regions were selected for the year just ended where data were most needed and where recourse could be had to an observatory for the necessary reductions.

A special examination of the locally disturbed area in the vicinity of the local magnetic pole on Douglas Island, Alaska, opposite Sheep Creek, disclosed by the observa-

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*For previous results, see United States Magnetic Declination Tables and Isogonic Charts for 1902, and Principal Facts Relating to the Earth's Magnetism, by L. A. Bauer. Washington, Government Printing Office, 1902. A second edition of this special publication of the Coast and Geodetic Survey was issued in 1903.

Magnetic Dip and Intensity Observations, January, 1897, to June 30, 1902, by D. L. Hazard, with preface by L. A. Bauer. Appendix 6, Report for 1902. Washington, Government Printing Office, 1903.

Results of Magnetic Observations made by the Coast and Geodetic Survey between July 1, 1902, and June 30, 1903. Appendix 5, Report for 1903. Washington, Government Printing Office, 1904.

†The five observatories are situated at Cheltenham (Maryland); Baldwin (Kansas); Sitka (Alaska); near Honolulu (Hawaii); and Vieques Island (Porto Rico).

For description of observatories, see Appendix 5, Report for 1902.

tions of the Inspector of Magnetic Work in 1900, was made during July and August by Mr. S. J. Barnett, Magnetic Observer. The results of this work at 45 stations in the vicinity of Juneau and Douglas Island will be found in the tables under Alaska.

The magnetic survey of Louisiana, under the charge of Mr. L. B. Smith, Magnetic Observer, was completed this year with the effective and zealous co-operation of the Director of the State Experiment Station, Dr. W. C. Stubbs, and of the State Geologist, Dr. G. D. Harris. The latter secured, with an outfit loaned him by the Coast and Geodetic Survey, a successful series of observations at 20 stations.

The results of this detailed work in Louisiana have been extremely interesting. First, it has been clearly demonstrated that there was a reversal in the expected course of the secular variation which took place about 1898. Past observations made in the vicinity of New Orleans show that the magnetic declination, which is east, reached a maximum amount of about 8¾° near the year 1830. It then began to diminish, and, in accordance with the laws of the secular variation pertaining north and east of the agonic line, i. e., in the Atlantic States, where west declination is known to be increasing at present on the average about three minutes per year, a turning point was under ordinary conditions not to be expected before some time about the middle of the present century. Instead, however, it was reached about 1898, so that east declination reached a minimum value of 5½° in about seven decades after a maximum value—the shortest interval between a maximum and a minimum value thus far revealed anywhere on the earth. East declination is now increasing in Louisiana at the rate of about one and one-half to two minutes per annum. The total change between maximum and minimum at New Orleans, as above stated, was about 3¼°.

The early reversal produced a larger annual change between the years 1860 and 1870—about six minutes—than has generally been experienced in the United States, although elsewhere, as, for example, England, such large annual changes and even greater ones occur. Values of the magnetic declination secured four to five decades ago, if referred to the present time with the aid of secular change values as were expected, in accordance with the experience in other parts of the United States, would be in error one-third to one-half degree.

Observations in other States near Louisiana show that this change in the course of the secular variation is manifesting itself in greater or less degree, according to locality, likewise in these States.

How permanent the present change may be, i. e., whether it will continue for but a comparatively short period, so that before long another reversal may be expected, after which east declination will begin to diminish once more, can not be stated at present.

The magnetic survey of Louisiana has revealed other most interesting features, as shown by the lines of equal magnetic declination, dip, and horizontal intensity, drawn in conformity with the observations.

There were noticed marked relations with well-known physiographic features. The curvatures and bendings of the lines of equal magnetic declination appear to conform with courses of principal streams and shore lines of certain bodies of water. Also a marked difference manifested itself in the general direction of these lines in the middle of the southern part of the State, just where there is a dividing line between the newer and older geological formations.

It is especially interesting that the irregularities in the distribution of the earth's magnetism, as exhibited by the three sets of lines, occur chiefly in the regions of the alluvial deposits brought down by the Mississippi River. Owing to these irregularities the compass needle is deflected from the direction it would ordinarily have assumed by amounts varying from about 0°.1 to 0°.5. They are not local disturbances of such amount, which ordinary instruments would readily reveal, but they are of such a magnitude as only approved instruments and methods would indisputably expose. This point can not be emphasized too strongly for the sake of geologists who undertake to discover relations between magnetic disturbances and geological formations, employing crude instruments, and using imperfect methods.

Quite likely these irregularities are to be referred to small local deposits of iron ore brought down from the upper states by the Mississippi River.

The table below gives a summary of the results on land which appear in the present publication. With but few exceptions they were obtained during the fiscal year July 1, 1903, to June 30, 1904.

Summary of results on land.

State	Number of localities	Number of stations	Old localities reoccupied	Declinations observed	Dips observed	Intensities observed
Alabama	8	8	1	8	8	8
Alaska	40	64	5	63	51	39
California	6	6	3	6	7	6
Delaware	1	1	0	1	0	0
District of Columbia	2	2	1	6	7	10
Georgia	2	2	0	2	2	2
Guam	6	6	0	9	1	0
Hawaii	6	7	4	7	1	1
Kansas	5	5	2	10	10	7
Kentucky	37	38	2	38	37	37
Louisiana	50	51	5	56	51	51
Maine	2	2	2	2	2	2
Maryland	3	4	3	11	18	10
Massachusetts	1	1	1	1	1	1
Missouri	13	13	1	13	12	13
Montana	7	7	2	6	7	7
New Jersey	27	30	11	34	29	33
North Carolina	1	1	1	1	1	1
Ohio	40	41	1	44	43	43
Philippines *	30	30	3	30	12	12
Porto Rico	7	7	5	11	11	11
South Carolina	14	16	4	18	20	18
Tennessee	32	32	2	33	33	33
Washington	3	3	2	4	5	4
Foreign countries	5	7	3	6	5	5
Total	348	384	64	420	374	354

It is thus seen that results are given for 384 stations, of which about one-sixth were in old localities, for determining the secular change. The stations were located principally in Alaska, Kentucky, Louisiana, Missouri, New Jersey, Ohio, South Carolina, and Tennessee, the remainder being distributed over 16 other States and Territories and two foreign countries.

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* Includes results in previous years not heretofore published.

The stations in the Bahamas were secured by co-operation with the expedition of the Baltimore Geographical Society under the leadership of Dr. G. B. Shattuck. All of the observations were made by Dr. O. L. Fassig with instruments loaned by this Survey.

Upon the completion of five years' work since the formation of the Division of Terrestrial Magnetism in 1899, it may not be amiss to take a retrospective glance of the work thus far accomplished.

Observations embracing in general the three magnetic elements—declination, dip, and intensity—have been made at 1 636 stations, of which about one-eighth are "repeat stations"—i. e. points at which observations had been made previously by the Coast and Geodetic Survey.

The average distance between the stations is generally about 25 miles, although in regions of pronounced local disturbances the distances are much less. The area covered is about one-third of the entire area of the United States and its outlying possessions, or over one-third of the area of the whole of Europe. About a dozen States have been practically completed except for special investigations and "repeat" observations for ascertaining the secular change, and some others are nearing completion. The results of this entire work have been reduced at the Office and either have been published already or appear in the present paper.

Observatory work has been carried on at five stations already enumerated, the length and completeness of the series obtained at each varying from one to four years, according to time of establishment of the observatory. The results are in process of preparation for publication.

Magnetic work at sea on the vessels of the Survey was begun in February, 1903, and various results obtained, which will be found in the present publication.

In addition, a variety of investigations of a miscellaneous nature, relating to instruments, constants, local disturbances, etc., have been made.

While the work achieved during these past five years is gratifying, it is hoped that the next five years may witness even greater progress, as the greater part of the time-consuming initial work involved in the procuring and testing of outfits, establishment of base stations, training of observers, etc., has been accomplished.

OBSERVATIONS AT SEA AND THEIR DISTRIBUTION.

The results obtained at sea must be secured incidentally to the regular surveying duties of the vessels of the Coast and Geodetic Survey. It is, therefore, not possible to make rapid progress, nor can the accuracy attained be such as would be reached by vessels especially designed for magnetic work and continuously engaged therein. The problem is to secure the best possible results under the conditions involved.

All of the ships are provided with the usual standard liquid compass and azimuth circle of the Ritchie or Negus pattern, sufficiently accurate for purposes of navigation, but not especially designed for magnetic work. It was the belief, however, that with proper methods and skilled observers and favorable conditions of sea and weather nearly the same degree of accuracy could be obtained in determining the magnetic declination at sea with such compasses as hitherto has been reached with special standard compasses of the liquid or of the dry form. This belief has been strengthened by the results thus far accumulated and compared with those published by other nations. If the dry compass is to be regarded as superior to the liquid compass for scientific work, as some believe, then its possibilities may not yet have been fully determined.

The question of prime consideration, of course, is the elimination of the ship's own magnetism, and the problem of doing this completely depends upon the construction of the vessel and her equipment. All of the vessels thus far engaged in the work are steamers, the *Blake*, *Endeavor*, *Hydrographer*, *McArthur*, and *Patterson* being of wooden construction and the *Bache* and *Gedney* of composite construction.

The instructions issued to the commanding officers of the ships, *for observations to determine the magnetic declination*, call for complete swings (by steaming in a circle) of the vessel, on 16 equidistant headings, forward and back, whenever the conditions permitted, observing the magnetic and solar bearing of the ship's head on each course, holding the vessel long enough on each heading to secure good results, and spending, on the average, about two hours in all for both swings. Special attention is paid to the disposition of all articles likely to affect the compass. The constant *A* depending chiefly, for the cases considered, on the placement of the lubber's line of the compass in the central fore and aft line, is controlled by observations in port or waters where the magnetic declination is known from accurate shore observations, the endeavor being made to select places free of local disturbance. In accordance with the directions, these check observations are made at ports of departure and of destination, both on the outward and the return trips and elsewhere, if opportunity permits.

Not only has the same ship been swung at the same place at various times and under different conditions, but also various vessels were swung in the same locality with different degrees of compensation of compass. In each case the vessel was swung by steaming in a circle. The results thus derived warrant the statement that when the conditions approximate those near port, a value of the magnetic declination can be obtained the absolute error of which need not exceed 5 to 10 minutes of arc. For the results obtained out at sea, using the methods described, it is believed that under favorable conditions an absolute accuracy of about 10 to 15 minutes may be secured.

When time did not permit complete swings over 16 points, 8 were permitted, and the accuracy reached from this number was nearly the same as with the larger number. Some results have been obtained also from observations on and near the course—e. g., on course, one point starboard, two points port, and back again on course. However, the inaccuracy of such values is, in general, too great to warrant their individual publication. When results in the same locality have been accumulated as derived under various conditions and from different vessels, their mean may have sufficient value for utilization.

The general experience has been that it is better over the deep waters of the sea, where local irregularities need not be feared, to observe less often, but secure each time a value dependent on a complete swing, with port helm and with starboard helm, on 8 to 16 equidistant headings, under as favorable conditions regarding sea, weather, and time of day as possible.

For securing results of magnetic dip and intensity of magnetic force three vessels have been supplied with a Lloyd-Creak dip circle, known as the L. C. dip circle, and the accompanying gimbal stand, with which outfit dip and intensity observations are secured at sea.

The sea work was begun first on the *Blake*, on a trip from Baltimore to Porto Rico in February, 1903. Observations were made daily by the commanding officer and the writer under varying conditions and trying various methods. During the early part of 1904 similar instruments were mounted on the *Bache*, working in Atlantic waters, and on the *Patterson*, operating on the Pacific coast. At the time of writing two additional instruments have been received to be supplied to other vessels of the Survey. So that, although the magnetic work at sea is merely incidental to the other duties of the vessels, all arrangements have been made now to procure a steady accumulation of data with all accuracy attainable under the conditions imposed both in the Atlantic and in the Pacific oceans. Such desultory work can not, however, satisfy the actual demands. It is most gratifying, therefore, that the Carnegie Institution of Washington, through its Department of International Research in Terrestrial Magnetism, proposes to co-operate in securing systematic magnetic surveys of oceanic areas.

The following summary includes only the results derived from complete swings of the vessels:

Summary of results at sea.

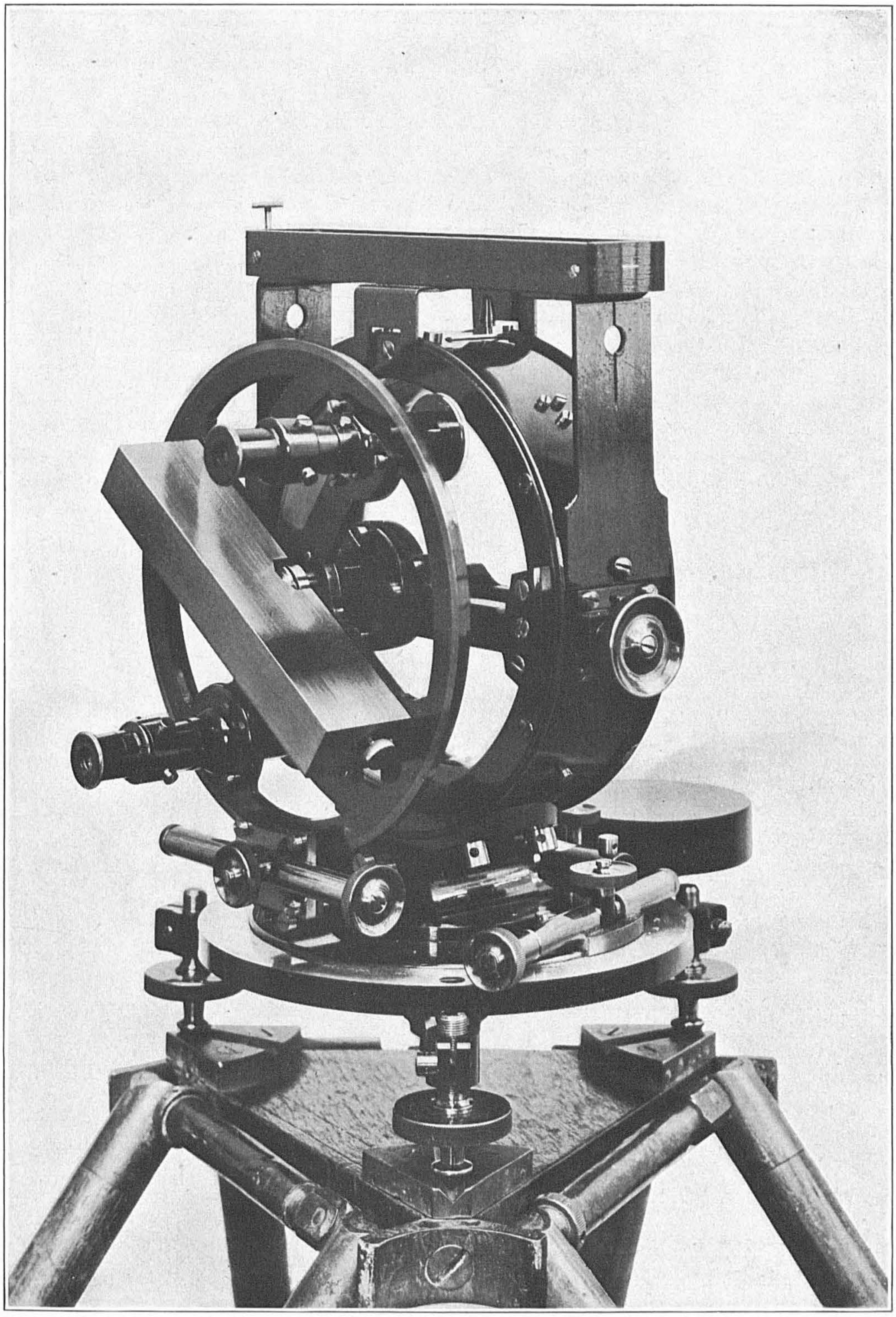
General region	Declinations observed	Dips observed	Intensities observed
Atlantic Ocean	45	30	28
Pacific Ocean	7	4	4
Total	52	34	32

The Lloyd-Creak dip circle replaces the old Fox instrument, used for about seven decades in making dip and intensity observations at sea, and represents a great improvement upon it. Briefly described, the new instrument applies the method of Lloyd's needles for the purpose of determining the absolute dip and the relative total intensity at sea. The improvements were devised by Capt. Ettrick Creak before his recent retirement from the Superintendency of the Compass Department of the British Admiralty, and the expenses of the initial experiments were defrayed by the British Admiralty. Such instruments were used by the recent Antarctic expeditions.

Illustration No. 1 shows this instrument mounted on a tripod for shore observations. The counterpoise shown attached to the base is only used for balancing the instrument when mounted on board ship on the gimbal stand. The illustration also shows a compass attachment, added by this Survey for land work, as described later.

The back circle and other parts of the Fox circle are in this instrument omitted and replaced by thick ground glass. There is, therefore, only the one graduated vertical circle for reading the inclination of the needle, the circle being graduated to every 10 minutes. At the request of this Survey the recent instruments have the vertical circle numbered every two degrees instead of every five as formerly, counting continuously from zero to 360° instead of from zero to 90° for each quadrant.

The microscopes for reading the position of the needle are faced with ivory and contain a single central thread, the microscope being turned until the thread is set on



LLOYD-CREAK DIP CIRCLE, MOUNTED FOR OBSERVATIONS ON LAND.

the point of the needle, whereupon the degrees and minutes (by estimation into tenths of a ten-minute space) are read directly upon the circle. It is not absolutely necessary, however, to set the thread directly on the point of the needle, but instead, the reading can be taken by noting the position of the point directly on the circle; in the deflection observations of the intensity determinations, however, in order to secure perpendicularity of the two needles to one another, it is essential to set the thread on the point of the suspended needle.

The great improvement over the Fox circle consists in the construction of the needles and removal of the upper halves of the jewels in which the pivots of the needle work, so as to permit making observations in all of the positions employed for securing absolute results on land and the ready removal and replacing of the needle. The dip needles can, therefore, have their polarities reversed for elimination of error due to eccentricity of center of gravity, just as for land work. A lifter is provided and an ivory scraper, to be used in rubbing or slightly tapping the vertical brass point shown on the top of the instrument (below the compass attachment). With this ivory scraper, sufficient vibration is imparted to the pivots of the suspended needle to overcome the friction between them and the sides of the jewels, so that the needle is made to drop down to the lowest point.

The horizontal circle is so numbered that when the instrument is mounted on the gimbal stand previously placed with its lubber's line in the vertical plane passing through the central fore-and-aft line, the arrow on the vernier shall be at zero. If, then, the ship is heading to the magnetic north and the circle is set at zero, the plane of suspension of the needle will be in the magnetic meridian. So that from the course, as shown by the standard compass, with deviation corrections applied, if necessary, the instrument can readily be placed with sufficient accuracy in the magnetic meridian without resorting to the magnetic prime vertical method.

In the recent instruments constructed, as requested by this Survey, the horizontal circle was graduated continuously from 0° to 360° in the direction of counting azimuths (S. W. N. E.) instead of the usual quadrantal (0°—90°) graduation. This was done especially to facilitate the determination of the declination on land with the aid of the above-mentioned compass attachment.

The brass shield shown at right angles to the microscopes is for the purpose of protecting the deflecting needle from injury to the pivots and changes of temperature during intensity observations.

The gimbal stand is solidly constructed of brass, the upper part consisting of two gimbal rings of which the inner one has three radiating grooves for receiving the foot screws of the dip circle; the brass balancing weight is adjustable in height by a screw cut in the rod passing through it, so that the period can be regulated to suit the conditions. These gimbal rings, in the recent stands, move on knife-edges. For readily placing the gimbal stand in the required position on deck, a lubber's line is cut across the outer fixed ring encircling the gimbal rings.

When this lubber's line has been placed in the vertical plane passing through the central fore-and-aft line of the ship, the stand is firmly bolted down to the deck. To overcome the ship's vibration somewhat, a solid sheet of rubber about three-fourths inch thick was put under the base of the stand in each case. The stand was furthermore surrounded by a brass railing, not touching the stand, against which the observer could lean while observing. (See illustration No. 2.)

For shore observations a special nonmagnetic tripod is provided. As stated, for securing also declination results, a compass attachment has been added with which observations are made, as later described.

GENERAL METHODS OF OBSERVING.

LAND WORK.

The same general method has been followed as described in the previous publications. Observers regularly and continuously engaged in magnetic work are supplied with a complete magnetic outfit, consisting of theodolite-magnetometer, dip circle, half-second pocket chronometer, small accessories, and an observing tent, whereas those who are expected to get magnetic results incidental to other work; e. g., geodetic or astronomic work, are supplied with more or less complete outfits according to circumstances. Where only declination results can be secured under the conditions involved, a compass declinometer is supplied; but to those who can attempt more, a dip circle with compass attachment is furnished, with which compact outfit, knowing the azimuth of some mark from triangulation or other source, the declination, dip, and total intensity (Lloyd's method) can be obtained with a very fair degree of accuracy. It has been demonstrated that with care and a good instrument, the results derived from this dip-circle combination instrument will not be much below in accuracy those derived from the more complete outfits.

In all instances scrupulous care is taken to secure standardizations and control of instrumental constants of all outfits as often as possible during the season's work. Comparisons are secured also not only at the magnetic observatories, but likewise in the field, under the actual local conditions—a matter of importance when observations are distributed over as large an area as here concerned.

SEA AND SHORE WORK.

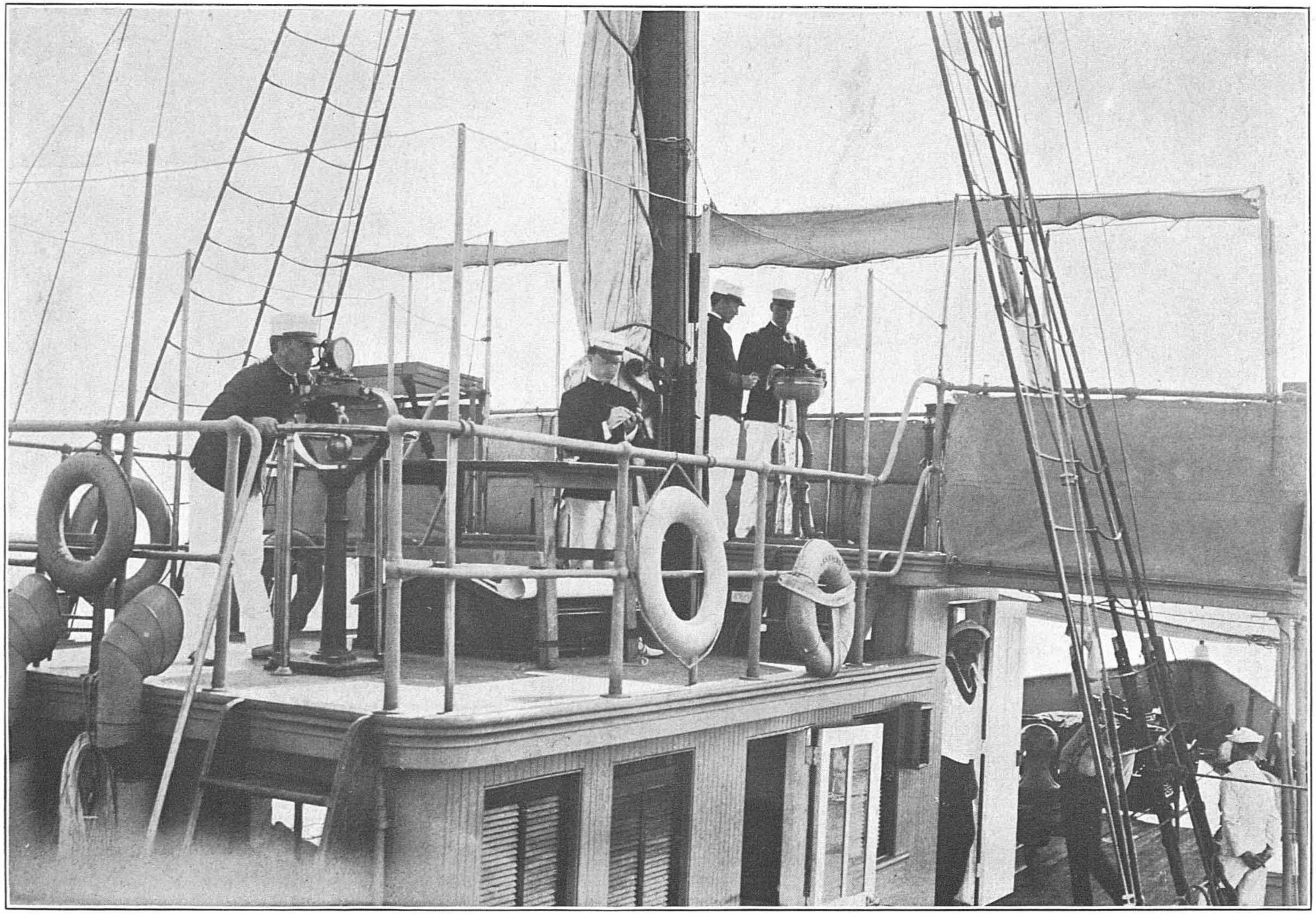
For the determination of the deviations of the standard compass and the magnetic declination, the ship, as has already been stated fully, is swung forward and back through the complete circle, steadying her on each of 16 or 8 equidistant headings. (See previous sections.)

The observations made near port yield values of the constant A and an analysis of the various swings furnish the coefficients B, C, D, and E. Knowing A and swinging completely over equidistant headings, the declination will be the mean compass error with the constant correction, A, applied.

The magnetic dip and intensity are obtained on board with the Lloyd-Creak dip circle described in a previous section; this instrument, mounted on a gimbal stand, is placed on the upper deck of the vessel at the most suitable spot, and not far from the standard compass.

The dip observations can be made with the needles 1 and 2 provided for this purpose, in the same manner and nearly with the same facility as with the instruments for land work. The only difference is that the ivory scraper must be continuously used to

No. 2.



MAGNETIC OBSERVATIONS AT SEA.

cause needle to settle on proper bearing surface of jewels and a reading, owing to the large arc through which the needle swings on account of the ship's motion, must be quickly estimated (not attempting, of course, to get minutes), and the extremes of the arc must be read and recorded instead of the mean position. If the observations be extended over the same time as on land, 45 to 60 minutes, the errors due to the various motions of the ship are, apparently, effectually eliminated. From the comparative observations made by the commanding officer of the *Blake* (Assistant R. L. Faris) and the writer on the trip to Porto Rico, the conclusion was reached that the relative accuracy attainable is about 5′. The range in the results, the observations having been so arranged that the mean time of observation and position of ship was the same for both observers, rarely exceeded 10′. This statement is borne out by subsequent results derived from complete swings and it would appear as though under favorable conditions and in a wooden ship, for which the deviation coefficients can be readily and safely controlled, the absolute accuracy may likewise be of about the same order (5′). This statement even applies to the dip obtained with needle No. 3 from the deflection observations involved in getting total intensity as described below. Since this needle can not have its polarity reversed, the dip derived from it requires the application of the correction due to eccentricity of center of gravity of needle—a correction which it has been found can be quite well controlled.

The relative total intensity is obtained by Lloyd's method, which involves, first, the determination of the angle of dip with a loaded needle (designated No. 4), and second, a determination of the angle through which another needle (No. 3) is deflected by the loaded needle, when the latter is placed at right angles to it in the place provided between the reading microscopes and protected by the brass shield.

Let W=total intensity, I=the dip, u_1=the angle of deflection, η=the dip with loaded needle and $u=I-\eta$=the angle through which the loaded needle is turned from its normal position by the load, then $W=C\sqrt{\cos\eta \operatorname{cosec} u_1 \operatorname{cosec} u}$, in which C is a constant determined as frequently as possible by similar observations at stations where W is known from standard magnetometer and dip observations. (See Appendix 8, Report for 1881, p. 24.)

As the determination of total intensity by this method is *relative*, it is necessary to avoid as far as possible any change in the magnetism of the two needles 3 and 4. Their polarities are therefore never reversed, and they are guarded from close proximity to disturbing influences and to the bar magnets when these are used for reversing the polarity of the regular dip needles.

Since a complete determination of dip and relative intensity on each of 16 headings of the forward and back swings would consume too much time, the following scheme of observations was provisionally adopted as the result of the experimental work on the *Blake*. This scheme has been found exceedingly satisfactory in all of the subsequent work and no change appears warranted at present.

(1) Observe deflections alone while swinging ship in one direction, and dip with loaded needle alone while ship is swinging in the reverse direction. Besides the total intensity derivable from the combination of these observations, a value of dip also results from the deflection observations, since the suspended needle is deflected first in one direction and then in the other from its normal position.

(2) On each heading observations are made in only one position of circle and needle, so as not to require more than 3 to 5 minutes. In the deflections the position for the first four headings will be Circle East, needle face East; for the next four, Circle West, circle face West; for the third four, Circle West, needle face East; and for last four headings, Circle East, needle face West. The position of circle and needle in making observations of dip with loaded needle will be the same as for the corresponding heading in the deflection observations.

(3) As the gimbal stand is set so that the zero of the horizontal circle corresponds to the ship's head, the dip circle may be placed in the magnetic meridian with sufficient accuracy by means of the ship's head by standard compass, applying the deviation correction if large enough to warrant it.

(4) As the motion of the ship will, in general, make it impossible to reduce the swing of the needle to as small an arc as is usual on land, the circle readings for both extremes of a swing are read and recorded in each case.

(5) For each position of the circle two readings are taken of each end of the needle.

(6) The time of beginning and ending of observations for each group of four headings and the corresponding temperature is recorded, also facts relating to weather, sea, etc. The programme outlined above can be carried out in about the same time as requisite for the compass observations which are made simultaneously by an independent observer.

The successful determination of declination, dip, and intensity at sea requires, first, that observations should be made with the dip circle at a base station on shore at the beginning and end of the cruise, to determine the relative intensity constant for the particular weight used at sea and the correction to the dip as derived from the deflection observations; and second, that the ship be swung at the beginning and end of the cruise (and if possible in the highest and lowest latitude reached) at a place near shore where the declination, dip, and intensity are known with reasonable accuracy from shore observations, in order to determine the deviations of the standard compass and of dip and intensity at the dip circle position. As the compass deviations are, in general, not the same at the dip circle position as indicated by the standard compass, especially if the latter is compensated, it is desirable at the beginning and end of a cruise to steady the ship successively on each of 16 equidistant headings by means of the standard compass and determine the magnetic prime vertical by means of the dip circle. These observations combined with known deviations of the standard compass will give the compass deviations at the dip circle position and complete the data necessary for an analysis of the ship's magnetism.

The present indications are that with the method above described, swinging ship completely forward and back, the total intensity has been determined within about 1 part in 300.

For shore observations the declination is determined (if the ship has no magnetometer) with the compass attachment alluded to above. The general scheme of observing is as follows: The observations are made preferably under a tent, or certainly in a spot sheltered from wind. After the compass has been mounted on the dip circle and the instrument leveled, and adjusted if necessary, shift the weight on the south end of the needle so that the latter will lie horizontal, and see that the center of the agate rests on the supporting pivot; then clamp the needle and point on the mark through the azimuth sights with vertical circle right, passing the eye up and down the slit to make sure that the mark has been accurately pointed upon. Read the vernier of the horizontal circle and record. Then turn the instrument 180° in azimuth, the vertical circle now being to the left, and again point on the mark and read the horizontal circle. Next, turn the instrument until the needle points approximately magnetic north and south, release the needle, and, with aid of tangent screw, turn the instrument until the north end of the needle exactly cuts the zero of the graduated arc of the compass, using a pocket magnifying lens, and holding the eye directly over the needle to avoid parallax. Before making the final setting, disturb the needle slightly with a bit of steel—as for example, a pocket knife or adjusting pin, being careful to remove it to a safe distance afterwards before needle comes to rest. Then quickly set the south end of the needle before it comes to rest at the zero of its arc and read and record both readings and the time of observation. Next, disturb the needle slightly and repeat the pointings in the reverse order—that is, first south end and then north end. In a similar manner make four readings with the north end of the needle pointing 5° east of zero, or the south end 5° west of zero; then four readings with the north end 5° west of zero or the south end 5° east of zero, and finally, four more with the ends pointing at zero. Record the time of ending, clamp the needle, and again make two pointings on the mark, as at beginning. If the compass box contains no impurity affecting the needle and the pivot is in good condition, the mean of the second and third set of four readings will correspond practically with the mean of the first and last four. When impurities or imperfections were thus detected they were removed.

The difference between the readings on the mark and the magnet gives the magnetic azimuth of the mark, and knowing the true azimuth from other sources (triangulation or astronomic observations) the declination is found.

A correction must be applied which depends partly on the relative position of the vertical plane of the sights and the vertical plane passing through the opposite zeros of the graduated arcs of the compass box and partly on the relative position of magnetic axis of the needle and a line passing through the ends of the needle. The error due to the first source may be regarded as constant, whereas that due to the latter source is variable, depending upon the fluctuations of the magnetic axis within the blade of the needle. However, repeated tests have shown that with a fairly thin, slender, vertical blade and a good initial magnetization of the needle, any variations to be ascribed to fluctuations of magnetic axis are on the order of the error of observation, so that the total correction may be regarded as a constant, *provided proper care is bestowed upon the compass.* The value of this constant is controlled whenever a station is reached where the absolute declination is known from some reliable source.

The experience has been that with proper care the declination can be secured with this simple arrangement, using above method, correct within 2′, and that it can certainly be obtained as accurately as with the compass declinometer, which has a needle constructed so as to be reversible on the pivot.

If desired, and in regions where the magnetic prime vertical method is not sufficiently accurate, this compass attachment can serve also to set the plane of the dip circle in the magnetic meridian for the dip and intensity observations.

GENERAL ACCURACY OF RESULTS.

The endeavor, in general, is to secure on land declination and dip observations whose absolute error (including everything involved—error of observation and reduction) shall not exceed 2′, and that the horizontal intensity be determined within 1 part in 1000. The experience of the Coast and Geodetic Survey has been, that under all of the conditions involved in a campaign of field work covering a large area, including the standardization of instruments and the determination of the reduction errors, this accuracy can not be much reduced. In observatory work, with special instruments, or when special investigations are made under the best conditions by special observers, there is no difficulty in reducing these limits of error. But in a large organization, where results must be secured from all kinds of observers, under all conditions, and at times under great physical difficulties, and when all the errors are considered before results can be utilized, the degrees of accuracy stated must be regarded as satisfactory and sufficient. It happens, of course, that these limits, for one reason or another, are occasionally exceeded, and there may be a few isolated cases in which the errors are two to three times the amounts given.

Some preliminary statements regarding the accuracy reached in the determinations of the magnetic elements at sea have been made in the previous sections.

COMPARISON OF INSTRUMENTS.

The absolute instruments at the Cheltenham Observatory, comprising declinometer, magnetometer, earth inductor, and theodolite, have been adopted as the standard instruments to which all other instruments are referred.

During the year special observations were made at Cheltenham to standardize the three Lloyd-Creak dip circles, Nos. 28, 32, and 33, for use on shipboard. Other instruments were standardized as circumstances required, and numerous comparisons were obtained as the result of the occupation of the same station by different observers with different instruments. These observations show that few changes are required in the instrumental constants adopted last year. The various dip circles used and the corrections which have been applied to the results by each are given in the following table. The figures after the decimal point indicate the particular needles to which the correction applies; thus 15.24 means dip circle 15, needles 2 and 4.

Corrections to dip circles.

Dip circle	Needles	Pattern	Designation	Correction
				′
5	1 and 2	Gambey	5. 12	−11. 0
12	1 and 2	Robinson-Barrow	12. 12	+ 2. 0
15	2 and 4	Kew-Casella*	15. 24	+ 0. 5
18	1 and 4	Kew-Casella†	18. 14	0. 0
20	1 and 2	Kew-Casella	20. 12	+ 3. 4
21	1 and 2	Kew-Casella	21. 12	+ 6. 0
22		Earth Inductor	22 E I	− 0. 2
23	2 and 2	Kew-Casella‡	23. 22	+ 1. 7
23	3	Kew-Casella‖	23. 3	+ 0. 5
24	1 and 2	French Magnetic Survey	24. 12	+ 6. 6
25	IV and VIII	Tesdorpf	25. 48	− 3. 6
27	21 and 24	Tesdorpf	27. 14	− 0. 2
27	22 and 23	Tesdorpf	27. 23	− 1. 8
27	21, 22, 23, 24	Tesdorpf§	27 IV	
28	1 and 2	Lloyd-Creak‖	28. 12	− 5. 4
32	1 and 2	Lloyd-Creak‖	32. 12	− 2. 0
33	1 and 2	Lloyd-Creak‖	33. 12	− 0. 3
33	3	Lloyd-Creak‖	33. 3	+ 5. 0
4655	1 and 2	Kew-Casella	55. 12	− 1. 7
56	3 and 4	Kew-Casella‖	56. 34	− 1. 2
5677	1 and 2	Kew-Casella	77. 12	− 2. 4
5678	1 and 2	Kew-Casella	78. 12	− 1. 2

Comparative observations show that magnetometers Nos. 20 and 21 give results for horizontal intensity less than the standard. The results with these two instruments have therefore been corrected as follows:

No. 20	$+.0025\,H$
No. 21	$+.0070\,H$

Index corrections have been applied to declination results obtained with compass declinometer or compass needle. Numerous comparisons with other magnetometers during the past four years show that declination results with magnetometer No. 19 are systematically in error by about 1′.5. Declinations determined with that instrument have therefore been corrected by 1′.5, decreasing west declinations and increasing east declinations. The same correction should be applied to results with magnetometer No. 19, published in Appendix 5, Report for 1903.

REDUCTION OF THE OBSERVATIONS.

The general practice stated in the report of the results for the previous fiscal year has been retained. The reductions applied to the field results after they had been revised in the Office and referred to the standard instruments are:

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* Needle No. 2 by Dover.

† Needle No. 1 by Dover.

‡ One Dover and one Casella needle.

‖ Dover needles.

§ In combining results with all four needles double weight is given to the regular dip needles 21 and 24.

(*a*) Referring the magnetic declination results to the mean of the particular month in which the observations occur, by the aid of the continuous magnetic observations at the magnetic observatories nearest to the station. Where there is much difference in magnetic latitude, allowance is made in accordance with the general law of the increase of the diurnal variation with increasing dip and decreasing horizontal intensity.

(*b*) Applying, for the present, to the dip and intensity results merely the corrections necessary for referring them to the adopted standard instruments.

In accordance with the methods of observation the reduction-corrections for dip and intensity are usually of the order of the error of observation. When the observer has reason to suppose that a magnetic storm was prevailing at the time of his observations, as judged either at the time or from a careful scrutiny of the work before leaving the station, his directions require the repetition of the work. Experience shows that the laws of change both of the periodic and a-periodic magnetic fluctuations over as large an area as the one under consideration, must be much better known than at present before it will be safe to apply reduction-corrections to observations made at considerable distance from a magnetic observatory. It was deemed best, therefore, to defer these corrections, since they are in general of the same order as the error of observation; they are, moreover, considerably smaller than the station errors due to irregularity of distribution of the Earth's magnetism. It is very much questioned whether as far as investigations of distribution of magnetic elements are concerned, it will really pay to spend the time necessary to determine the small reduction-corrections as it is rather the multiplication of stations that is desired than the highest refinement. For certain special investigations as, e. g., the secular variation, it is necessary to apply all reduction-corrections known with certainty.

The office work involved in the reduction and revision of results and preparation for publication was intrusted principally to Messrs. D. L. Hazard and C. J. Houston, Computers, of whose efficiency and faithfulness the writer takes pleasure in making acknowledgment.

ARRANGEMENT OF THE TABLES.

LAND OBSERVATIONS.

The values of declination, dip, and horizontal intensity presented in Table I are arranged by States alphabetically, the results for each State being given in the order of increasing latitudes. The latitudes and longitudes are in most cases the result of solar observations made with the small theodolite which forms a part of the magnetometer. In default of observations the geographic position was scaled from the best available map, either the United States Geological Survey topographic sheets, a Post Route map, or a Rand & McNally State map. In such cases only the nearest whole minute of latitude and longitude is given. The horizontal intensity is expressed in terms of the one hundred thousandth part of a C. G. S. unit of intensity of magnetic force. The unit used represents the limit of accuracy attainable in the determination of the absolute horizontal intensity with the most refined instruments. There appears no hope that this accuracy, *in absolute measure*, will ever be exceeded. This unit is therefore a very practical and convenient one, and the late Professor Eschenhagen about eight or ten years ago suggested that the Greek gamma (γ) be used as the symbol to designate it, the hard sound of *g* reminding one of Gauss. His suggestion met with such favor and fulfilled the practical needs of magneticians so admirably that it has been adopted by the leading investigators, and is accordingly used in the tables.

In order to include the desired amount of information in the available space, the following abbreviations were adopted. Only the month and day of the date are given, since the observations were all made between July 1, 1903, and June 30, 1904, unless otherwise noted. The names of the months have been abbreviated as follows:

January	Ja.	July	Jy.
February	Fe.	August	Au.
March	Mh.	September	Se.
April	Ap.	October	Oc.
May	My.	November	No.
June	Je.	December	De.

In the column headed "Instruments," M. stands for "magnetometer" and D. C. for "dip circle." Italicized numbers in the magnetometer column mean that the declination was determined with a compass declinometer of the number given.

When the declination was determined with the compass attachment of the dip circle, the letter C is placed in the magnetometer column. The dip circles have been given the designations indicated on page 223, the figures after the decimal point denoting the needles used, as already explained. The letters BF refer to a small magnetometer called the Bache Fund, which is used in connection with Dip Circle No. 27 to determine the horizontal intensity. The magnet used to deflect the dip needles Nos. 22 and 23 is suspended for oscillations in the Bache Fund magnetometer and is also used to determine the declination.

The observer is indicated by the initials of his name. The names of the observers are as follows:

W. D. Alexander.
J. P. Ault.
J. Bach.
B. A. Baird.
S. J. Barnett.
L. A. Bauer.
J. B. Baylor.
H. L. Beck.
J. E. Burbank.
S. A. Deel.
R. B. Derickson.
P. H. Dike.
H. M. W. Edmonds.
W. B. Fairfield.
R. L. Faris.
O. L. Fassig.
H. F. Flynn.
A. E. Franklin.
J. J. Gilbert.
G. D. Harris.
D. L. Hazard.
J. S. Hill.
W. M. Hill.
C. J. Houston.
W. B. Keeling.
S. M. Kerns.
J. M. Kuehne.
F. M. Little.
J. E. McGrath.
H. L. Marindin.
C. J. Metlicka.
J. W. Milburn.
J. B. Miller.
H. C. Mitchell.
C. E. Morford.
R. E. Nyswander.
G. B. Pegram.
H. O. Pixley.
E. D. Preston.
E. C. Sasnett.
E. Smith.
L. B. Smith.
D. C. Sowers.
A. T. Stiles.
H. M. Trueblood.
W. F. Wallis.
H. I. Woods.
C. C. Yates.

Sea Observations.

The results obtained at sea from swings of ships during the period January 1, 1903, to June 30, 1904, are presented in Table II. The general arrangement is indicated by the headings. The month is abbreviated as in Table I and the last figure of the year is prefixed in the date column. The names of the ships taking part in the work and their commanding officers are as follows:

Bache	R. L. Faris and E. B. Latham
Blake	P. A. Welker and J. B. Boutelle
Gedney	E. F. Dickins
Hydrographer	W. I. Vinal and W. E. Parker
Patterson	J. F. Pratt

Unless otherwise indicated the ship was swung with both starboard and port helms. In the column headed "Sea," Sm means smooth; Sw, swell; Hvy, heavy, and Mod, moderate.

Table I.—*Results of magnetic observations on land, July 1, 1903, to June 30, 1904.*

ALABAMA

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	Instruments		Observer
							M.	D. C.	
	° ′	° ′		*East* ° ′	° ′	γ			
Birmingham	33 31.4	86 50.3	De. 21, 22	2 52.0	64 27.2	25132	BF	27 IV	L. B. S.
Ashville	33 50.6	86 15.7	De. 18	2 51.3	64 53.1	24750	BF	27 IV	Do.
Oneonto	33 57.7	86 27.7	De. 24, 25	2 38.7	64 55.3	24735	BF	27 IV	Do.
Gadsden	34 00.7	86 00.1	De. 14	2 07.5	65 07.2	24630	BF	27 IV	Do.
Center	34 10.1	85 41.4	De. 15, 16	1 56.6	64 57.4	24601	BF	27 IV	Do.
Guntersville	34 22.0	86 20.6	De. 4, 5	2 58.4	65 33.6	24360	BF	27 IV	Do.
Fort Payne	34 28.7	85 42.4	De. 10, 11	1 38.4	65 27.6	24349	BF	27 IV	Do.
Scottsboro	34 41.9	86 01.6	De. 1, 2	3 21.8	66 15.3	23531	BF	27 IV	Do.

ALASKA

	° ′	° ′		*East* ° ′	° ′	γ			
Dutch Harbor	53 53.4	166 32.1	Je. 27	17 57.3	66 55.6	20973	20	32.12	H. L. B.
Do.	53 53.4	166 32.1	Oc. 1	.. ....	67 06.0	20911	11	15.24	J. W. M.
Iphigenia Bay									
Gull	55 44.9	133 44.4	Se. 12	29 03.6	.. ....	.....	*744*	.....	C. E. M.
Surf	55 49.9	133 37.9	Se. 8	29 01.0	.. ....	.....	*744*	.....	J. B. M.
Do. A	55 49.9	133 37.9	Se. 8	29 00.4	.. ....	.....	*744*	.....	Do.
Lichen	55 54.0	133 50.5	Se. 4	26 05.7	.. ....	.....	*744*	.....	A. T. S.
Do. A	55 54.0	133 50.5	Se. 4	26 37.6	.. ....	.....	*744*	.....	Do.
Black	55 52.3	133 45.7	Se. 7	28 25.0	.. ....	.....	*744*	.....	J. B. M.
Do. A	55 52.3	133 45.7	Se. 7	28 33.2	.. ....	.....	*744*	.....	Do.
Do. B	55 52.3	133 45.7	Se. 7	28 24.6	.. ....	.....	*744*	.....	Do.
Green	55 54.4	133 37.2	Se. 21	29 28.3	.. ....	.....	*744*	.....	C. E. M.
Do. A	55 54.4	133 37.2	Se. 21	29 22.1	.. ....	.....	*744*	.....	Do.
Warren	55 56.2	133 53.7	Au. 31	32 05.9	.. ....	.....	*744*	.....	A. T. S.
Do. A	55 56.2	133 53.7	Au. 31	30 47.1	.. ....	.....	*744*	.....	Do.
Heather	55 56.6	133 48.9	Se. 2	28 32.5	.. ....	.....	*744*	.....	Do.
Do. A	55 56.6	133 48.9	Se. 2	28 34.4	.. ....	.....	*744*	.....	Do.
Albans	56 04.8	133 58.3	Au. 29	29 08.7	.. ....	.....	*744*	.....	Do.

TABLE I.—*Results of magnetic observations on land, etc.*—Continued.

ALASKA—Continued.

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	Instruments		Observer
							M.	D.C.	
	° ′	° ′		*East* ° ′	° ′	γ			
Sitka Mag. Obsy.	57 02.9	135 20.2	De.-Ja.	29 55.8	74 44.4	15448	25	25.48	H.M.W.E.
Do.	57 02.9	135 20.2	Jy. 12	29 54.6	74 48.9	15430	21	24.12	S. J. B.
Do.	57 02.9	135 20.2	Jy. 23, 24	.. ....	74 50.1	15504	11	15.24	J. W. M.
Vicinity of Juneau									
Station 14	58 11.9	134 15.4	Au. 2	30 54.7	75 46.8	14551	21	24.12	S. J. B.
" 17	58 12.4	134 22.1	Au. 3	31 09.5	75 25.4	14809	21	24.1	Do.
" 18	58 13.0	134 30.2	Au. 4	31 07.8	75 38.7	14706	21	24.12	Do.
" 23	58 13.3	134 17.4	Au. 13	30 12.2	75 41.0	14666	21	24.1	Do.
" 15	58 13.7	134 15.8	Au. 2	31 39.2	76 02.5	14559	21	24.1	Do.
" 13	58 14.4	134 17.4	Au. 2	32 32.3	74 44.2	15484	21	24.1	Do.
" 16	58 14.7	134 20.1	Au. 3	29 31.8	75 31.2	14834	21	24.1	Do.
" 11	58 15.1	134 20.6	Au. 1	24 05.9	75 04.7	15673	21	24.1	Do.
" 12	58 15.1	134 18.7	Au. 1	9 40.7	75 58.8	14429	21	24.1	Do.
" 19	58 15.2	134 37.8	Au. 4	1 08.1	75 39.6	14626	21	24.1	Do.
				West					
Treadwell	58 15.2	134 20.9	Au. 5	174 55	.. ....	.....	21	.....	Do.
Do.	58 15.2	134 20.9	Au. 22	158 27	89 21.1	.....	C	24.2	Do.
				East					
Station 30	58 15.2	134 20.9	Au. 18	11 02	86 12.4	4495	C	24.1	S. J. B.
" 31	58 15.2	134 20.9	Au. 19	44 10	84 47.7	.....	C	24.1	Do.
" 32	58 15.2	134 20.9	Au. 19	170 10	81 53.6	.....	C	24.1	Do.
" 33	58 15.2	134 20.9	Au. 19	150 15	87 33.4	.....	C	24.1	Do.
" 34	58 15.2	134 20.9	Au. 22	85 43	85 09.6	.....	C	24.2	Do.
" 35	58 15.2	134 20.9	Au. 22	89 24	88 10.5	.....	C	24.2	Do.
" 36	58 15.2	134 20.9	Au. 22	57 17	88 41.2	.....	C	24.2	Do.
" 37	58 15.2	134 20.9	Au. 22	48 09	89 17.0	.....	C	24.2	Do.
" 38	58 15.2	134 20.9	Au. 24	126 05	87 35.0	.....	C	24.2	Do.
" 39	58 15.2	134 20.9	Au. 24	Indet.	89 59.4	.....	C	24.2	Do.
				West					
" 40	58 15.2	134 20.9	Au. 24	137 16	89 00.1	.....	C	24.2	Do.
" 41	58 15.2	134 20.9	Au. 24	78 53	88 38.0	.....	C	24.2	Do.
" 42	58 15.2	134 20.9	Au. 24	66 09	87 25.0	.....	C	24.2	Do.
				East					
" 20	58 15.3	134 20.8	Au. 4-18	16 07.3	77 11.4	15129	21	24.1	Do.
" 29	58 15.3	134 20.9	Au. 18	16 27.6	77 07.6	14330	21	24.1	Do.
" 4	58 15.4	134 21.4	Jy. 25	36 13.8	75 06.9	15391	21	24.1	Do.
" 7	58 15.8	134 20.1	Jy. 28	30 12.0	76 39.3	14036	21	24.1	Do.
" 24	58 16.3	134 21.2	Au. 13	32 40.6	76 10.8	14223	21	24.12	Do.
" 2	58 16.4	134 23.0	Jy. 20	33 03.2	75 36.3	14767	21	24.12	Do.
" 1	58 16.5	134 23.1	Jy. 17	32 56.0	75 38.6	14680	21	24.12	Do.
" 9	58 17.0	134 24.4	Jy. 29	32 09.0	75 40.4	14681	21	24.1	Do.
" 25	58 17.4	134 23.5	Au. 14	32 29.1	75 41.7	14658	21	24.12	Do.
" 28	58 17.6	134 40.8	Au. 17	30 54.4	75 40.0	14595	21	24.12	Do.
" 26	58 17.8	134 26.0	Au. 14	31 57.8	75 35.6	14688	21	24.12	Do.
Juneau School	58 18.0	134 24.8	Au. 24-29	31 51.9	75 38.7	14628	21	24.12	Do.
Station 22	58 18.0	134 25.1	Au. 12	31 50.0	75 38.3	14635	21	24.12	Do.
Juneau Hill	58 18.2	134 24.3	Jy. 27	33 33.1	.. ....	15492	21	.....	Do.
Station 5	58 18.3	134 23.0	Jy. 27	31 39.4	75 55.8	14341	21	24.1	Do.
" 8	58 18.4	134 26.2	Jy. 29	31 43.4	75 33.4	14735	21	24.1	Do.
" 10	58 18.4	134 24.0	Au. 1	32 16.3	76 02.7	14335	21	24.12	Do.
" 3	58 19.7	134 28.3	Jy. 22, 23	31 41.0	75 36.6	14722	21	24.12	Do.
" 21	58 20.6	134 29.8	Au. 10, 15	31 28.2	75 36.4	14668	21	24.12	Do.
" 27	58 20.6	134 32.1	Au. 15	31 18.2	75 46.8	14510	21	24.12	Do.
Yakutat	59 33.7	139 46.8	Au. 2	.. ....	75 54.7	14476	11	15.24	J. W. M.
Orca 1	60 34.7	145 41.2	Au.-Se.	.. ....	75 21.5	14846	11	15.24	Do.
Do. 2	60 34.7	145 41.2	Se. 22	.. ....	75 18.0	14870	11	15.24	Do.

TABLE I.—*Results of magnetic observations on land, etc.*—Continued.

CALIFORNIA

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity.	Instruments		Observer
							M.	D. C.	
	° ′	° ′		*East* ° ′	° ′	γ			
Santa Cruz	36 57.0	122 01.6	Ap. 26, 27	16 53.0	61 39.0	25703	20	·15.24	D. L. H.
San Jose	37 18.0	121 52.0	My. 3, 4	18 13.2	61 44.2	26216	20	15.24	Do.
Palo Alto	37 25.7	122 10.2	Ap.30,Ma.2	17 14.6	61 53.6	25500	20	15.24	Do.
Presidio Hill, San Francisco	37 47.5	122 27.9	Ap. 21, 22	16 54.6	62 54.7	24817	20	15.24	Do.,
Do.	37 47.5	122 27.9	Ap. 22	.. ....	62 52.6	.....	..	32.12	Do.
Goat Island	37 48.8	122 21.7	My. 11, 12	17 36.5	62 15.3	25328	20	15.24	Do.
Berkeley	37 52.2	122 15.6	My. 7, 9	17 38.6	62 17.9	25310	20	15.24	Do.

DELAWARE

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity.	M.	D. C.	Observer
	° ′	° ′		*West* ° ′					
Delaware Breakwater	38 47.9	75 06.2	Se. 12, 28	5 45.7	.. ....	.....	*737*	.....	H. L. M.

DISTRICT OF COLUMBIA

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity.	M.	D. C.	Observer
	° ′	° ′		*West* ° ′		γ			
Washington	38 53.2	77 00.5	Oc. 21	5 14.6	.. ....	20276	31	.....	D. L. H.
Do.	38 53.2	77 00.5	Oc. 22	5 14.8	69 56.4	.....	BF	27.14	Do.
Do.	38 53.2	77 00.5	De. 22	5 14.4	69 55.2	20324	19	55.12	Do.
Do.	38 53.2	77 00.5	De. 31	. ....	.. ....	20282	10	.....	J. E. B.
Do.	38 53.2	77 00.5	Mh. 3	5 15.8	.. ....	20280	21	.....	D. L. H.
Do.	38 53.2	77 00.5	Ap. 6–9	5 15.2	.. ....	20290	10	.....	P. H. D.
Do.	38 53.2	77 00.5	Mh.–My.	. ....	69 55.9	.....	..	18.14	Various
Do.	38 53.2	77 00.5	My. 3–27	. ....	69 56.1	*20312**	..	23.22	Do.
Do.	38 53.2	77 00.5	My. 2–19	. ....	69 54.6	*20304**	..	56.34	Do.
Do.	38 53.2	77 00.5	Je. 28–30	. ....	.. ....	*20292**	..	56.34	Do.
Washington near Zoological Park	38 55.2	77 02.5	Je. 15–18	4 21.8	70 25.7	20110	8	23.22	Do.
Do.	38 55.2	77 02.5	Je. 16	. ....	70 27.4	*20105**	..	23.3	Do.

GEORGIA

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity.	M.	D. C.	Observer
	° ′	° ′		*East* ° ′	° ′	γ			
Statesboro	32 27.3	81 47.3	Fe. 25	0 51.9	63 43.4	25166	19	55.12	F. M. L.
Trenton	34 54.6	85 30.0	De. 7, 8	2 34.2	66 06.2	23928	BF	27.IV	L. B. S.

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* For the values in italics, the total intensity as determined by Lloyd's method was combined with the observed value of dip for the station.

TABLE I.—*Results of magnetic observations on land, etc.*—Continued.

GUAM

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	Instruments		Observer
							M.	D. C.	
	° ′	East ° ′		East ° ′	° ′				
Daño Island	13 13.9	144 38.3	No. 12	1 42.6	.. ....	.....	*15*	.....	E. S.
Merizo	13 15.9	144 39.5	No. 12	1 00.2	.. ....	.....	*15*	.....	Do.
Umata	13 17.8	144 39.3	No. 13	0 48.0	.. ....	.....	*15*	.....	Do.
Agat	13 23.9	144 39.2	Oc. 19	2 21.3	.. ....	.....	*15*	.....	Do.
Soumaye	13 26.4	144 38.7	Au. 15–18	2 23.8	14 36.7	.....	*15*	12.12	Do.
Do.	13 26.4	144 38.7	Oc. 1	2 20.6	.. ....	.....	*15*	.....	Do.
Do.	13 26.4	144 38.7	No. 10	2 20.8	.. ....	.....	*15*	.....	Do.
Do.	13 26.4	144 38.7	De. 17	2 22.8	.. ....	.....	*15*	.....	Do.
Agaña	13 28.3	144 44.4	Au. 24	2 45.4	.. ....	.....	*15*	.....	Do.

HAWAII

	° ′	° ′		East ° ′	° ′	γ			
Honolulu	21 18.0	157 51.5	Se.–No.	10 30	.. ....	.....	*743*	.....	W. D. A.
Honolulu Magnetic Obs'y	21 19.2	158 03.8	De.	9 19.2	40 12.2	29176	22	22EI	S. A. D.
Nonopapa	21 52.0	160 13.7	De. 10, 18	9 04	.. ....	.....	*743*	.....	S. M. K.
Hanapepe Bay 1	21 54	159 36	Fe. 25	12 28	.. ....	.....	*742*	.....	J. W. M.
Do. 2	21 54	159 35	Mh. 5, 8	12 17	.. ....	.....	*742*	.....	Do.
Waimea	21 57.4	159 40.2	De. 29	10 19	.. ....	.....	*743*	.....	W. D. A.
Kii	21 58.6	160 03.3	De. 21	10 35	.. ....	.....	*743*	.....	S. M. K.

KANSAS

	° ′	° ′		East ° ′	° ′	γ			
Marion	38 21.3	97 01.0	Je. 27–29	9 03.5	67 47.6	22621	BF	27.14	R. E. N.
Cottonwood Falls	38 24.2	96 31.6	Je. 23, 24	9 12.4	67 37.7	22765	BF	27.14	Do.
Emporia	38 24.9	96 12.1	Je. 21	9 57.0	67 56.3	22558	BF	27.14	Do.
Council Grove	38 41	96 29.5	Je. 18, 20	9 18.0	68 16.3	22298	BF	27.14	Do.
Baldwin Magnetic Obs'y	38 47.0	95 10.0	De.–Ja.	8 25.8	68 39.9	21875	30	5.12	J. P. A. & D. C. S.
Do.	38 47.0	95 10.0	Jy. 1–3	8 26.9	68 40.8	21911	10	78.12	H. I. W.
Do.	38 47.0	95 10.0	Se. 4–25	8 27.2	68 42.3	21883	10	78.12	L. B. S.
Do.	38 47.0	95 10.0	Ap. 6	8 25.0	68 41.1	.....	BF	27.14	Do.
Do.	38 47.0	95 10.0	My. 10, 11	8 27.4	68 41.1	.....	BF	27.14	Do.
Do.	38 47.0	95 10.0	Je. 8–13	8 26.5	68 40.5	.....	BF	27.14	R. E. N.

TABLE I.—*Results of magnetic observations on land, etc.*—Continued.

KENTUCKY

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	Instruments		Observer
							M.	D. C.	
	° ′	° ′		° ′	° ′	γ			
Williamsburg	36 44.9	84 08.7	Jy. 6	1 05.9 E	68 10.0	22268	19	55.12	F. M.L.
Pineville	36 46.9	83 41.2	Jy. 10	1 15.9 E	67 56.3	22516	19	55.12	Do.
Monticello	36 50.8	84 51.2	Oc. 10	4 07.2 E	67 42.3	22631	19	55.12	Do.
Barboursville	36 51.4	83 52.8	Jy. 8	0 09.3 W	68 16.4	22344	19	55.12	Do.
Harlan	36 51.7	83 19.7	Jy. 15	1 01.1 W	68 37.9	21737	19	55.12	Do.
Somerset	37 05.6	84 36.9	Oc. 8, 9	1 16.0 E	68 20.0	22503	19	55.12	Do.
Whitesburg	37 07.0	82 50.3	Jy. 17	0 46.1 W	68 25.3	21890	19	55.12	Do.
London	37 07.1	84 04.0	Jy.30, Au.1	0 46.0 E	68 53.7	21548	19	55.12	Do.
Hyden	37 09.5	83 23.1	Jy. 24	0 41.0 E	69 09.5	21275	19	55.12	Do.
Manchester	37 09.5	83 45.9	Jy. 27	0 23.2 W	69 06.2	21358	19	55.12	Do.
Hazard	37 15.0	83 11.2	Jy. 22	0 18.5 W	68 44.9	21546	19	55.12	Do.
Hindman	37 19.2	82 58.5	Jy. 20	0 02.6 W	68 49.0	21537	19	55.12	Do.
McKee	37 26.1	83 59.0	Au. 16	0 31.2 E	69 08.9	21178	19	55.12	Do.
Boonville	37 28.5	83 40.0	Au. 15	0 14.3 W	68 57.3	21238	19	55.12	Do.
Pikeville	37 29.0	82 31.2	Se. 4	0 46.1 W	68 39.8	21943	19	55.12	Do.
Jackson	37 33.3	83 22.8	Au. 21	1 15.5 E	68 58.1	21312	19	55.12	Do.
Beattyville	37 34.6	83 41.8	Au. 11	0 06.1 W	69 02.8	21293	19	55.12	Do.
Do. A	37 34.6	83 41.8	Au. 11	0 04.2 W	.. ....	.....	19	.....	Do.
Lancaster	37 36.9	84 32.4	Oc. 7	2 53.3 E	69 05.9	21580	19	55.12	Do.
Prestonsburg	37 40.6	82 45.4	Se. 2	0 06.1 W	68 52.1	21604	19	55.12	Do.
Irvine	37 42.2	83 58.1	Au. 12, 13	0 14.6 E	69 11.9	21041	19	55.12	Do.
Campton	37 43.6	83 32.3	Au. 8	1 23.3 E	68 46.7	21597	19	55.12	Do.
Salyersville	37 45.0	83 04.8	Au. 29	0 14.6 E	69 02.8	21417	19	55.12	Do.
Harrodsburg	37 45.6	84 49.8	Oc. 3	1 31.5 E	69 11.1	21346	19	55.12	Do.
Paintsville	37 48.8	82 48.6	Au. 31	0 08.3 W	69 03.5	21466	19	55.12	Do.
Stanton	37 51.0	83 50.4	Au. 6	1 00.0 E	69 04.3	21399	19	55.12	Do.
Inez	37 52.0	82 34.0	Se. 17, 18	0 36.1 W	69 11.6	21464	19	55.12	Do.
West Liberty	37 55.3	83 16.4	Au. 25	0 39.9 E	69 10.1	21328	19	55.12	Do.
Frenchburg	37 57.2	83 36.4	Au. 4	0 16.7 W	69 12.7	21358	19	55.12	Do.
Lawrenceburg	38 02.4	84 53.2	Oc. 2	1 53.7 E	69 39.5	20894	19	55.12	Do.
Versailles	38 03.7	84 43.2	Se. 29, 30	1 00.3 E	69 46.1	20880	19	55.12	Do.
Sandy Hook	38 04	83 08.2	Au. 26, 27	0 48.3 E	69 21.2	21316	19	55.12	Do.
Louisa	38 06.8	82 34.6	Se. 12–14	0 33.9 W	69 31.1	21109	19	55.12	Do.
Georgetown	38 13.2	84 33.2	Se. 28	0 39.5 E	69 31.0	20896	19	55.12	Do.
Owenton	38 33	84 51.3	Se. 25	1 34.1 E	69 48.2	20781	19	55.12	Do.
Williamstown	38 38.5	84 35.5	Se. 24	1 32.5 E	69 35.7	20959	19	55.12	Do.
Falmouth	38 40	84 21.8	Se. 22, 23	1 20.9 E	69 43.9	20992	19	55.12	Do.
Brooksville	38 41.2	84 07.1	Se. 21	0 54.7 E	70 00.0	20693	19	55.12	Do.

TABLE I.—*Results of magnetic observations on land, etc.*—Continued.

LOUISIANA

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	Instruments		Observer
							M.	D. C.	
	° ′	° ′		*East* ° ′	° ′	γ			
Pointe a la Hache	29 35.7	89 47.8	Ja. 2	5 22.9	59 47.6	27735	BF	27 IV	L. B. S.
Côte Blanche	29 44	91 43	Fe. 16	6 17.8	.. ....	.....	C56	......	G. D. H.
Franklin	29 48.5	91 30.0	Ja. 7, 8	6 05.6	59 42.5	27872	BF	27 IV	L. B. S.
Do	29 48.5	91 30.0	Ja. 5–13	6 05.9	59 41.7	27860*	C56	56.34	G. D. H.
Baldwin	29 49.2	91 36	Fe. 15, 18	6 07.7	59 40.2	27999*	C56	56.34	Do.
Grande Côte	29 50.2	91 47	Ja. 15–20	6 13.2	59 36.8	28003*	C56	56.34	Do.
St. Bernard	29 52.6	89 51.0	De. 30	5 30.0	60 02.4	27640	BF	27 IV	L. B. S.
Do	29 52.6	89 51.0	Fe. 5	5 30.4	60 00.2	27678	21	32.12	L. A. B.
Do	29 52.6	89.51.0	Mh. 23	5 28.9	60 01.8	27690	BF	27 IV	L. B. S.
Do	29 52.6	89 51.0	Mh. 25	5 26.6	59 54.9	27754*	C56	56.34	G. D. H.
Averys Island	29 55	91 53	Fe. 19	6 21.6	.. ....	.....	C56	......	Do.
Gretna	29 56.2	90 03.1	Ja. 5, 6	5 40.1	60 01.9	27650	BF	27 IV	L. B. S.
Abbeville	29 58	92 07	Mh. 22, 23	6 28.1	59 41.6	27845*	C56	56.34	G. D. H.
New Iberia	30 00	91 48	Fe. 18, 19	6 18.4	59 49.3	27927*	C56	56.34	Do.
St. Martinville	30 08	91 49	Fe. 12, 13	6 22.2	60 00.1	27853*	C56	56.34	Do.
Crowley	30 12	92 20	Mh. 8	6 31.8	60 04.6	27727*	C56	56.34	Do.
Jennings	30 12	92 37	Mh. 16	6 38.0	60 03.5	27718*	C56	56.34	Do.
Lafayette	30 13	92 00	Fe. 2, 4	6 32.4	60 09.4	27633*	C56	56.34	Do.
Lake Charles	30 14.2	93 13.0	Ja. 11	6 50.5	60 02.4	27695	BF	27 IV	L. B. S.
Anse la Butte	30 15	91 56	Fe. 1	6 26.6	.. ....	.....	C56	......	G. D. H.
Evangeline	30 16.0	92 33	Mh. 11	6 39.2	59 57.9	27842*	C56	56.34	Do.
Plaquemine	30 17.7	91 15.3	Mh. 25, 26	5 51.2	60 30.4	27367	BF	27 IV	L. B. S.
Springville	30 26	90 40.9	Mh. 19, 21	5 41.9	60 42.0	27234	BF	27 IV	Do.
Opelousas	30 33	92 04	Fe. 10, 11	6 22.8	60 20.6	27575*	C56	56.34	G. D. H.
Marble Quarry	30 47	92 28	Fe. 27, 28	6 44.9	60 46.7	27027*	C56	56.34	Do.
Oakdale	30 48	92 38	Mh. 1, 2	6 43.0	60 41.4	27172*	C56	56.34	Do.
Franklinton	30 52	90 09.2	Mh. 17, 18	5 33.9	61 04.8	26973	BF	27 IV	L. B. S.
Cheneyville	30 59	92 18	Fe. 24	6 38.2	60 58.8	27131*	C56	56.34	G. D. H.
Marksville	31 07	92 03	Fe. 25	6 32.7	61 03.2	27188*	C56	56.34	Do.
Leesville	31 10.7	93 15.1	Ja. 13, 14	7 02.2	60 59.8	27072	BF	27 IV	L. B. S.
Alexandria	31 19.8	92 25.1	Fe. 16, 17	6 38.0	61 14.0	26982	BF	27 IV	Do.
Do.	31 19.8	92 25.1	Mh. 2	6 39.8	.. ....	.....	C56	......	G. D. H.
Colfax	31 32.2	92 42.1	Fe. 15	6 42.8	61 28.7	26823	BF	27 IV	L. B. S.
Many	31 34.4	93 29.4	Ja. 15	7 04.6	61 30.7	26856	BF	27 IV	Do.
Vidalia	31 34.7	91 26.3	Mh. 4, 5	6 03.6	61 38.5	26722	BF	27 IV	Do.
Natchitoches	31 45.8	93 03.9	Fe. 13	6 44.4	61 39.5	26751	BF	27 IV	Do.
Harrisonburg	31 47.2	91 49.4	Mh. 2	6 17.3	61 56.2	26546	BF	27 IV	Do.
St. Joseph	31 56.5	91 14.4	Mh. 7, 8	6 03.6	62 08.2	26437	BF	27 IV	Do.
Winnfield	31 56.9	92 36.4	Fe. 9	6 48.6	61 53.9	26552	BF	27 IV	Do.
Coushatta	32 00.9	93 21.9	Mh. 28	6 57.3	61 51.9	26596	BF	27 IV	Do.
Mansfield	32 02.9	93 41.4	Ja. 18	7 00.6	61 53.4	26582	BF	27 IV	Do.
Winnsboro	32 09	91 42.3	Fe. 29	6 12.9	62 15.8	26348	BF	27 IV	Do.
Tallulah	32 25.1	91 12.0	Fe. 23, 24	6 00.7	62 33.4	26190	BF	27 IV	Do.
Rayville	32 28	91 45	Fe. 25	6 18.7	62 36.3	26166	BF	27 IV	Do.
Monroe	32 30.3	92 05.9	Fe. 19–22	6 26.6	62 33.7	26214	BF	27 IV	Do.
Shreveport	32 31.0	93 45.9	Ja. 20–23	6 59.1	62 23.7	26357	BF	27 IV	Do.
Do. B	.. ....	.. ....	Ja. 25	6 56.0	.. ....	.....	BF	.....	Do.
Ruston	32 32.6	92 37.4	Fe. 4	6 45.0	62 33.2	26157	BF	27 IV	Do.
Arcadia	32 32.8	92 55.8	Fe. 3	6 49.8	62 33.2	26204	BF	27 IV	Do.
Minden	32 38.4	93 16.7	Ja. 26, 27	7 01.1	62 32.0	26253	BF	27 IV	Do.
Benton	32 40	93 43.9	Mh. 30, 31	7 04.6	62 41.6	26120	BF	27 IV	Do.
Floyd	32 42.3	91 23.8	Mh. 12, 14	6 14.5	62 59.0	25896	BF	27 IV	Do.
Farmerville	32 46	92 23.1	Fe. 6	6 39.9	62 50.3	26051	BF	27 IV	Do.
Bastrop	32 46.6	91 54.2	Fe. 26, 27	6 19.7	62 53.5	26053	BF	27 IV	Do.
Lake Providence	32 48	91 09.5	Mh. 10	6 04.4	62 58.1	25947	BF	27 IV	Do.
Homer	32 48.4	93 03.4	Ja. 29, 30	6 53.7	62 46.7	26056	BF	27 IV	Do.

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*For the values in italics, the total intensity determined by Lloyd's method was combined with the observed dip.

TABLE I.—*Results of magnetic observations on land, etc.*—Continued.

MAINE

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	Instruments		Observer
							M.	D.C.	
	° ′	° ′		West ° ′	° ′	γ			
Kennebunk Port	43 20.5	70 28.1	Oc. 24	14 12.4	73 57.7	16626	8	21.12	J. B. B.
Portland	43 38.8	70 16.6	No. 19	14 32.5	73 58.4	16659	8	21.12	Do.

MARYLAND

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	M.	D.C.	Observer
	° ′	° ′		West ° ′	° ′	γ			
Cheltenham Magnetic Obs'y.	38 44.0	76 50.5	De.-Ja.	5 11.6	70 25.0	20117	26	26 EI	W. F. W.
Do.	38 44.0	76 50.5	Au.-No.	. ....	70 24.6	.....	..	28.12	Do.
Do.	38 44.0	76 50.5	Oc. 1, 2	5 09.8	70 23.1	.....	BF	27.14	L. A. B.
Do.	38 44.0	76 50.5	Oc. 1-6	5 10.8	70 24.1	20128	31	1 EI	W. F. W.
Do.	38 44.0	76 50.5	Oc. 7	5 11.1	.. ....	20141	8	.....	Do.
Do.	38 44.0	76 50.5	De. 2-5	5 11.7	70 24.5	20125	19	55.12	Do.
Do.	38 44.0	76 50.5	De. 15-19	5 11.3	70 25.0	20120	21	24.12	Do.
Do.	38 44.0	76.50.5	Ja. 5-7	5 10.0	70 26.0	20136	21	24.12	J. E. B.
Do.	38 44.0	76 50.5	Ja. 14	. ....	70 26.5	.....	..	33.12	D. L. H.
Do.	38 44.0	76 50.5	Fe. 11-13	. ....	70 25.0	.....	..	24.12	W. F. W.
Do.	38 44.0	76 50.5	Fe. 11	. ....	70 26.2	.....	..	32.12	Do.
Do.	38 44.0	76 50.5	Mh.-Ap.	. ....	70 25.0	.....	..	78.12	Various
Do.	38 44.0	76 50.5	Ap. 5-16	. ....	70 24.6	.....	..	20.12	Do.
Do.	38 44.0	76 50.5	Je. 21, 22	. .. .	70 24.6	.....	..	23.22	Do.
Do.	38 44.0	76 50.5	Je. 23, 24	. ....	70 22.3	.....	..	33.12	Do.
Linden	39 00.5	77 03.1	Je. 11, 13	3 50.8	70 46.3	19656	8	23.22	L. A. B.
Do.	39 00.5	77 03.1	Je. 13	3 49.0	70 46.1	*19663**	C	23.3	J. E. B.
Baltimore:									
Ft. McHenry	39 15.7	76 34.8	Ja. 15	5 47.0	70 56.2	*19525**	C	33.3	D. L. H.
Patterson Park	39 17.5	76 34.4	Ja. 21	5 44.8	70 45.4	*19630**	C	33.3	Do.

MASSACHUSETTS

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	M.	D.C.	Observer
	° ′	° ′		West ° ′	° ′	γ		′	
Fairhaven	41 37.4	70 54.1	Oc. 20	12 09.5	72 55.5	*17669**	C 28	28.12	R. L. F.

MISSOURI

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	M.	D.C.	Observer
	° ′	° ′		East ° ′	° ′	γ			
Marshfield	37 21	92 50.3	Au. 14	6 54.0	.. ....	23022	10	78.12	H. I. W.
Bolivar	37 38.0	93 23.2	Au. 11, 12	7 16.7	67 48.4	22582	10	78.12	Do.
Osceola	38 03.9	93 41.4	Au. 7, 8	7 40.2	68 02.8	22300	10	78.12	Do.
Clinton	38 22.4	93 46.1	Au. 3, 4	7 25.4	68 10.0	22300	10	78.12	Do.
Fayette	39 09.9	92 41.1	Jy. 31	7 22.9	69 52.1	21056	10	78.12	Do.
Mexico	39 10.2	91 51.8	Jy. 27, 28	6 32.5	69 27.0	21438	10	78.12	Do.
Lexington	39 12.2	93 51.8	Jy. 7, 8	7 37.0	69 16.2	21503	10	78.12	Do.
Bowling Green	39 21.1	91 10.9	Jy. 24, 25	5 50.0	69 45.4	20995	10	78.12	Do.
Plattsburg	39 34.8	94 26.5	Jy. 9-11	8 41.1	69 30.1	21252	10	78.12	Do.
Chillicothe	39 47.6	93 32.6	Jy. 18	7 11.4	70 14.1	20701	10	78.12	Do.
Gallatin	39 54.9	93 58.6	Jy. 14	7 54.2	69 53.3	21132	10	78.12	Do.
Edina	40 10	92 10.1	Jy. 21, 22	6 55.3	70 37.9	20386	10	78.12	Do.
Albany	40 13.6	94 23.2	Jy. 16, 17	7 02.1	70 18.2	20728	10	78.12	Do.

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*For the values in italics, the total intensity determined by Lloyd's method was combined with the observed dip.

TABLE I.—*Results of magnetic observations on land, etc.*—Continued.

MONTANA

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	Instruments		Observer
							M.	D.C.	
				East					
	° ′	° ′		° ′	° ′	γ			
Helena	46 37.0	112 02.2	Se. 16	19 44.6	72 11.5	18552	20	18.14	E. D. P.
Glasgow	48 11.7	106 36.8	Oc. 25	19 09.6	74 51.4	16320	20	18.14	Do.
Chinook	48 36.0	109 13.7	Oc. 12–19	19 21.2	74 26.8	16708	20	18.14	Do.
Gateway	49 00	115 10.2	Oc. 27, 28	23 48.2	73 29.6	*17537**	C23	23.22	A. E. F.
Flathead River	49 00	114 27	No. 4	23 35.6	73 47.7	*17151**	C23	23.22	Do.
Phillips Ranch	49 00	115 03.5	No. 10	.. ....	73 25.1	*17454**	....	23.22	Do.
Monument No. 11	49 00	115 15	No. 11, 12	23 41.8	73 20.4	*17526**	C23	23.22	Do.

NEW JERSEY

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	M.	D.C.	Observer
				West					
	° ′	° ′		° ′	° ′	γ			
Cape May Point	38 55.8	74 57.8	Jy. 24	6 27.6	70 32.1	19786	BF	27 IV	G. B. P.
Sea Isle City[1]	39 10.2	74 41.0	Jy. 21–23	6 51.5	70 36.5	19777	BF	27 IV	Do.
Egg Island L. H.	39 10.6	75 08.2	Jy. 19	6 20.0	70 46.4	19547	BF	27 IV	Do.
Port Norris	39 14.6	75 01.4	Jy. 16, 17	6 35.0	70 46.0	19574	BF	27 IV	Do.
Atlantic City	39 22.0	74 24.9	Jy. 27–29	7 22.8	70 45.3	19580	BF	27 IV	Do.
Do. B	39 22.0	74 24.9	Jy. 28	7 14.1	.. ....	.....	BF	.....	Do.
Bridgeton	39 24.7	75 15.9	Jy. 14, 15	6 29.6	70 38.1	19812	BF	27 IV	Do.
Mays Landing	39 27.2	74 43.6	Jy. 31, Au. 3	7 00.4	71 05.5	19412	BF	27 IV	Do.
Long Beach	39 31.8	74 15.4	Au. 11, 12	7 53.0	71 01.3	19374	BF	27 IV	Do.
Salem	39 34.3	75 27.5	Jy. 10	6 51.7	70 51.6	19541	BF	27 IV	Do.
Do.	39 34.3	75 27.5	Se. 28, 29	6 48.3	70 52.4	19525	31	27 IV	L. A. B.
Do.	39 34.3	75 27.5	Se. 29	6 51.1	.. ....	19518	BF	.....	Do.
Barnegat L. H.	39 45.8	74 06.4	Au. 8	7 58.8	71 09.1	19237	BF	27 IV	G. B. P.
Mount Royal	39 49.1	75 12.5	Jy. 8, 9	7 12.2	71 15.4	19171	BF	27 IV	Do.
Chatsworth	39 49.1	74 32.2	Au. 6	7 40.6	71 14.9	19159	BF	27 IV	Do.
Camden	39 54.8	75 04.7	Jy. 4, 6	7 08.6	71 07.4	19274	BF	27 IV	Do.
Toms River	39 57.3	74 11.5	Au. 15	8 03.6	71 20.1	19085	BF	27 IV	Do.
Mount Holly	40 00.4	74 47.8	Au. 18, 19	7 36.8	71 15.0	19244	BF	27 IV	Do.
Trenton	40 14.5	74 48.3	Au. 20–22	8 00.6	71 23.4	19208	BF	27 IV	Do.
Freehold	40 15.3	74 17.3	Se. 10–12	8 27.6	71 22.3	19071	31	27 IV	Do.
Do.	40 15.3	74 17.3	Se. 12	. ....	.. ....	19085	BF	.....	Do.
Mount Rose	40 22.2	74 43.1	Au. 25, 26	8 36.7	71 45.0	19005	BF	27 IV	Do.
Do. A	40 22.2	74 43.1	Au. 25	8 05.0	.. ....	.....	BF	.....	Do.
Sandy Hook	40 27.7	74 00.3	Se. 1–5	8 52.9	71 41.3	18866	31	27 IV	Do.
Do.	40 27.7	74 00.3	Se. 1–5	. ....	.. ....	18861	BF	.....	Do.
New Brunswick	40 30.2	74 27.2	Se. 21, 22	8 17.5	71 49.0	18760	31	27.14	Do.
Do. A	40 30.2	74 27.2	Se. 22	8 19.2	.. ....	.....	31	.....	Do.
Flemington	40 30.5	74 51.6	Je. 8, 9	8 14.2	71 41.0	18910	19	20.12	W. M. H.
Perth Amboy	40 31.8	74 17.4	Se. 18, 19	8 57.5	71 47.2	18844	31	27.14	G. B. P.
Somerville	40 34.0	74 35.5	Je. 10, 11	9 07.7	71 43.9	18891	19	20.12	W. M. H.
Elizabeth	40 40.5	74 13.0	Se. 24, 25	8 54.7	71 49.7	18740	31	27 IV	L. A. B.
Do.	40 40.5	74 13.0	Se. 25	8 56.9	.. ....	18738	BF	.....	Do.
Do.	40 40.5	74 13.0	Je. 13–15	8 59.6	71 50.8	18711	19	20.12	W. M. H.
Newark	40 45.7	74 11.4	Je. 18, 20	8 59.1	72 06.2	18693	19	20.12	Do.
Hackensack	40 53.5	74 03.4	Je. 28	8 56.3	72 10.5	18450	19	20.12	Do.
Paterson	40 55.1	74 08.7	Je. 22, 23	8 54.7	72 08.3	18517	19	20.12	Do.

NORTH CAROLINA

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	M.	D.C.	Observer
				West					
	° ′	° ′		° ′	° ′	γ			
Wadesboro	34 57.6	80 03.2	Ja. 6, 7	0 11.7	66 39.7	22936	19	55.12	F. M. L.

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*For the values in italics the total intensity determined by Lloyd's method was combined with the observed dip.

TABLE I.—*Results of magnetic observations on land, etc.*—Continued.

OHIO

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	Instruments		Observer
							M.	D. C.	
	° ′	° ′		° ′	° ′	γ			
Lancaster	39 45.6	82 37.5	Oc. 25, 26	0 07.8 W.	70 54.1	19913	BF	27 IV	L. B. S.
Eaton	39 48.3	84 39.2	Oc. 21–23	0 50.7 E.	70 51.0	20107	10	78.12	Do.
Greenville	40 07.2	84 32.2	Jy. 6	0 52.8 E.	71 20.2	19656	8	21.12	J. M. K.
Marysville	40 15.8	83 22.7	Au. 10	0 25.8 E.	71 29.0	19484	8	21.12	Do.
Sidney	40 16.1	84 08.4	Jy. 1, 2	0 04.0 W.	71 24.8	19486	8	21.12	C. J. H.
Delaware	40 21.6	82 57.8	Au. 12	0 40.0 W.	71 28.3	19578	8	21.12	J. M. K.
Mt. Vernon	40 27.3	82 31.0	Oc. 24–27	0 38.1 W.	71 58.1	18908	10	78.12	L. B. S.
Celina	40 33.7	84 34.3	Jy. 8	0 36.3 E.	71 36.3	19382	8	21.12	J. M. K.
Mt. Gilead, N. M.	40 33.5	82 48.8	Au. 17	0 28.9 W.	.. ....	.....	8	.....	Do.
Mt. Gilead	40 34.4	82 47.8	Au. 14	0 39.2 W.	71 43.5	19286	8	21.12	Do.
Wapakoneta	40 36.1	84 11.2	Jy. 9, 10	0 14.6 W.	71 35.8	19298	8	21.12	Do.
Kenton	40 40.0	83 38.0	Au. 7	1 02.2 E.	71 49.7	19119	8	21.12	Do.
Lima	40 45.4	84 02.2	Jy. 11	0 25.8 W.	71 42.9	19213	8	21.12	Do.
Bucyrus	40 49.0	82 58.8	Au. 20	0 32.6 W.	72 15.5	18714	8	21.12	Do.
Forest	40 49.1	83 34.8	Au. 24	0 19.1 E.	71 59.8	18966	8	21.12	Do.
Upper Sandusky	40 51.4	83 17.6	Au. 22	0 28.0 W.	72 14.7	18778	8	21.12	Do.
Mansfield	40 52.8	82 28.6	Au. 18	1 54.2 W.	72 02.3	18891	8	21.12	Do.
Do.	40 52.8	82 28.6	Oc. 28, 29	1 48.8 W.	72 01.1	18863	10	78.12	L. B. S.
Vanwert	40 53.5	84 34.6	Jy. 15	0 01.7 W.	71 49.0	19144	8	21.12	J. M. K.
Ottawa	41 01.4	84 01.8	Jy. 14	0 26.0 W.	71 53.3	18986	8	21.12	Do.
Findlay	41 03.2	83 40.7	Au. 6	0 01.0 E.	72 06.3	18853	8	21.12	Do.
Tiffin	41 06.1	83 10.7	Au. 26	0 55.6 W.	72 07.5	18736	8	21.12	Do.
Medina	41 10.0	81 51.2	No. 2, 3	2 42.8 W.	72 12.2	18668	10	78.12	L. B. S.
Paulding	41 12	84 32.2	Jy. 17	0 01.7 E.	72 03.4	18994	8	21.12	J. M. K.
Ravenna	41 13.5	81 14.7	No. 6–11	2 21.0 W.	72 26.0	18415	10	78.12	C. J. M.
Do.	41 13.5	81 14.7	No. 9, 10	2 17.6 W.	72 27.5	18427	BF	27 IV	L. B. S.
Norwalk	41 15.0	82 37.8	Se. 11, 12	1 06.2 W.	72 31.9	18465	8	21.12	J. M. K.
Oberlin	41 18.3	82 16.5	Se. 14	1 59.9 W.	72 14.2	18805	8	21.12	Do.
Defiance	41 18.9	84 24.0	Jy. 20	0 08.2 W.	72 09.8	18904	8	21.12	Do.
Bowling Green	41 21.0	83 38.3	Au. 3, 4	0 24.9 W.	72 13.9	18918	8	21.12	Do.
Elyria	41 22.0	82 09.9	Se. 15, 16	2 08.5 W.	72 27.7	18621	8	21.12	Do.
Fremont	41 23.0	83 05.9	Au. 28, 29	1 00.8 W.	72 18.9	18662	8	21.12	Do.
Berea	41 23.7	81 50.6	Se. 18	2 31.4 W.	72 20.8	18694	8	21.12	Do.
Napoleon	41 26.2	84 09.8	Jy. 22	0 45.2 W.	72 11.2	18834	8	21.12	Do.
Bryan	41 29.7	84 34.4	Jy. 25	0 27.0 W.	72 15.4	18832	8	21.12	Do.
Sandusky	41 30.9	82 43.0	Se. 2	0 55.8 W.	72 36.9	18398	8	21.12	Do.
Port Clinton	41 32.1	82 58.3	Se. 4	1 05.7 W.	72 30.0	18488	8	21.12	Do.
Maumee	41 33.7	83 39.2	Jy. 29, 30	0 44.3 W.	72 21.8	18659	8	21.12	Do.
Wauseon	41 35.9	84 10.5	Jy. 23	1 05.4 W.	72 24.2	18716	8	21.12	Do.
Chardon	41 37.0	81 10.7	No. 17	3 21.6 W.	72 31.0	18415	BF	27 IV	L. B. S.
Do.	41 37.0	81 10.7	No. 13, 14	3 21.0 W.	72 29.9	18408	10	78.12	C. J. M.
Kelleys Island	41 37.8	82 44.1	Se 10	0 53.8 W.	72 28.6	18596	8	21.12	J. M. K.
Put in Bay	41 41.3	82 51.1	Se. 8, 9	0 50.4 W.	72 39.1	18362	8	21.12	Do.
Toledo	41 41.7	83 26.5	Jy. 27	1 00.0 W.	72 44.1	18322	8	21.12	Do.

TABLE 1.—*Results of magnetic observations on land, etc.*—Continued.

PHILIPPINE ISLANDS

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	Instruments		Observer
							M.	D. C.	
		East		*East*					
Mindanao	° ′	° ′	1902	° ′	° ′	γ			
Iligan	8 14.1	124 13.7	No. 24, 26	1 42.7	4 08.7	38332	18	77.12	H. C. M.
			1903						
Surigao	9 47.6	125 29.3	Je. 20–24	2 14.1	5 39.3	38062	18	77.12	J. S. H.
Leyte									
Kanagao I.	10 14	124 44	Mh. 20	1 35.4	.. ....	.....	*739*	.....	C. C. Y.
Negros									
Valle Hermosa	10 20.1	123 19.9	Ja. 8–10	1 19.6	7 12.3	38254	18	77.12	H. C. M.
Panay									
San José de Buena Vista	10 44.3	121 56.0	De. 10–16	1 49.7	7 49.7	38331	18	77.12	W. B. F.
Cuyo									
Cuyo	10 51.4	121 00.4	Oc. 19–24	1 29.5	8 02.5	38616	18	77.12	Do.
Negros			1902						
Danao	10 50	123 33	N. 29, D. 4	1 15.4	.. ....	.....	*733*	.....	C. E. M.
Samar			1903						
Guiuan	11 04.3	125 34.6	Fe. 3	1 22.2	.. ....	.....	*739*	.....	C. C. Y.
Panay									
Port Batan	11 36.0	122 29.5	Oc. 12	1 19.5	.. ....	.....	*734*	.....	R. B. D.
Samar			1902						
Catbalogan	11 46.6	124 52.7	Se. 5	1 22.5	10 26.7	37992	18	77.1	H. C. M.
Calbayoc	12 04.1	124 35.6	Oc. 7	1 05.6	11 36.2	38100	18	77.12	Do.
Mindoro			1903						
Mangarin	12 19.5	121 05.0	Mh. 25	1 19.2	.. ....	.....	*734*	.....	R. B. D.
Romblon									
Romblon	12 34.7	122 16.1	Mh. 20–23	1 08.2	12 06.7	38293	18	77.12	J. E. McG.
Luzon			1902						
San Bernardino Light House	12 45.3	124 17.2	Au. 15	1 30.3	.. ....	.....	*739*	.....	C. C. Y.
Reef	12 51.5	124 09.5	Jy. 29	0 49.0	.. ....	.....	*739*	.....	Do.
Gubat	12 55.3	124 07.7	Je. 21-Jy. 7	1 00.2	.. ....	.....	*733*	.....	C. E. M. & J. B.
Castilla	12 57.3	123 53.1	Oc. 1	1 00.9	.. ....	.....	*733*	.....	J. B.
Sorsogon	12 58.2	124 00.4	Au. 6	0 35.6	.. ....	.....	*733*	.....	C. E. M.
Albay Gulf	13 04.2	124 11.8	Jy. 17	1 12.3	.. ....	.....	*734*	.....	H. O. P.
Legaspi	13 09.2	123 45.4	Jy. 27, 28	0 30.5	13 14.7	37778	18	77. IV	H. C. M.
Batan I.	13 15.7	124 06.0	Jy. 26	0 58.4	.. ....	.....	*734*	.....	R. B. D.
Mindoro			1903						
Calapan	13 25.0	121 10.7	Mh. 30, 31	1 08.5	14 12.7	38250	18	77.12	J. S. H.
Marinduque									
Boac	13 26.3	121 48.8	My. 16, 17	0 52.2	13 48.3	37799	18	77.12	Do.
Mindoro									
Puerto Galera	13 30.6	120 56.6	Fe. 5	0 57 6	.. ....	.....	*734*	.....	R. B. D.
Luzon									
Lagonoy G. Short	13 41.6	123 49.3	Se. 30	0 48.1	.. ....	.....	*739*	.....	J. J. G.
Do. Tall	13 42.5	123 40.4	Se. 23	1 02.4	.. ....	.....	*739*	.....	B. A. B.
Batangas	13 45.4	121 02.9	Ap. 13, 14	0 46.1	14 18.7	38081	18	77.12	J. S. H.
Vigan	17 33.9	120 22.9	Fe. 10	0 25.6	.. ....	.....	*733*	.....	H. F. F.
Currimao	18 01.2	120 28.7	Mh. 27	0 18.8	.. ....	.....	*733*	.....	Do.
Culili	18 05.4	120 28.1	Ap. 4	0 25.9	.. ....	.....	*733*	.....	Do.

TABLE 1.—*Results of magnetic observations on land, etc.*—Continued.

PORTO RICO

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	Instruments		Observer
							M.	D. C.	
				West					
	° ′	° ′		° ′	° ′	γ			
Guaniquilla	18 02.7	67 12.1	Mh. 29	1 00.0	48 27.5	_30117_*	C33	33.12	E. C. S.
Porto Rico Magnetic Obsy.	18 08.9	65 26 4	De.-Ja.	1 15.2	.. ....	29040	31	.. ..	W.B.K.
Mayaguez	18 11.8	67 08.6	Fe. 15, 16	1 23.6	49 16.2	_29418_*	C33	33.12	E. C. S.
Do.	18 11.8	67 08.6	My. 14	1 21.0	49 22.0	_29368_*	C33	33.12	Do.
Battle Cay	18 18.1	65 15.2	Ap. 28	0 42.6	46 31.7	_30218_*	C28	28.12	R. L. F.
Scorpion Point	18 18.2	65.18.7	Ap. 2, 12	1 55.4	49 35.0	_29118_*	C28	28.12	Do.
Obispo Cayo	18 20.6	65 37.2	Mh. 18	1 38.1	49 12.5	_29793_*	C28	28.12	Do.
Do.	18 20.6	65 37.2	Ap. 16	1 35.4	49 17.4	_29776_*	C28	28.12	H.M.T.
Do.	18 20.6	65 37.2	My. 27	1 39.1	49 17.4	_29776_*	C28	28.12	Do.
San Juan, S. Base	18 27.2	66 08.3	Mh. 8	1 17.2	49 59.2	_29229_*	C33	33.12	E. C. S.
Do.	18 27.2	66 08.3	My. 26	1 12.3	50 03.4	_29251_*	C33	33.12	Do.

SOUTH CAROLINA

	° ′	° ′		° ′	° ′	γ			
Beaufort	32 26.5	80 40.9	Fe. 23	0 23.1 E.	63 39.2	25188	19	55.12	F. M. L.
Walterboro	32 54.0	80 39.6	Fe. 18	0 19.3 E.	64 32.9	24579	19	55.12	Do.
St. George	33 11.0	80 33.5	Fe. 3	0 00.2 W.	64 30.4	24594	19	55.12	Do.
Moncks Corner	33 11.5	80 00.6	Fe. 1, 2	0 34.2 W.	64 38.4	24474	19	55.12	Do.
Barnwell	33 15.3	81 22.8	Fe. 5	1 32.9 E.	65 13.2	23947	19	55.12	Do.
Bamberg	33 17.3	81 01.8	Fe. 17	0 17.5 E.	65 04.2	24110	19	55.12	Do.
Darlington	33 18.7	79 52.1	Ja. 9	0 32.7 W.	66 10.9	23406	19	55.12	Do.
Georgetown	33 22.6	79 16.7	Ja. 21	0 50.9 W.	65 03.3	24204	19	55.12	Do.
Aiken A	33 33.9	81 43.8	Fe. 8	0 33.6 E.	65 08.3	24152	19	55.12	Do.
Do. B	33 33.9	81 43.8	Fe. 12	0 35.7 E.	65 07.5	24129	19	55.12	Do.
Do. A	33 33.9	81 43.8	Fe. 9	0 36.3 E.	65 07.6	24145	21	24.12	L. A. B.
Do. A	33 33.9	81 43.8	Fe. 9	. ....	65 11.4	.....	..	32.12	Do.
Do. B	33 33.9	81 43.8	Fe. 8, 9	0 36.3 E.	65 09.8	24137	21	24.12	Do.
Do. B	33 33.9	81 43.8	Fe. 8	. ....	65 08.3	.....	..	32.12	Do.
Do.	33 33.9	81 43.2	Fe. 15	0 33.7 E.	65 13.1	24074	19	55.12	F. M. L.
Kingstree	33 40.3	79 49.3	Ja. 26	0 36.5 W.	65 35.2	23863	19	55.12	Do.
Manning	33 42.7	80 12.8	Ja. 27	0 22.9 W.	65 22.0	24104	19	55.12	Do.
Conway	33 51.4	79 02.7	Ja. 18, 19	1 13.7 W.	65 33.2	23778	19	55.12	Do.
Marion	34 10.6	79 24.1	Ja. 14, 15	1 09.4 W.	66 00.2	23428	19	55.12	Do.
Bennettsville	34 37.2	79 41.6	Ja. 12	1 07.3 W.	66 11.5	23273	19	55.12	Do.

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* For the values in italics the total intensity determined by Lloyd's method was combined with the observed dip.

TABLE I.—*Results of magnetic observations on land, etc.*—Continued.

TENNESSEE

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	Instruments		Observer
							M.	D.C.	
	° ′	° ′		° ′	° ′	γ			
Jasper	35 04.6	85 37.2	No. 11, 12	3 34.7 E	66 10.3	23677	19	55.12	F. M. L.
Cleveland	35 09.7	84 52.6	Au.31, Se.1	1 27.6 E	65 50.9	23951	20	18.14	E. D. P.
Benton	35 10.4	84 39	Au. 28	1 41.8 E	65 58.2	23781	20	18.14	Do.
Dunlap	35 22.6	85 21.6	No. 9	2 58.8 E	66 37.1	23450	19	55.12	F. M. L.
Athens	35 26.6	84 35.9	Se. 3	0 40.8 E	65 58.5	24020	20	18.14	E. D. P.
Do.	35 26.6	84 35.9	No. 14	0 43.3 E	66 01.7	23986	19	55.12	F. M. L.
Dayton	35 29.7	85 01.3	No. 5	2 26.8 E	66 24.7	23852	19	55.12	Do.
Madisonville	35 30.0	84 21	Au. 25, 26	0 59.2 E	66 12.2	23666	20	18.14	E. D. P.
Decatur	35 31	84 48	No. 16	1 40.5 E	66 23.7	23822	19	55.12	F. M. L.
Pikeville	35 36.5	85 11.6	No. 6, 7	2 54.4 E	66 50.2	23222	19	55.12	Do.
Loudon	35 44.6	84 21.5	No. 23	0 17.1 W	66 21.3	23997	19	55.12	Do.
Maryville	35 45.0	83 58.2	Au. 21	1 02.0 E	66 42.2	23262	20	18.14	E. D. P.
Sevierville	35 51.4	83 33	Au. 11, 12	0 28.0 E	66 56.2	23143	20	18.14	Do.
Kingston	35 51.8	84 30.0	No. 3	1 21.9 E	67 16.8	23110	19	55.12	F. M. L.
Knoxville	35 56.3	83 57.6	Au. 7, 8	0 18.1 W	66 40.9	23346	20	18.14	E. D. P.
Newport	35 56.9	83 10	Jy. 29, 30	0 15.8 E	67 04.0	23037	20	18.14	Do.
Crossville	35 57	85 01.9	Oc. 29, 31	3 27.5 E	67 36.4	23317	19	55.12	F. M. L.
Dandridge	36 01.4	83 25	Au. 1, 3	0 15.8 E	67 03.5	23038	20	18.14	E. D. P.
Clinton	36 06.2	84 07.7	Oc. 22	0 05.6 E	67 07.6	23112	19	55.12	F. M. L.
Wartburg	36 06.6	84 36	Oc. 23	1 09.1 E	66 50.6	23745	19	55.12	Do.
Erwin	36 08.6	82 25.9	Jy. 16, 17	0 11.6 E	67 34.0	22571	20	18.14	E. D. P.
Greeneville	36 10	82 50	Jy. 21, 22	0 23.7 W	67 13.5	22847	20	18.14	Do.
Morristown	36 11.9	83 18	Jy. 27, 28	0 20.4 E	67 16.0	22943	20	18.14	Do.
Maynardville	36 14.6	83 48.1	Au. 18, 19	0 10.6 W	67 04.8	23373	20	18.14	Do.
Jonesboro	36 15.6	82 28	Jy. 18, 19	0 19.4 E	67 30.5	22486	20	18.14	Do.
Rutledge	36 16.6	83 32	Au. 5, 6	0 02.9 W	67 09.8	22991	20	18.14	Do.
Elizabethton	36 20.4	82 12.8	Jy. 6	0 10.8 E	67 44.7	22358	20	18.14	Do.
Rogersville	36 24.2	83 00	Jy. 24, 25	0 08.1 W	67 39.2	22617	20	18.14	Do.
Huntsville	36 24.6	84 30	Oc. 24	0 24.1 W	67 56.8	22695	19	55.12	F. M. L.
Tazewell	36 26.7	83 33.9	Au. 15	0 43.5 W	67 33.9	23051	20	18.14	E. D. P.
Jamestown	36 26.8	84 56.2	Oc. 27	3 05.1 E	67 28.1	23049	19	55.12	F. M. L.
Mountain City	36 28.3	81 48.6	Jy. 9, 10	0 32.4 W	67 57.9	22201	20	18.14	E. D. P.
Blountville	36 29.5	82 20.6	Jy. 13	0 24.9 W	67 38.3	22448	20	18.14	Do.

WASHINGTON

				East					
	° ′	° ′		° ′	° ′	γ			
Seattle	47 39.6	122 18.4	No. 12-20	22 59.5	70 49.5	19331	20	15.24	J. W. M.
Do.	47 39.6	122 18.4	Mh. 15	23 09.2	70 49.5	19373	20	15.24	D. L. H.
Do.	47 39.6	122 18.4	Mh. 16	.. ....	70 48.2	.....	..	32.12	Do.
Port Townsend	48 07.4	122 45.3	Fe. 20-24	23 15.7	71 15.0	19005	20	15.24	H. L. B.
Port Angeles	48 08.4	123 26.0	Ap. 5	23 40.7	70 57.5	19402	20	32.12	Do.

TABLE I.—*Results of magnetic observations on land, etc.*—Concluded.

FOREIGN COUNTRIES

Station	Latitude	Longitude	Date	Declination	Dip	Horizontal intensity	Instruments		Observer
							M.	D. C.	
Canada	° ′	° ′		*East* ° ′	° ′	γ			
Union	49 35.9	124 53.5	Ap. 2	26 05.6	71 26.4	18979	20	32.12	H. L. B.
Do.	49 35.9	124 53.5	Ap. 2	.. ....	.. ....	*18973**	..	32	Do.
Bahama Islands				*West*					
Clarence Town	23 06	74 59	Jy. 14, 15	0 13.4	53 47.3	*29391**	C†	56.34	O. L. F.
Cockburntown	24 04	74 26	Jy. 13	0 18.0	55 03.2	*28816**	C†	56.34	Do.
Nassau				*East*					
Old Govt. House	25 05	77 22	Jy. 2, 3	0 20.1	56 09.5	*28721**	C†	56.34	Do.
Public Square	25 05	77 21	Jy. 4	0 13.1	.. ....	.....	C†	.....	Do.
Hog Island	25 06	77 21	Jy. 5	0 24	.. ....	.....	C†	.....	Do.
Hope Town	26 31	76 58	Jy. 22	.. ....	58 06.7	.....	..	56.3	Do.

TABLE II.—*Results of magnetic observations at sea, January 1, 1903, to June 30, 1904.*

ATLANTIC OCEAN

Place	Latitude	Longitude	Date, 190—	Declination	Dip	Total intensity	Ship	Number of headings	Sea
	° ′	° ′		*West* ° ′	° ′	γ			
Mayaguez, P. R.	18 15	67 12	4, Fe. 18	0 49	49 10	44860	Bache	16	Sm.
Do.	18 15	67 12	4, My. 14	0 58	49 20	45310	Do.	16	Sm.
Fajardo Roads, P. R.	18 21	65 36	3, Ja. 30	1 45	49 02	.....	Blake	16‡	Mod. sw.
Do.	18 21	65 36	3, My. 25	1 35	49 15	45800	Do.	16	Sm.
Do.	18 21	65 36	4, My. 31	. ..	49 28	45700	Do.	16	Sm.
Do.	18 22	65 36	4, Mh. 19	0 52	49 19	45580	Do.	16	Mod. sw.
At sea	20 14	66 51	4, Mh. 14	1 50	51 18	47010	Do.	16	Mod. sw.
Do.	21 12	67 17	4, Mh. 14	. ..	53 06	47670	Do.	16	Mod. sw.
Do.	22 00	68 00	4, Fe. 9	1 57	54 08	47820	Bache	8	Rough
Do.	23 30	68 09	4, Mh. 13	2 29	55 20	49430	Blake	16	Sm.
Do.	24 29	68 35	4, Mh. 13	3 26	56 26	50050	Do.	16	Sm.
				East					
Key West, Fla.	24 30	81 51	3, Je. 9	2 48	.. ..	.....	Hydrog.	16‖	
Do.	24 32	81 50	4, Mh. 13	2 48	.. ..	.....	Do.	16	Sm.
Do.	24 32	81 49	3, Je. 8	2 39	.. ..	.....	Bache	16	Sm.
				West					
At sea	25 16	69 35	4, Fe. 8	2 40	57 34	50310	Do.	8	Hvy. sw.
Do.	27 28	70 52	4, Je. 5	3 40	59 09	52350	Blake	16	Mod. sw.
Do.	28 10	71 10	4, Fe. 7	3 04	60 24	52980	Bache	8	Hvy. sw.
Do.	28 12	71 04	3, Je. 2	. ..	60 03	53490	Blake	8	Rough.
Do.	28 16	71 00	3, Ja. 24	3 58	59 55	.....	Do.	8	Mod. sw.
Do.	30 46	72 39	4, Je. 6	3 52	62 47	54720	Do.	16	Mod. sw.
Do.	31 15	72 52	4, Fe. 6	3 12	63 32	54850	Bache	8	Sm.
Do.	31 40	72 56	4, Je. 1	4 07	63 07	55650	Do.	8	Rough

* For the values in italics the total intensity determined by Lloyd's method was combined with the observed dip.

† Compass attachment of theodolite No. 3416.

‡ Swung only one way.

‖ Observations made on 16 equidistant points while swinging one way and on the other 16 points while swinging the other way.

TABLE II.—*Results of magnetic observations at sea, etc.*—Concluded.

ATLANTIC OCEAN—Continued.

Place	Latitude	Longitude	Date, 190—	Declination	Dip	Total intensity	Ship	Number of headings	Sea
				West					
	° ′	° ′		° ′	° ′	γ			
Off Charleston, S.C.	32 42	79 46	3, Je. 12	0 51	.. ..	.....	Bache	16	Roll
Do.	32 45	79 53	3, Je. 13	1 01	.. ..	.....	Hydrog.	16*	
At sea	33 13	73 17	4, Mh. 10	4 35	65 00	56580	Blake	16	Mod. sw.
Do.	34 00	74 35	4, Fe. 5	4 23	66 08	56780	Bache	8	Sm.
Hampton Roads, Va	36 57	76 22	4, Fe. 2	4 22	68 26	58560	Do.	16	Choppy
Do.	36 57	76 22	4, Fe. 2	4 36	68 38	58430	Do.	16	Do.
Do.	36 57	76 22	4, Je. 3	4 33	68 27	58520	Do.	16	Sm.
Do.	36 57	76 22	4, Mh. 6	4 45	68 31	58530	Blake	8	Sm.
Do.	36 57	76 22	4, Je. 8	4 33	68 38	58490	Do.	16	Sm.
Do.	36 58	76 21	3, Je. 16	4 12	.. ..	.....	Bache	16	Sm.
Do.	36 59	76 08	3, Au. 7	4 30	.. ..	.....	Blake	16	Sm.
Do.	36 59	76 08	3, Au. 7	4 37	.. ..	.....	Do.	8†	Sm.
Do.	37 01	76 14	3, Je. 19	4 07	.. ..	.....	Hydrog.	16*	
Chesapeake Bay, Md	38 06	76 30	3, No. 21	5 12	.. ..	.....	Do.	16	Sm.
Do.	38 20	76 23	3, Oc. 25	5 14	69 22	59870	Blake	16	Sm.
Do.	38 22	76 20	4, Mh. 5	4 49	69 43	59650	Do.	16	Sm.
Do.	38 30	76 25	3, Ja. 21	5 09	69 56	59590	Do.	16	Sm.
Delaware Br'kwater	38 48	75 07	3, Au. 15	5 59	.. ..	.....	Bache	16	Sm.
Do.	38 49	75 07	3, Au. 15	6 02	.. ..	.....	Do.	16	Hvy. sw.
New York Harbor	40 34	74 02	3, No. 21	8 25	.. ..	.....	Do.	16	Sm.
Gay Head, Mass.	41 24	70 50	3, Au. 18	12 47	.. ..	.....	Do.	16	Sm.
Cuttyhunk, Mass.	41 27	70 54	3, Se. 14	12 08	.. ..	.....	Blake	16	Sm.
New Bedford, Mass.	41 31	70 53	3, Au. 10	11 50	.. ..	.....	Do.	16	Sm.
Buzzards Bay, Mass.	41 32	70 52	3, Oc. 21	12 34	72 19	60100	Do.	16	Sm.
Johns Bay, Me.	43 51	69 32	3, Oc. 30	15 33	.. ..	.....	Bache	16	Sm.
Bar Harbor, Me.	44 20	68 09	3, Se. 9	17 15	.. ..	.....	Do.	16	Sm.

PACIFIC OCEAN

				East					
San Francisco, Cal.	37 48	122 22	4, Je. 7	17 19	62 15	54410	Patterson	16	Sm.
At sea	45 49	130 55	4, Ap. 9	22 23	67 28	56460	Do.	16	Mod. sw.
Do.	46 10	130 05	4, Ap. 9	23 26	67 36	56360	Do.	16‡	Mod. sw.
Port Angeles, Wash.	48 08	123 25	4, Ap. 7	24 27	70 58	59470	Do.	16‖	Sm.
Victoria, B. C.	48 24	123 25	3, Je. 20	23 17	.. ..	.....	Do.	32	Sm.
Sitka, Alaska	57 02	135 19	3, Jy. 22	29 56	.. ..	.....	Do.	32	Sm.
Gastineau Channel, Alaska	58 14	134 18	3, Oc. 11	25.9	.. ..	.....	Gedney	1	Sm.

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* Observations made on 16 equidistant points while swinging one way and on the other 16 points while swinging the other way.

† Swung only one way.

‡ Compass observations made only while swinging with port helm.

‖ Swung on 16 points one way and on 32 the other way.

DESCRIPTIONS OF STATIONS.

Magnetic observers are instructed to mark every station in as permanent a manner as possible, either with a stone or a post of some durable wood, so that it may be available for future occupation. They are also required to furnish a detailed description, so that the station may be located even if the marking should be destroyed, and to determine the true bearing of two or three prominent objects in addition to the one used as a reference mark in the azimuth and declination observations. The information is given in abridged form on the following pages for each of the stations occupied during the year. Further details can usually be obtained on application to the Superintendent of the Coast and Geodetic Survey. The usual method of marking a station is by a stone post about 3 feet long and 6 or 8 inches square set so as to project an inch or two above ground and lettered on top U. S. C. & G. S., with a drill hole in the center to mark the exact point. Whenever the local authorities desired and were willing to bear the expense, a second stone was set to denote the true meridian.

The descriptions of stations are arranged alphabetically by States and by name of station.

ALABAMA.

Ashville, St. Clair County.—The station is about one-fourth of a mile southwest of town in a piece of rough land lying just west of the cemetery and on the left-hand side of the road from Ashville to Springville. It is 13.6 feet from a small pine tree to the northwest, 65 paces from the southwest corner of the cemetery, 23 paces from the fence across the road to the northwest, and 44 paces from the northwest corner of the farm to the south. It is marked by a limestone 36 by 6 by 6 inches, lettered on top U. S. C. & G. S., 1903, and projecting 4 inches above ground. The south edge of the chimney of the house on Mrs. Ashley's farm bears 73° 54′.4 west of true south. The left edge of the chimney of a small house on Mr. Thomas Hodge's property bears 33° 26′.3 east of true north.

Birmingham, Jefferson County.—The station of 1903 is in the southern part of Elm Leaf Cemetery, which is about 2½ miles southwest of the court-house and 1½ miles southwest of the station of 1900. It is in the middle of the alley between sections 5 and 6 of Division E, and is 152.6 feet from a large pine tree, slightly east of south, and 73.2 feet from the east edge of a driveway. It is marked by a limestone 36 by 5 by 7 inches, lettered U. S. C. & G. S., 1903, and sunk flush with the ground. The spire of the Irvington College building bears 21° 47′.9 west of true north. The east edge of the smokestack of the old cotton factory bears 41° 47′.6 east of true north.

Center, Cherokee County.—The station is in the unused street one block east of the court-house. It is 11 feet from the fence on the east side of the street, 27.3 feet from the fence on the west side of the street, 69 feet from the south line of the cross street to the north, and 19 feet from a small oak tree north of east. It is marked by a limestone 34 by 6 by 6 inches, lettered U. S. C. & G. S., 1903, and set flush with the surface of the ground. The Baptist Church spire bears 57° 47′.1 east of true south.

Fort Payne, Dekalb County.—The station is in the northwest corner of the campus of North Alabama College, which is in the eastern part of the city. The station is 193 feet from the northwest corner of the porch of the college building, 28.8 feet from the north fence, and 27 feet from the west fence of the campus. It is marked by a limestone 34 by 6 by 6 inches, lettered U. S. C. & G. S., 1903, and set flush with the ground. The court-house spire bears 83° 40′.9 west of true south. The Baptist Church spire bears 73° 05′.8 west of true south.

Gadsden, Etowah County.—The station is in Cherry street, 43.6 feet west of the west line of South First street. It is 14 feet north of the south line of Cherry street and 93 feet west of an angle in the fence inclosing Hughes's cemetery. It is marked by a limestone 34 by 6 by 6 inches, lettered U. S. C. & G. S., 1903, set flush with the ground. The Methodist Church spire bears 13° 13′.9 west of true north.

Descriptions of stations—Continued.

ALABAMA—Continued.

Guntersville, Marshall County.—The station is on the high hill just west of town. It is located at what would be (if extended) the intersection of two streets, namely, the street passing north of Samuel's Hotel and south of the court-house square, and the fourth street west of the court-house. It is marked by a limestone post 34 by 6 by 6 inches, lettered U. S. C. & G. S., 1903, and projecting 2 inches above ground. The court-house spire bears 72° 10′.7 east of true south. The spire of the M. E. Church South bears 34° 50′.4 east of true south.

Oneonto, Blount County.—The station is in the street not far from the base of the mountain west of town and is about 2½ blocks southwest and 2½ blocks northwest of the court-house. It is 40.5 feet from the northeast corner of the fenced lot to the south and 78.8 feet from the northwest corner of the fenced lot to the east. It is marked by a limestone post 36 by 5 by 7 inches, lettered U. S. C. & G. S., 1903, and projecting 4 inches above the ground. The court-house spire bears 88° 20′.9 east of true south. The Methodist Church spire bears 69° 01′.4 east of true south. The shoolhouse spire bears 12° 28′.4 west of true south.

Scottsboro, Jackson County.—The station is in the southwest corner of the campus of Scottsboro Baptist Institute, about 250 feet from the southwest corner of the college building. It is 38 feet from the south fence, 39 feet from the west fence, and 17.6 feet from a small hickory tree north of east. It is marked by a limestone 38 by 6 by 6 inches, lettered U. S. C. & G. S., 1903, and set flush with the ground. The highest point on the court-house dome bears 47° 53′.6 west of true north. The north gable of Jackson County Flour Mills bears 72° 36′.0 west of true south.

ALASKA.

Dutch Harbor, Unalaska Island.—The station of 1900 was reoccupied. It is on the west slope of the hill southeast of Dutch Harbor at an elevation of about 130 feet. The station is on line from the azimuth mark to the Coast and Geodetic Survey astronomic station in Unalaska, being 115 feet south of the former.

IPHIGENIA BAY.

Albans, Cape St. Albans.—The station is 78.3 feet northerly from the triangulation station Albans and in line with it and Warren 2. The mark, the signal at Warren 2, bears 16° 17′.9 east of true south.

Black, on Black Rock.—The station is in line from Black to Lichen and is 12.6 meters from station Black of the triangulation. The mark, triangulation station Lichen, bears 58° 33′.8 west of true north.

Black A, on Black Rock.—The station is in line with triangulation stations Black and Gull, being 2.6 meters from station Black. The mark, station Gull, bears 5° 37′.1 east of true south.

Black B, on Black Rock.—The station is in line with triangulation stations Black and Surf, being 6.2 meters from station Black. The mark, triangulation station Surf, bears 61° 25′.2 east of true south.

Green, Green Island.—The station is 42.6 feet northerly from triangulation station Green and in line with it and Surf. The mark, Surf, bears 5° 49′.6 west of true south.

Green A, Green Island.—The station is 28.6 feet southwesterly from triangulation station Green and in line with it and Wolf. The mark, Wolf, bears 55° 30′.6 east of true north.

Gull, on Gull Island.—The station is in line from Gull to Black, being 40 feet from the former. The mark, Black, bears 5° 36′.1 west of true north.

Heather, west shore of Kosciusko Island.—The station is in line from Heather to Warren 2, being 56.3 feet from the signal at Heather. The mark, Warren 2, bears 81° 09′.7 west of true south.

Heather A, west shore of Kosciusko Island.—The station is in line from Heather to Lichen, being 73.1 feet from the signal at Heather. The mark, Lichen, bears 18° 37′.9 west of true south.

Lichen, east shore of Warren Island—The station is in line from triangulation station Lichen to Heather, being 37.5 feet from the signal at Lichen. The mark, Heather, bears 18° 36′.6 east of true north.

Descriptions of stations—Continued.

ALASKA—Continued.

Lichen A, east shore Warren Island.—The station is 32.2 feet from triangulation station Lichen and in line with it and Black. The mark, station Black, bears 58° 37′.9 east of true south.

Surf, entrance to Port Alice.—The station is 7.5 meters from triangulation station Surf and in line with it and Black, which bears 61° 18′.8 west of true north.

Surf A, entrance to Port Alice.—The station is 12.3 meters from triangulation station Surf and in line with it and Green, which bears 5° 48′.7 east of true north.

Warren, north shore of Warren Island.—The station is 41.4 feet from the signal at Warren 2, and in line with it and Albans, which bears 16° 14′.1 west of true north.

Warren A, north shore of Warren Island.—The station is 113.5 feet from the signal at Warren 2 and in line with it and Heather, which bears 81° 05′.8 east of true north.

JUNEAU AND VICINITY.

Juneau school.—The station is in the southwest corner of the native school yard, 6.6 feet nearly southwest from the southwest corner of the school building and 4.2 feet northwest from an electric-light pole. The first pile west of Juneau Island in a group of small piles between it and Douglas Island bears 29° 23′.0 east of true south.

Station 1.—The station is located 4.5 feet south of a large prominent dead spruce tree near the northwest end of Juneau Island. The station was marked by the central one of three copper nails driven into the middle one of three large roots projecting southward from the trunk of this tree. The cross on the Catholic Church in Douglas city bears 26 °47′.2 west of true south.

Station 2.—The station is within 6 inches of Dr. L. A. Bauer's station of 1900 on the northeast corner of Juneau Island. It is located 2.5 feet south of a large dead spruce tree, "the most prominent tree on the island," and is marked by the central one of three large copper nails driven in a row in the central one of three large roots diverging from the trunk of the tree toward the south. The cross on the Catholic Church in Douglas city bears 41° 09′.6 west of true south.

Station 3, Gastineau Channel, Salmon Creek.—The station is at about high-water mark on the beach, just southeast of the branch of Salmon Creek next to Juneau. It is 15 feet west northwest from an old United States signal, 2 feet south southwest from a line of fence posts, and about 400 feet east southeast from "Creek Jim's" house, on a small creek south of Salmon Creek. A tree on a remote hill across the channel bears 68° 20′.2 west of true north.

Station 4, Douglas Island.—The station is about 120 feet southeast of the oil house of the Ready Bullion mine, in a gulch or part of an old mine drift, between two railroad tracks. The station is about 90 feet from the railroad track along the beach and about 150 feet from the northeast corner of the blacksmith shop. The west edge of the schoolhouse at the azimuth station, Juneau, bears 34° 39′.1 west of true north.

Station 5, Gold Creek Basin.—The station is near the east end of the basin near Juneau, in the gravel on the north side of the creek and near the steep bank to the north. The station is about 150 feet east of a cabin on the opposite side of the creek. A distant tree trunk on a hill bears 81° 33′.1 west of true south.

Juneau Hill.—The station established in 1900 by Dr. L. A. Bauer on the hill east of town was reoccupied. It is marked by a nail in a spruce stump about 6 feet in diameter. The flagpole on Capt. M. Campbell's house bears 8° 44′.7 west of true south.

Station 7, Gastineau Channel, Sheep Creek.—The station is almost exactly one-half mile northwest of the mouth of Sheep Creek and on the beach of Gastineau Channel. The station is about 540 feet northwest of the Sheep Creek pier and 46 feet southeast of a large rock on the beach. The southern edge of the lowest southernmost window in the stamp mill of the Ready Bullion mine bears 62° 35′.4 west of true south.

Station 8, Gastineau Channel, point near Price's farm.—The station is on the beach and on the "point" northwest of Price's farm. It is 4 feet northwest of a post firmly set and marked *N. W. Corner Price's.* The tree at Station 1, Juneau Island, bears 40° 44′.9 east of true south.

Station 9, Gastineau Channel, Lawson Creek.—The station is in the northwestern corner of

Descriptions of stations—Continued.

ALASKA—Continued.

Douglas City Cemetery, some 500 feet southeast of Lawson Creek on the Douglas city side. It is about 50 feet from the wire fence on the northeast side of the cemetery, 250 feet from the wire fence on the northwest side, and about 100 feet from the beach to the northeast. The signal at the azimuth station in the school yard at Juneau bears 10° 34′.0 west of true north.

Station 10, Gold Creek Basin.—The station is about 120 feet north of and across the creek from the old blacksmith shop, and on the hillside in the west end of Gold Creek Basin. It is 23.2 feet south southeast from Post No. 1 U. S. S. 289, 6.8 feet from a copper nail in the base of an old tree stump to the east southeast and 8.2 feet from a second copper nail in the top of a second old stump to the south southwest. The tip of a dead tree almost on the brink of the north side of Juneau Hill bears 60° 53′.4 west of true south.

Station 11, Bullion Creek or South Branch of Parts Creek.—The station is on the beach a few feet north of the creek and about 50 feet toward the channel from the precipitous bank through which the creek issues. The north frame of the north window in the red house north of the Stamp Mill at Sheep Creek bears 50° 37′.7 east of true north.

Station 12, Gastineau Channel, south of Sheep Creek.—The station is south of Sheep Creek, a little northwest of a mass of rock, and on a small semicircular shell-covered beach along Gastineau Channel. The left edge of the building on the wharf at Sheep Creek bears 50° 25′.1 west of true north.

Station 13, Gastineau Channel.—The station is on the beach near high-water mark almost exactly 600 feet southeast of the second creek below Sheep Creek. The mark was the first prominent bare tree trunk to the right of the cabin, north of the tent, north of Nevada Creek across the channel, and bears 74° 26′.8 west of true south.

Station 14, Marmion Island.—The station is above the extreme high-water mark on the north beach of Marmion Island and is 10 or 15 feet north of the most northern portion of the rock bluff. The mark, a prominent grave pole in the Indian burial ground across the channel, bears 76° 12′.8 east of true north.

Station 15.—The station is about 50 feet east of the most southern creek on the mainland. It is on the beach not far below high-water mark and is marked by a bowlder a foot and a half in diameter. The mark, a prominent post or dead-tree trunk across Gastineau Channel, bears 50° 00′.6 west of true south.

Station 16.—The station is on the beach about 50 feet south of the first creek to the south of Bullion Creek, and 31.7 feet from an upward projection on a large misshapen stump at about high-water mark. It is almost in line with this stump and the first telephone or electric-wire pole south of a large dead-tree trunk south of Sheep Creek Wharf across the channel. This pole is the mark and bears 10° 15′.2 east of true north.

Station 17.—The station is on the beach close to the rocky shore of Stephens Passage, a few feet above high water. It is about 10 feet south of a small creek, about the same distance southwest from a large granite bowlder and 4.5 feet west from a copper nail driven into a large mass of natural rock. The mark, the trunk of a prominent tree on a hill across Stephens Passage, bears 69° 50′.3 west of true south.

Station 18, Hilda Point.—The station is located on the beach of Stephens Passage, a little to the north of the center of Hilda Point, and about 70 feet below the high-water line. The mark, the first fence post to the left of the corner of the farm on the creek to the north, bears 14° 52′.4 east of true north.

Station 19, Two Tree Point.—The station is on the beach, some 20 feet below high-water mark, and is 690 paces north of the signal erected at about the center of Two Tree Point. The station is in line with this signal and a prominent branch projecting vertically upward from a dead tree lying on the beach about 15 feet to the north. The mark was a point just below the supports of the signal and bears 21° 48′.8 east of true south.

Station 20.—The station is on Treadwell Point, and is marked by three copper nails in a large stump south of the powder magazine. It is about 15 feet from the upper edge of the cliff or rocky wall facing the channel. Stations 30, 31, and (B), Bauer's station of 1900 on Bullion Creek, are very near.

Descriptions of stations—Continued.

ALASKA—Continued.

The north window frame in the red house north of the Stamp Mill at Sheep Creek bears 62° 36′.7 east of true north.

Station 21, near Lemon Creek.—The station is at about high-water mark on the shore of Gastineau Channel, about 100 feet south of a corner post nearly at the top of the prominent projection south of Lemon Creek. It is marked by a board, nailed with copper nails to the top of a rotten stump, which is 200 yards northwest along the beach from a big dike. The mark is a signal north of Salmon Creek and bears 36° 51′.6 east of true south.

Station 22.—The station is on the Gold Creek delta, some 125 feet below a point taken to be the point of separation of the two branches of the creek. It is 10.5 feet southeast from the center of a certain stump and is almost in line with this stump and the dead spruce tree at Station 1, Juneau Island. This tree is the mark and bears 33° 57′.2 east of true south.

Station 23, near Nevada Creek.—The station is on the first point south of Nevada Creek, at just about high-water mark. It is about 400 feet southeast of the southern end of the precipitous cliffs south of Nevada Creek. About 50 feet inland a small creek issues into the channel. The instruments were set over a "corner post" to some claim and a tree trunk across the channel was used as a mark. It bears 25° 37′.2 east of true north.

Station 24.—The station is on the north beach of Gastineau Channel, almost exactly east of the Treadwell Wharf, and is 700 feet southeast along the beach from the creek east and a little north of Treadwell City. At this place there is a very small "point" formed by a small creek falling down the mountain side, and the station is on the north side of this creek a little below high-water line. The mark, the Alaska-Mexican flagpole, bears 39° 23′.0 west of true south.

Station 25.—The station is on the north beach of Gastineau Channel, 418 feet northwest of Shattuck's powder magazine, and about 30 feet below high-water mark. The mark, the left window sash in the fish house on the end of Douglass City Wharf, bears 3° 19′.8 east of true south.

Station 26.—The station is not far north of the north shore of Conee Creek and is 10.5 feet northwest of the U. S. L. Monument No. 5. The mark, the center of the uppermost window in Chief Johnson's house across the channel near the south end of Juneau, bears 87° 55′.9 east of true south.

Station 27.—The station is at the northwest corner of the northernmost point of Douglas Island, a little below high-water mark, on the beach facing the mud and sand bar. The mark, a tree on the rocky projection across the flats, bears 35° 55′.7 east of true north.

Station 28. The station is on the beach of the east shore of Stephens Passage and south of Outer Point. The station is about 15 feet below high-water mark and the same distance north from the southern end of the strip of land ending in Outer Point. The mark, a tree across Stephens Passage, bears 70° 02′.0 west of true south.

Station 29.—The station is on the beach of Treadwell Point, about 30 feet from the main part of the precipitous shore and 138 feet from the pier of the powder magazine. The mark, the signal at Juneau School azimuth station, bears 36° 41′.7 west of true north.

Stations 30 to 42.—Treadwell Point: These stations are all very near together and were occupied for the purpose of locating the local magnetic pole, the center of marked local disturbance, at this place.

Orca 1.—The station is on the eastern coast of Prince William Sound on Cordova Bay. It is about 100 feet back of Orca post-office, 85 feet northeast of the Pacific Packing and Navigation Company's laborers' bunk house and 150 feet southwest of the west wing of L house back of the post-office, in a small cleared space. The station is marked by a round spruce stub, 18 inches long and 4 inches in diameter, with a copper tack in the top, sunk flush with the ground. A prominent dead tree on Hawkins Island bears 89° 15′ west of true north.

Orca 2.—The station is very near Orca 1, and is marked by a 3-inch circular fir stub, sunk flush with the ground. It is 49.8 feet north of west from Orca 1. The prominent dead tree on Hawkins Island bears 61° 28′.2 west of true north.

Sitka Magnetic Observatory.—In the absolute building. For description of observatory see Appendix 5, Report for 1902.

Descriptions of stations—Continued.

ALASKA—Continued.

Yakutat.—The station is on a narrow point of land, the southerly end of Khantaak Island. It is about 30 feet from high-water mark on the Port Mulgrave side and 50 feet from a small lake which is about midway between Port Mulgrave and the De Monti Bay shore. This station is at the extreme northerly end of an old Indian graveyard, and is about 250 yards northwest from the mark, the northwest gable of the grave house nearest the Port Mulgrave beach, at the south end of the graveyard. This mark bears 30° 51′.8 west of true south. The station is marked by a round fir stub, 3 by 18 inches, sunk flush with the ground.

CALIFORNIA.

Berkeley, Alameda County.—The station is on the grounds of the University of California, west of and in line with the north face of South Hall. It is 261.5 feet from the northwest corner of South Hall, 31 feet west of the center of the path leading from the gymnasium to North Hall, 46 feet north of the path leading from South Hall to the Center street entrance to the grounds, and 54 feet from the edge of the driveway. It is marked by a granite post 24 by 8 by 8 inches, set flush with the ground and lettered U. S. C. & G. S. The west edge of the gymnasium, just above the porch, bears 44° 34′.4 west of true south. The northwest edge of North Hall bears 14° 46′.1 east of true north.

Goat Island, San Francisco County.—The station is near the center of the plateau just west of the hill at the extreme eastern end of the island. It is nearly in line with the top of the hill and the smokestack at the naval training station and about 50 feet north of the line of the two flagpoles, one on the highest part of the island and the other on the southern part of the lawn in front of the officers' quarters. The station is on the ground belonging to the Army. It is marked by a rough stone 12 by 6 by 6 inches with a flat top in which there is a small hole. This stone projects about an inch above ground and has a cairn of loose stones piled over it. The base of the flagstaff on the lawn bears 42° 47′.3 west of true south. The flagstaff on the highest part of the island bears 44° 59′.5 west of true south.

Palo Alto, Santa Clara County.—The station is about a mile south from the railroad depot and is on the grounds of Stanford University. It is about 700 feet northeast of the new gymnasium and about 400 feet northeast of the Faculty Club House, near the fence which bounds their baseball field on the north. It is 121 feet northwest from a eucalyptus tree and is 11 feet from the north fence. It is marked by a granite post 24 by 14 by 7 inches with a drill hole in the top, which projects 2 inches above ground. The cross on Memorial Church bears 36° 05′.2 west of true south.

San Francisco, San Francisco County.—The station of 1898 being no longer available, observations were made at the triangulation station on Presidio Hill. This station is in a northwesterly direction from the gate on the south side of the Presidio grounds at the edge of the woods, and is marked by a stone post 6 inches square on top, which projects about 6 inches, and is lettered U. S. C. & G. Survey, 1881. The cross on Lone Mountain bears 34° 06′.2 east of true south. The center of the top of Drake Cross bears 27° 03′.7 west of true south.

San José, Santa Clara County.—The station of 1896 was reoccupied. It is just west of the reservoir on the hill in the extreme southwestern part of Oak Hill Cemetery and is 102 feet from a fence corner to the south, 71 feet from the middle one of three posts to the southwest, and 86 feet from the nearest part of the outer face of the cement coping about the reservoir. It is marked by a piece of granite 10 inches square on top and 6 inches thick, lettered U. S. C. & G. S., with a drill hole in the center. The court-house flagstaff bears 27° 37′.9 west of true north. The normal school flagstaff bears 20° 38′.9 west of true north.

Santa Cruz, Santa Cruz County.—The station of 1897 was reoccupied. It is on the United States light-house reservation, 105 feet from the flag pole, and 42 feet northwest of the center of the top of a brick cistern near the road fence. It is marked by a marble post 6 inches square, set flush with the ground and lettered U. S. C. & G. S. The spire of Twin Lakes Baptist Church bears 60° 34′.3 east of true north. The base of the flagstaff and the ball on the light-house tower each bear 12° 07′.7 west of true north.

Descriptions of stations—Continued.

DELAWARE.

Delaware Breakwater, Sussex County.—Triangulation station E of 1900 was occupied. From this station Green Hill Light-house bears 80° 48′.7 west of true south. Cape Henlopen Light-house bears 37° 56′.8 east of true south.

DISTRICT OF COLUMBIA.

Washington.—The principal station was in the small magnetic observatory in the yard adjoining the Coast and Geodetic Survey Office. A second station was established in the vacant field west of the "Brown-Goode" cottage and the Ontario apartment house, on the bluff overlooking the Zoological Park and about south of the present bear pit. It is about 50 feet south of the wire fence of the Zoological Park, about 18 feet southwest of a tree, and about 32 feet northeast of an oak tree 20 inches in diameter. It is marked by an oak stub 12 by 1½ by 1½ inches. The dome of the Ontario bears 61° 02′.8 east of true south.

GEORGIA.

Statesboro, Bulloch County.—The station is on a vacant lot west of the Jaeckel Hotel. It is 83.5 feet from the northwest corner and 92.6 feet from the southwest corner of this hotel. It is also 71 feet from the northeast corner of J. W. Olliff's residence. It is marked with a pine peg driven flush with the ground. The Presbyterian Church steeple bears 32° 19′.3 east of true south. The Baptist Church cupola bears 18° 01′.3 west of true north.

Trenton, Dade County.—The station is in a street and is 2 blocks north and about 5 blocks west of the court-house. It is 96 paces from a gate in a rail fence north of west, and 100 paces from the northwest corner of a small fenced lot owned by Mr. Williams. It is marked by a limestone 20 by 6 by 6 inches, lettered U. S. C. & G. S., 1903, and projecting 1 inch above ground. The Cumberland Presbyterian Church spire bears 32° 33′.1 east of true south. The north edge of the chimney on the I. O. O. F. Hall bears 54° 15′.5 east of true south.

GUAM.

Agat.—The station is near the high-water mark on the beach and about 150 feet southwest of the new schoolhouse.

Agaña.—The magnetic station is the island triangulation station No. 7 on the northwest corner of the old fort above the town. It is 11 600 feet north of the naval astronomical station at Fort Santa Cruz and 29 700 feet east of the same. Triangulation station No. 23 on the reef bears 35° 16′.0 east of true north.

Daño Island.—The magnetic station is 110 feet from triangulation station No. 55, on a coral reef at the west end of the island. It is in line with this station and triangulation station No. 60, which is Schroeder Peak. Triangulation station No. 55 is marked with a short iron tube. From the magnetic station Schroeder Peak bears 34° 17′.1 east of true north.

Merizo.—The station is in the main street of the town and 350 feet west of the center of the bridge. The station is marked with a glass bottle. The azimuth mark is the corner of a house about 800 feet distant; this mark bears 57° 01′.6 east of true south.

Soumaye.—The magnetic station is on the coral rocks on a bluff about 70 feet above sea level. It is about 75 feet southeast of the Coast and Geodetic Survey astronomical station. It is marked by a coral post with a cross cut upon it. A prominent lone tree on a mountain about 4 miles distant bears 18° 11′.6 east of true south.

Umata.—The station is in the main street in the middle of the village, and between the houses of José Sanchez and Vicente Babranta. From this station island triangulation station No. 60 bears 49° 17′.8 east of true south.

HAWAII.

Hanapepe Bay, Kauai Island.—Magnetic station No. 1 is on the west side of the bay, 212.5 meters a little east of north from triangulation station Cave and 47.5 meters west of the edge of the bluff along the bay shore. Magnetic station No. 2 is on the east side of the bay, 170 meters a little west of north from triangulation station Old and 17.5 meters east of the edge of the bluff along the bay shore.

Descriptions of stations—Continued.

HAWAII—Continued.

Honolulu, Oahu Island.—The station of 1900 was reoccupied. It is in the public yard near the government survey building. The precise point is marked by a wooden stake with a nail in the top of it, and can be pointed out by members of the Hawaiian survey office. The azimuth mark is the triangulation mark on the Punch Bowl, the geodetic azimuth of which is 55° 19′.5 east of true north.

Honolulu Magnetic Observatory, Oahu Island.—The observatory is about 12½ miles west of Honolulu and about three-quarters of a mile south of the station Sisal on the Oahu Railway. The observatory is described in Appendix 5, report for 1902.

Kii, Niihau Island.—The station is near the anchorage on the northeastern coast of Niihau, about 2 miles north of the great "pali" or precipice, a little southeast of Aubrey Robinson's house on the beach. A fence post about 800 feet distant bears 10° 35′.0 east of true north.

Nonopapā, Niihau Island.—The station is on the west coast of Niihau near the usual landing place, 456 feet from the large crane at the landing. The crane was used as a mark and bears 25° 54′ west of true north from the station.

Waimea, Kauai Island.—The station of 1892 and designated Waimea A was reoccupied. It is near the old transit of Venus station occupied by the English party in 1874 and reoccupied by Mr. Preston in 1887 and 1892. The station is 105.3 feet northwest from the face of a steep cliff, 103.5 feet from the west corner and 131 feet from the south corner of Doctor Campbell's house. The mark used was the triangulation station on Puu o Papai and bears 62° 36′.0 east of true south.

KANSAS.

Baldwin, Douglas County.—Observations were made in the absolute house of the magnetic observatory, or at a point outside the observatory in line with the azimuth mark. The mark used is the flagstaff on Science Hall, Baker University, and bears 48° 20′.6 west of true north.

Cottonwood Falls, Chase County.—The station is in the northwest corner of the county school grounds in the western part of the city. It is 55.2 feet from the north fence, 21.1 feet from the west fence, 23.5 feet a little west of south from a small catalpa tree, and 16.2 feet northeast from a second small catalpa tree. The station is marked by a Bedford limestone post 33 by 8 by 5 inches, set flush with the ground and lettered on top U. S. C. & G. S., 1904. The Presbyterian Church spire bears 20° 35′.7 east of true south.

Council Grove, Morris County.—The station is inside of the race track and southwest of the amphitheater in the county fair grounds northeast of the city. It is 65.2 feet from the inner fence of the race track, 92 feet from the judge's stand, and 104.2 feet a little west of south from a large walnut tree. The station is marked by a limestone post 18 by 8 by 10 inches, set flush with the ground and lettered U. S. C. & G. S., 1904. The right edge of the city standpipe bears 61° 41′.1 west of true south.

Emporia, Lyon County.—The station of 1902 was reoccupied. It is in the grounds of the College of Emporia, near their southwest corner. The station is 493 feet from the southwest corner of Stuart Hall to the northeast, 42.3 feet from a wire fence (at the inner edge of the semicircular drive) to the west, 105.4 feet from the south wire fence, and 15.2 feet from an elm tree (at the edge of a grove to the south). The station is marked by a stone post 30 by 7 by 7 inches, sunk flush with the ground and lettered on top U. S. C. & G. S., 1902. The steeple of the Arundel Avenue Presbyterian Church bears 1° 26′.5 east of true south. The apex of the dome of Anderson Memorial Library bears 55° 57′.4 east of true north.

Marion, Marion County.—The station is a half mile southeast of the city, on an unsettled tract of land. It is 11 feet east of the west line of Coble street, 12.8 feet south of the south line of Weldon street, and in Coble street just east of lot 16 of block 26 of the southern addition. The station is marked by a Bedford limestone post 36 by 6 by 4 inches, lettered U. S. C. & G. S., 1904, on top, which projects 1 inch above ground and has a drill hole in the center to mark the exact position. A cement post 30 inches long and 6 inches in diameter and marked with a cross on top, which projects about 5 inches above ground, was set 295.4 feet due south to mark the meridian. The flag pole on L. F. Keller's house bears 46° 35′.9 west of true north. The Presbyterian Church spire bears 60° 33′.3 west of true north.

Descriptions of stations—Continued.

KENTUCKY.

Barboursville, Knox County.—The station is near the southwest corner of the court-house square, 30 feet from a large maple tree, 48.8 feet from the west corner of L. C. Miller's store, 57 feet from the east corner of Sampson's law office, and 58.4 feet northeast from the south meridian stone. A meridian line 346.8 feet long is marked by two sandstones 12 inches square on top and projecting 6 inches above ground. The south monument is lettered U. S. C. & G. S., 1903. Each stone has a 1-inch drill hole in its top. From the magnetic station the spire of the M. E. Church bears 39° 17′.8 west of true north.

Beattyville, Lee County.—The station is on a knoll between the depot and the Ninaweb Inn, 31.5 feet a little south of west from a large tree and 40.5 feet nearly south from a second tree. The station is marked by an irregular triangular-shaped rock with a drill hole in its top. The court-house cupola bears 65° 44′.0 west of true north. The flagpole on the Beattyville bank bears 72° 53′.0 west of true north. Declination observations were also made at a point 120 feet north of the magnetic station.

Boonville, Owsley County.—The station is in the southeast corner of the court-house square, 43.2 feet from the southeast corner of the court-house, 20.1 feet from the south fence, and 36.2 feet from the east fence. It is marked by an oak peg. The southwest edge of the M. E. Church bears 55° 47′.1 east of true south. The southeast edge of Doctor Sanders's house bears 13° 55′.4 east of true north.

Brooksville, Bracken County.—The station is in the court-house square between the sheriff's office and the jailer's residence. It is 42 feet north and 7.8 feet east from the south stone of a meridian line 173.6 feet long. The south monument is a stone 24 by 17 by 7 inches, with a drill hole in its top, which is flush with the ground. It is 29.2 feet from the southwest corner of the sheriff's office and 22.2 feet from the northeast corner of the county superintendent's office. From the magnetic station the southeast gable of Sam Hawes's barn bears 72° 37′.1 west of true north.

Campton, Wolfe County.—The station is in the northeast corner of the court-house square, 9.6 feet from the north fence, the same distance from the east fence, and 35.8 feet from the northeast corner of the court-house. It is marked by a sandstone 24 by 9 by 7 inches, projecting 2 inches above ground, with a drill hole in its top. The cupola of the Wesleyan Academy bears 73° 00′.5 west of true south. The east gable of the public school bears 89° 14′.0 west of true north.

Falmouth, Pendleton County.—The station is in the court-house yard, 59.5 feet from the northwest corner of the court-house and 25.9 feet from the west fence. It is marked by a wagon spoke driven flush with the ground. The Catholic Church steeple bears 13° 59′.4 west of true north. The cupola of the Lutheran Church bears 11° 10′.4 west of true north.

Frenchburg, Menifee County.—The station is in the northeast corner of the court-house square, 28.2 feet from the east fence, 22.1 feet from the north fence, and 41.3 feet from the northeast corner of the court-house. It is marked by a stone 6 inches square on top, on which a cross is cut. This is the north end of a meridian line 100 feet long, established by the United States Geological Survey. The south end of this line is similarly marked. The cupola of the M. E. Church bears 18° 53′.5 east of true south. The center of the chimney on the E. Hoover mills bears 39° 28′.2 east of true north.

Georgetown, Scott County.—The station is in the northwest corner of the Baptist College grounds 3.6 inches west of the center of the north meridian stone. The meridian line is 345 feet long. The north stone is 31 by 10 by 4 inches, with a drill hole in its top which projects 7 inches above the ground. The south stone is 43 by 4 by 7 inches, with a cross cut on its top which projects 1 foot above ground. From the magnetic station the cupola of the Colored Baptist Church on Mulberry street bears 27° 40′.3 west of true north. The spire of the Baptist Church bears 81° 16′.5 west of true north.

Harlan, Harlan County.—The station is in the court-house grounds, in line with the north end of the court-house and 51.5 feet from its northwest corner. It is marked by an oak peg driven flush with the ground. A meridian line about 600 feet long is established in the street on the west side of the court-house. The north stone is at the north end of the street near its west side, and the south stone is at the south end of the street near its east side. The south monument is a hard sandstone 36 inches long, champered off to about 10 inches square on top, which projects 9 inches above the ground. The north stone is 30 inches long, squared to about 7 inches on top and sunk flush with the sidewalk. Each stone has a drill-hole in the center of its top. The cupola of G. W. Green's house bears from

Descriptions of stations—Continued.

KENTUCKY—Continued.

the magnetic station 18° 27′.6 west of true north. The southwest gable of the Harlan Hotel bears 1° 24′.6 west of true north.

Harrodsburg, Mercer County.—The station is in the grounds of Beaumont Female College a little south of east from the college building and 103.7 feet from the northeast corner of the hothouse. It is marked by a sandstone 16 by 8 by 7 inches set flush with the ground and with a drill hole in the center of the top. The east gable of the college barn bears 23° 40′.4 west of true south.

Hazard, Perry County.—The station is near the top of a hill behind the schoolhouse and almost in line with the north line of the schoolhouse lot. It is 200 feet from the northeast corner of the schoolhouse, 45 feet from a fence, and 465.5 feet from an iron pipe set in the ground. The station is marked by a sandstone 12 by 13 by 14 inches set flush with the ground. The cupola of the Presbyterian Church bears 20° 14′.6 west of true south. The court-house cupola bears 25° 54′.6 west of true south. The Baptist Church spire bears 39° 58′.9 west of true south.

Hindman, Knott County.—The station is in line with the east end of the post-office building and also with the east end of Carew Smith's residence. It is on the south side of the creek near the fork and is marked by a hickory peg driven flush with the ground. The cupola of the M. E. Church bears 82° 33′.1 west of true south. The court-house cupola bears 79° 42′.0 west of true north.

Hyden, Leslie County.—The station is in the college grounds, south of the building and approximately in line with its west end, and 60.7 feet from the southwest corner of its stone foundation. The station is marked by an oak peg driven flush with the ground. The cupola on the old schoolhouse bears 63° 20′.9 east of true north. The east gable of T. H. Hyden's house bears 79° 43′.0 west of true south.

Inez, Martin County.—The station is on the grounds of the Royal Hotel, 25 feet from its northwest corner and 28 feet from the north fence. It is marked by a hickory peg driven flush with the ground. The northwest edge of the court-house bears 32° 05′.2 east of true north.

Irvine, Estill County.—The station is in the southwest corner of the court-house square, 45.4 feet from the south fence, 31.2 feet from the west fence, and 51.2 feet from the southwest corner of the court-house. It is marked by an oak peg driven flush with the ground. The southeast edge of Powel's saloon bears 15° 40′.7 west of true south. The northwest edge of the jail bears 79° 24′.7 east of true north.

Jackson, Breathitt County.—Observations were made over the north monument of a meridian line established by D. L. Hazard in 1900 in the grounds of the S. P. Lee Memorial College. The cupola of Little Hall bears 25° 40′.6 east of true south. The east gable of the Arlington Hotel bears 84° 11′.2 west of true north.

Lancaster, Garrard County.—The station is in the town cemetery north of the receiving vault and a little west of the center of the driveway. It is 10.4 feet west of the stone rail around the Hiatt lot, 29 feet from the northeast corner of the base of the Allen O. Hiatt monument, and 19.8 feet from the northeast corner of the base of the Louisiana Salter monument. It is marked by a peg flush with the ground. The Baptist Church spire bears 25° 55′.3 west of true north. The cupola on the M. E. Church bears 69° 26′.8 west of true north. The east clock face on the court-house bears 54° 14′.9 west of true north.

Lawrenceburg, Anderson County.—The station is in a pasture belonging to the estate of John Dowling and across the pike opposite the residence of J. C. Vanarsdall. It is 19 feet from an oak 20° north of east, 22.5 feet from a second oak 8° east of south, and 87 feet from a third oak 2° north of west. It is marked by a rough limestone 22 by 6 by 6 inches projecting 2 inches above the ground with a drill hole in the top. The east face of the court-house clock bears 79° 33′.8 west of true south. The cupola of the Christian Church bears 82° 07′.4 west of true south.

London, Laurel County.—The station is in the grounds of the Southern Methodist Memorial College between the college building and the principal's residence. It is marked by a sandstone 24 by 9 by 9 inches set flush with the ground and with a drill hole in the top. This is the south end of a meridian line 450.5 feet long. The north stone is 24 by 8 by 8 inches, set flush with the ground and with a drill hole in the top. This point is almost in line with the southeast side of the college building and is 30.8 feet from its southeast corner. The steeple of the M. E. Church South bears from the south

Descriptions of stations—Continued.

KENTUCKY—Continued.

stone 30° 55′.2 east of true north. The steeple of the M. E. Church North bears 31° 26′.6 east of true north. The steeple of the Baptist Church bears 18° 28′.7 east of true north.

Louisa, Lawrence County.—The station is on the east side of the court-house square, 84.8 feet from the south corner of the court-house and 37.2 feet from the north corner of the Southern Methodist Episcopal Church. It is marked by a marble post 24 by 5 by 5 inches set flush with the ground and with a drill hole in its top. This is the south end of a meridian line 254.8 feet long, the north end of which, near the east fence, is similarly marked. The southwest gable of Mrs. M. J. Ferguson's house bears from the south stone 65° 28′.6 east of true south.

Manchester, Clay County.—The station is in the court-house square in line with the north side of the court-house and 139.5 feet from its northwest corner. It is marked by an oak peg driven flush with the ground. A certain church cupola bears 18° 26′.6 west of true south. The southwest edge of the court-house bears 65° 21′.0 east of true south.

McKee, Jackson County.—The station is in the southwest corner of the court-house square, 29.4 feet from the south fence, 18.6 feet from the west fence, and 55.8 feet from the northwest corner of the court-house. It is marked by a hickory peg driven flush with the ground. The cupola of the Christian Church bears 6° 51′.1 east of true north. The northwest edge of the jail bears 55° 53′.2 east of true north.

Monticello, Wayne County.—The station is in private grounds belonging to Mr. J. H. Shearer and adjacent to and north of Ramsey's Hotel. The station is 17.2 feet from the southwest fence and 37.2 feet from the southeast fence of these grounds. It is marked by an oak peg driven flush with the ground. The southwest gable of J. H. Shearer's house bears 63° 34′.8 east of true south. The northeast edge of Ramsey's Hotel bears 80° 46′.1 west of true south.

Owenton, Owen County.—The station is on the fair grounds in front of the grand stand and just inside the race track. It is 66.7 feet from the southeast corner and 48.9 feet from the northeast corner of the grand stand. It is marked by a hard limestone 24 by 5 by 3½ inches sunk flush with the ground and with a drill hole in its top. The court-house cupola bears 40° 45′.7 west of true north. The north gable of "Billy" Moore's house bears 17° 28′.6 west of true south.

Paintsville, Johnson County.—The station is on the public-school grounds northwest of the building. It is 16.2 feet from the north fence and 90.6 feet from the northwest corner of the school building. It is marked by a stone 43 by 5 by 7 inches projecting 6 inches above ground and with a drill hole in the center of its top. The middle of the tablet over the north door of the court-house bears 00° 00′.4 west of true south.

Pikeville, Pike County.—The station is in the grounds of the Presbyterian College east of the main building. It is 59.5 feet from the east corner of the building and 15.8 feet from the east fence. It is marked by a stone 14 by 18 by 4 inches set flush with the ground and with a drill hole in its top. This is the north end of a meridian line about 350 feet long. The south end is about 8 feet north of a tree 12 inches in diameter and on the south bank of the river. It is marked by a sandstone 30 by 8 by 6 inches projecting 4 inches above ground and with a drill hole in its top. The south clock face on the court-house bears 43° 06′.1 east of true north. The southwest gable of W. T. Huffman's house bears 00° 36′.2 east of true north.

Pineville, Bell County.—The station is in the northwest corner of the court-house square 25 feet from the west fence and 30.3 feet from the north fence. It is marked by a hickory peg driven flush with the ground. A meridian line passing through the magnetic station was marked on the curbstones on the north and south sides of the square. The north meridian mark is 14.7 feet from the northwest corner of the curbing. The cupola of the Baptist Church bears 68° 53′.6 west of true south. The Christian Church cupola bears 34° 07′.9 west of true north.

Prestonsburg, Floyd County.—The station is near the north corner of the court-house square, 19.9 feet from the northwest fence, 26.7 feet from the northeast fence, and 80.6 feet from the north corner of the court-house. It is marked by a pine peg set flush with the ground. The cupola of the Methodist Episcopal Church South bears 60° 20′.9 west of true south. The cupola of the Presbyterian Church bears 45° 08′.9 east of true south.

Descriptions of stations—Continued.

KENTUCKY—Continued.

Salyersville, Magoffin County.—The station is on a vacant lot north of the court-house and belonging to the heirs of William Adams. It is 33.4 feet south and 2.2 feet west of the north meridian stone which is 27 by 5 by 5 inches and projects 5 inches above ground. The meridian is 441 feet long; its south mark is a certain church cupola. From the magnetic station this church cupola bears 00° 17′.8 east of true south. The cupola on the public school bears 6° 48′.9 west of true south.

Sandy Hook, Elliott County.—The station is near the west corner of the court-house square, 64.2 feet from the west corner of the court-house. It is marked by a large irregular-shaped stone, set flush with the ground and with a drill hole in its top. The east gable of the Rose Hotel bears 67° 02′.6 west of true south. The north edge of the Masonic Hall bears 52° 11′.0 west of true south.

Somerset, Pulaski County.—The station is in the large open grounds to the rear and east of the Cumberland Hotel in South Somerset. It is 32.2 feet from the south fence and 29.1 feet from the east fence of these grounds. A tent peg driven flush with the ground marks the station. The west edge of the west oil tank, ¾ of a mile distant, bears 21° 18′.5 west of true south. The southwest edge of the Cumberland Hotel bears 88° 46′.7 west of true south.

Stanton, Powell County.—The station is in the rear of A. T. Pettit's saloon in line with the east side and 86.6 feet from its southeast corner. It is marked by a peg driven flush with the ground. The cupola on the court-house bears 20° 54′.4 east of true north. The Presbyterian Church belfry bears 36° 05′.2 east of true south.

Versailles, Woodford County.—The station is in the northwest corner of Versailles Cemetery about 150 feet from the west fence and about 21 feet from the edge of the terrace. It is 4 inches south and 16 inches east of the north meridian stone. This stone is marble, 28.5 by 9.5 by 9.5 inches, with a drill hole in the center of its top, which is lettered U. S. C. & G. S., 1903, and projects 2.5 inches above ground. About 400 feet south of the north stone is a sandstone 26 by 15 by 12 inches, with a drill hole in its top, which projects 3 inches above ground. From the magnetic station the spire of the Methodist Episcopal Church bears 17° 29′.3 west of true north. The spire of the Presbyterian Church bears 1° 11′.8 west of true north.

West Liberty, Morgan County.—The station is 33.9 feet southeast from the southeast corner of Commercial Inn and 38 feet from the southwest corner of the sample room or hotel annex. It is marked by a stone 14 by 5 by 6 inches with a drill hole in its top which is flush with the ground. The court-house cupola bears 21° 25′.2 west of true south.

Whitesburg, Letcher County.—The station is in the court-house square in line with the east side of the court-house and 42.1 feet from its southeast corner. The station is marked by a sandstone 22 by 6 by 4 inches, with a drill hole in its top, which is flush with the ground. A church cupola bears 30° 10′.6 east of true north. The east gable of M. D. Lewis's house bears 43° 18′.9 west of true north.

Williamsburg, Whitley County.—The station is in the court-house square 46.3 feet southwest from the southwest corner of the court-house, 64.2 feet from the west corner, and 35.2 feet from an iron fence to the southwest. It is marked by a sandstone 20 by 6 by 6 inches with a drill hole in its top, which is flush with the ground. The north end of the meridian line, established by D. L. Hazard in 1900, bears 00° 01′.8 west of true north. The cupola on the brick store south of the court-house bears 6° 25′.6 east of true south.

Williamstown, Grant County.—The station is near the southwest corner of the court-house square. It is 9 feet from a drill hole made in the west stone wall 25.1 feet from its southwest corner, and is 8.2 feet from a second drill hole in the same wall 32.4 feet from its southwest corner. The station is not marked. The cupola on Doctor O'Hara's house bears 39° 35′.6 west of true south. The northeast edge of the opera house bears 7° 17′.9 east of true south.

LOUISIANA.

Abbeville, Vermilion Parish.—The station is in a pasture belonging to Mr. Légé, which is north of the Eunice Branch of the Southern Pacific Railroad and of the railroad station, Abbeville. The station is about 15 feet east of a steep bank which forms the eastern bank of the Vermilion River. The mark is the tip of the ventilator in the west gable end of a schoolhouse about 200 yards east.

Descriptions of stations—Continued.

LOUISIANA—Continued.

This bears 78° 22′ east of true south. The station is marked by two iron pipes set in the azimuth line produced to the west. The first one is 8 feet from the station and is 2 feet long and ¾ inch in diameter. The second one is 14 feet from the station, is 1½ feet long, and 1 inch in diameter.

Alexandria, Rapides Parish.—The station of 1901 was reoccupied. It is in the national cemetery at Pineville, on the east side of Red River. It is marked by a marble post 6 inches square, set so as to leave 3 inches projecting above ground. This post is 135 feet from the brick fence on the southeast side of the cemetery and 223.8 feet from the brick fence on the northeast side. The top of the well house at the superintendent's lodge in the southern part of the grounds bears 46° 27′.0 west of true south. The southwest corner of the brick stable bears 24° 14′.9 west of true south.

Anse-la-Butte, St. Martin Parish.—The station is in the center of the oil field between Lafayette and Breaux Bridge, as shown in the forthcoming Louisiana Geological Survey Report.

Arcadia, Bienville Parish.—The station is on the prolongation of the meridian line established by Dr. G. D. Harris, of the State Geological Survey. It is 151.1 feet north of the present north monument and 216.7 feet from the northwest corner of the court-house. The station is marked by a rough concretionary bowlder set flush with the ground and having a cross (+) to mark the exact point. The spire of the Methodist Church bears 63° 21′.8 east of true north.

Averys Island, Iberia Parish.—Observations were made over the south monument of the meridian line previously established by Dr. G. D. Harris, of the State Geological Survey.

Baldwin, St. Mary Parish.—The station is marked by a stake driven in a levee along the south side of a ditch. This stake is east of the Southern Pacific Railroad depot and section house and is about 30 feet northwest along the levee from a road running northeast and southwest and across the railroad. The mark, a small cupola one-half mile distant, bears 72° 06′.2 east of true south.

Bastrop, Morehouse Parish.—The station is on the meridian line produced, being 265.4 feet south of the present south monument. It is in the open lot south of the school yard and is marked by a pine post 6 inches square projecting 2 inches above ground, and having a nail in the top to mark the exact point. The spire of the Episcopal Church bears 35° 31′.0 west of true north. The meridian line was established by Dr. G. D. Harris.

Benton, Bossier Parish.—The station is in the vacant lot southwest of the court-house. It is 78.5 feet from the fence to the south and 89 feet from the fence to the west. The station is marked by a large sandstone bowlder projecting 3 inches above ground and having a cross to mark the exact point. The spire of the Presbyterian Church bears 31° 49′.0 east of true north. Two limestone posts, each 6 by 8 by 30 inches, projecting 4 inches above ground, and having a cross to mark the exact point, are set in the court-house yard, and with the magnetic station form a meridian line. The south stone is 147 feet north of the magnetic station and 69.8 feet from the southwest corner of the court-house. The north stone is 204 feet north of the south monument and is 69.0 feet from the northwest corner of the court-house.

Cheneyville, Rapides Parish.—The station is in the fields southwest of the Texas Pacific Railroad depot. It is about 110 feet west of a narrow road running north and south and 40 feet west of the intersection of two paths, which with the narrow road surround a negro hut and barn on three sides. The station is marked by a stake. The Baptist Church spire bears 6° 49′ east of true north.

Colfax, Grant Parish.—The station is on the left or north bank of Red River, about one-fourth of a mile almost due south of the court-house. It is 110.7 feet from the northeast corner of a lot owned by J. H. McNeeley; 119.5 feet from the northwest corner of a lot belonging to Edd Evans, and 128.5 feet from the southwest corner of the lot of Mrs. Calhoun, these last two lots being on opposite corners of a street running northeasterly from the river and at its intersection with the street running along the river. The station is marked by a sandstone bowlder set flush with the ground and having a lead plug to mark the exact point. A meridian line was marked by a similar stone, set 267.5 feet to the north and 10.8 feet from the west fence of Dr. W. J. Robert's yard. The spire of the Catholic Church bears 16° 31′.6 west of true north. The court-house spire bears 3° 01′.9 west of true north.

Cote Blanche, Iberia Parish.—The station is in the center of the island in the locality known as "Oak Hill," perhaps 150 feet westward fron the former U. S. C. & G. S. triangulation monument now destroyed.

Descriptions of stations—Continued.

LOUISIANA—Continued.

Coushatta, Red River Parish.—The station is southeast of the court-house and is about 9 feet from the west edge of the street running south past the court-house yard. It is marked by a limestone post 6 by 6 by 36 inches, projecting 4 inches above ground and having a cross to mark the exact point. This is the south monument of a meridian line 367.9 feet long, the north end of which is marked in a similar manner. This north monument is 75.7 feet from the northeast corner of the court-house, 44.0 feet from the east fence, and 7.7 feet from the north fence of the court-house yard.

Evangeline, Acadia Parish.—The station is near the southeast corner sec. 45, T. 9 S., R. 2 W. It is just north of a small brook flowing through the southern portion of the oil field, and is 800 feet west of the bridge on the north and south road, passing on section line through the oil field. It is marked by a wooden plug driven in the ground.

Farmerville, Union Parish.—The station is about one-fourth mile southeast of the court-house in an open lot owned by J. M. Smith, which is on the east side of the road to Cox's Ferry. The station is 76.6 feet from the fence to the east, 73.7 feet from the fence to the south, and 115.7 feet from a lone pine tree near the edge of the road. The station is marked by a brown sandstone bowlder, set flush with the ground and having a cross to mark the precise point. Two similar stones set directly north of the magnetic station mark the meridian, the south stone being 410 feet and the north stone 850 feet north of the magnetic station. From the magnetic station the southwest corner of the jail bears 10° 58′.8 west of true north. The east gable of the Knights of Pythias hall bears 6° 25′.2 west of true north.

Floyd, West Carroll Parish.—The magnetic station is in the open lot south of the court-house and 37.6 feet north of a fence. It is marked by a 6-inch sewer pipe filled with mortar and embedded in a mass of mortar. A large spike set in the mortar marks the exact point. The steeple of the Methodist Church bears 22° 55′.2 west of true south. Two monuments similar to the above, with the magnetic station, mark the meridian line. The south monument is 174.7 feet north of the magnetic station, 158.7 feet southwest of the southwest corner of the court-house, 8.8 feet north of the south fence, and 30.8 feet east of the west fence of the court-house yard. The north monument is 269.6 feet north of the south monument, 132.2 feet northwest of the northwest corner of the court-house, 7.3 feet south of the north fence, and 33.1 feet east of the west fence of the court-house yard.

Franklin, St. Mary Parish.—The station of 1903 was reoccupied. It is the north stone of a meridian line established in 1902 by Dr. G. D. Harris, of the State geological survey. This line is 554.5 feet long and in a pasture across Bayou Teche, opposite the wharves. Part of this pasture is now used as a race track. The meridian line is marked by two sandstone posts about 8 inches square, with a hole filled with lead in the center of the top of each. The south stone is about 100 feet from the bayou and close to a fence; the north stone is about 100 feet north and somewhat more than 100 feet east of the inner fence of the race track. From this stone the flag pole on the jail bears 37° 10′.8 west of true south. The west edge of the city standpipe bears 88° 25′.6 west of true south.

Franklinton, Washington Parish.—The station is on the grounds of the Franklinton Collegiate Institute, in the northwestern part of town. It is southeast of the college building and east of the dormitory. The station is 33.2 feet east of a sweet-gum tree, 51.0 feet from the southeast fence and 59.7 feet from the northeast fence of the college grounds. It is marked by a large sandstone bowlder, projecting about 2 inches above ground and having a cross to mark the exact point. The spire of the Methodist Church bears 51° 26′.4 east of true south. The meridian line is marked by a second sandstone bowlder set about 635 feet north of the magnetic station on the property of Mr. Robert Babington. It is about 25 feet from a large oak tree and 15 feet from the corner of the rail fence inclosing the field to the west.

Grande Cote Weeks Island, salt mine, Iberia Parish.—The station is a little north of west from Weeks's residence, in the northwestern part of the island. It is south of a road leading past the residence to a landing on the south bank of Weeks Bayou.

Gretna, Jefferson Parish.—The station is in the baseball grounds about 6 blocks southeast of the court-house, being 59 feet from the southwest fence and 38.8 feet from the southeast fence. It is marked by a post of Georgia marble, 6 inches square, set flush with the ground and having a cross

Descriptions of stations—Continued.

LOUISIANA—Continued.

to mark the center. A similar post 291.3 feet to the north marks the meridian line. This north stone is 5 feet from the grand stand to the northeast and 22.6 feet from the grand stand to the northwest. The steeple of the "Old Colored" Baptist Church bears 51° 28′.5 west of true north. The east edge of the water tower at the Union Iron Works (in New Orleans) bears 16° 57′.9 west of true north.

Harrisonburg, Catahoula Parish.—The station is in the meridian line established by Dr. G. D. Harris upon the property owned by J. E. Griffin. It is 125.7 feet north of "S" stone in the meridian line. The magnetic station is marked by a sandstone bowlder set flush with the ground and having a cross to mark the exact point.

Homer, Claiborne Parish.—The station is in the parish fair grounds south of the city. It is southeast of the race track in an open space covered with small pine stumps and is 61.3 feet from the south fence, 58.8 feet from a large pine tree north of east, and 23.5 feet from a second pine tree to the northwest. The station is marked by a large tile, filled with cement and having the neck of a bottle in the center. A similar tile set 875 feet north marks the meridian line. This north monument is near the bank of a creek and is 17.4 feet east of a wild-cherry tree and 100 feet from the southwest corner of the largest fair building. The spire of the colored M. E. Church bears 21° 55′.4 west of true north. The spire of the court-house bears 11° 33′.9 east of true north.

Jennings, Calcasieu Parish.—The station is 40 feet south of the middle meridian monument in the meridian line previously established by Dr. G. D. Harris. This line is 1 mile east of the town. The observations were made at the north base of the south levee of the McFarlain Canal.

Lafayette, Lafayette Parish.—The station is 390 feet due south of the south monument of the meridian line previously established by Dr. G. D. Harris, back of the grounds of the Industrial School.

Lake Charles, Calcasieu Parish.—Observations were made over the north monument of the meridian line established by Dr. G. D. Harris on the grounds of Lake Charles College. This stone is about 7 feet inside the north fence. The south stone is near the south fence of the college grounds, which are nearly bisected by the meridian line. Both stones are marble posts 4 inches square embedded in a solid mass of concrete. The exact point is marked by a small copper nail in the center of a hole filled with lead. The east gable of the Baptist State Orphanage bears 49° 22′.1 west of true south.

Lake Providence, East Carroll Parish.—The station is in the lot owned by Miss Ethel Montgomery and south of the court-house yard. It is 27.6 feet from the fence to the northwest, 37.3 feet from the fence to the southwest, and 74.8 feet from the west corner of a very small one-story and one-room brick building. The magnetic station is marked by a block of cement 6 by 8 by 14 inches set flush with the ground and having a cross to mark the exact point. The spire of the African Methodist Church bears 64° 51′.8 west of true north. The meridian line is marked by the magnetic station and two stones, each 16 by 16 by 12 inches, set flush with the ground and having a large hole to mark the exact point. These two stones are near the fences of the court-house yard, the south stone being 193.7 feet north of the magnetic station and 7 feet inside the southwest fence of the court-house yard and the north stone being 284.7 feet north of the south stone, 20 feet inside the northeast fence of the court-house yard, and almost in line with the southeast fence around the jail.

Leesville, Vernon Parish.—The station is in the garden of Mr. Elzie Stokes, parish surveyor, and about 1½ miles northeast of Leesville. It is 22.7 feet from the east fence, 48.4 feet from the north fence, and 70.5 feet from the south fence of the garden. The station is marked by a copper nail in the end of a pine post, set flush with the ground. The east gable of Mr. M. Smart's house bears 86° 15′.2 west of true south. The west gable of M. J. Mitchell's barn bears 73° 24′.4 east of true south.

Mansfield, De Soto Parish.—The magnetic station is 99.8 feet from the south stone of a meridian line established by Dr. G. D. Harris, and is in the direction of the azimuth mark, the steeple of the Seventh Day Adventist Church. The station is also 100.8 feet from the wire fence to the south and 85 feet to the corner of the wire fence west of south. It is marked by a pine stake driven almost flush with the ground. The steeple of the Seventh Day Adventist Church bears 18° 31′.4 west of true north. The cross on the Episcopal Church bears 58° 23′.6 west of true north.

Descriptions of stations—Continued.

LOUISIANA—Continued.

Many, Sabine Parish.—The station is the south stone of the meridian line established by Dr. G. D. Harris. It is in the lot west of E. C. Dillon's house, 18.5 feet north of a wild crab-apple tree, 40 feet from the fence on the north side of the road, and 82.3 feet from the fence on the west. The station is marked by a calcareous lignitic bowlder set flush with the ground and having a cross to mark the exact point. A stone 900 feet north and near the edge of the pine woods marks the meridian. The court-house spire bears 76° 09′.5 east of true south.

Marble Quarry, St. Landry Parish.—The station is at an abandoned quarry now overgrown with pine forest in Sec. 34, T. 3 S., R. 1 W. It is southwest of three old kilns and the camp and is southeast of the lime quarry. Caney branch is north and east of the station. Two stakes were set 340 feet apart and observations made over the north stake. The south stake bears 13° 31′.5 east of true south.

Marksville, Avoyelles Parish.—The station is 22 feet north of the south monument of the meridian line established by Dr. G. D. Harris in 1903. This line is on the public Poor Farm.

Minden, Webster Parish.—The station is on the lot of the city pesthouse, which is about 1¼ miles northwest of the city. It is about 80 yards north and west of the pesthouse and 76.7 feet from an oak tree east of north. The station is marked by a large tile filled with cement and having the neck of a bottle at the center. Two other similar monuments were set to mark the meridian line, the south monument being 268.8 feet south of the magnetic station and about 6 feet from the south fence, while the north monument is 179.4 feet north of the magnetic station and about 18 feet from the road. The north gable of Mrs. Delphi Brown's house bears 49° 06′.7 west of true south.

Monroe, Ouachita Parish.—The station is in a pasture belonging to Mrs. Genie Layton and is about three-fourths mile south of the court-house. It is 60 feet from the east bank of the Ouachita River, 35 feet from a deep gully to the east and 75 feet from the fence to the south (the present line of the city limits). The station is marked by a Bedford limestone post 6 by 8 inches, projecting 4 inches above ground and having a small hole to mark the precise point. The northeast corner of the new brick cotton mill bears 39° 16′.5 east of true south. The spire of the Colored Baptist Church bears 5° 29′.1 east of true south. A similar monument, set 558.5 feet north of the magnetic station and near the fence along the road to Columbia, marks the meridian line.

Natchitoches, Natchitoches Parish.—The station is in the meridian line established by Dr. G. D. Harris upon the normal school grounds. It is 407.8 feet north of the present south meridian monument, which is about 25 feet south of the east and west road through the woods, and is 244.3 feet south of the present north meridian monument which is about 4 feet inside the northern line fence. The magnetic station is 13.5 feet from a small cedar tree north of west, 60.5 feet from the northwest corner, and 113 feet from the southwest corner of the poultry yard. It is marked by a brown sandstone bowlder, set flush with the ground and having a cross to mark the exact point. The south gable of J. H. Williams's house bears 44° 43′.8 east of true north.

New Iberia, Iberia Parish.—The station is southwest of the New Iberia Baseball Park, northwest of a ditch running by the south corner of the baseball park, and south of a pond and road leading to the northeast. The station is north of a fence running northwest and southeast. The Catholic Church spire bears 87° 05′.5 east of true south.

Oakdale, Calcasieu Parish.—The station is in a clearing one-sixth of a mile almost due east of Oakdale. It is north of the road to Oakdale from Chicot and is west of an abandoned wooden house. The station is marked by a fat pine stake, 1.2 feet long, 0.3 feet in diameter, driven nearly flush with the surface. The north edge of a chimney on a house to the west bears 79° 31′.8 west of true south.

Opelousas, St. Landry Parish.—The station is 18 feet south and 1.6 inches east of the south monument of the meridian line. The north monument was used as a target, being distant 400 feet. This meridian line is in the public cemetery about one-half mile east of the court-house.

Plaquemine, Iberville Parish.—The station is about one-third mile south of town in Mr. Edward Desobry's pasture. It is about 500 feet west of Mr. Desobry's house, 82.6 feet from the west corner of a large shed, 21 feet from the middle of a large ditch to the southeast, and 42 feet from the middle of a second large ditch to the southwest. The station is marked by a Bedford limestone post, 6 inches

Descriptions of stations—Continued.

LOUISIANA—Continued.

square, set flush with the ground and having a cross to mark the exact point. The Catholic Church spire bears 2° 21′.0 west of true north. A second limestone post marks the meridian. It is 652.5 feet north of the magnetic station, 13.5 feet inside the fence along the road, and 99.4 feet southwest from the south gatepost at the gate of the lane leading to the Desobry house.

Point a la Hache, Plaquemines Parish.—The station is in the open lot between the court-house and the Mississippi River. It is 147 feet from the south post of the gate to the court-house yard and 48 feet from the west corner of a house owned by John Johnson. The station is marked by the neck of a bottle set in cement. The north end of the meridian line, of which the magnetic station is the south end, is marked in a similar manner and is 309.4 feet from the south end and is near the fence northwest of the court-house. The east corner of the court-house bears 22° 43′.1 east of true north. The highest point of the sugar mill on Magnolia plantation bears 26° 42′.1 east of true south.

Rayville, Richland Parish.—The station is on the meridian line produced, at a point 145 feet north of the north monument. It is marked by a cypress stake projecting about 1 inch above ground. The meridian line was established by Dr. G. D. Harris and lies between the jail and court-house. It crosses the Vicksburg, Shreveport and Pacific Railroad and traverses a woody swamp to the north.

Ruston, Lincoln Parish.—The station is on the meridian line established by Dr. G. D. Harris on the grounds of the State Industrial College, in 1902. It is 55 feet north of the south monument and is marked by a round, hard-pine stake driven flush with the ground. The spire of the Methodist Church bears 58° 31′.8 east of true north.

St. Bernard, St. Bernard Parish.—The station is in the pasture lot owned by C. D. Armstrong, and is just north of Armstrong's quarters. It is 198.8 feet from the south fence, 58.7 feet from the west fence, and 116.8 feet from the east fence. The station is marked by a nail in the end of a cedar stub driven flush with the ground. The flag pole on the court-house bears 59° 52′.2 west of true south. The south edge of the smokestack at Creedmore Sugar Factory bears 68° 29′.9 east of true south. A meridian line is marked by two posts of Georgia marble, 6 inches square, projecting 4 inches. The north monument is 340.9 feet north and the south monument is 167.5 feet south of the magnetic station.

St. Joseph, Tensas Parish.—The station is in the public square in the southern part of the city. It is about 500 feet southeast of the court-house and on the line of the row of trees on the southwest side of the square. The station is 138.1 feet from the west corner of the Masonic Hall and 61.3 feet from the fence on the opposite side of the street. It is also 17.4 feet southeast of a box elder and 33.0 feet northwest of a second box elder, these two trees and the station being in nearly the same straight line. The magnetic station is the southern extremity of a meridian line 200.6 feet long, the north monument of which is on the line of the row of trees on the northeast side of the public square. This north stone is 19.2 feet southeast of a box elder and 31.4 feet northwest of a maple, the two trees and the north stone being in nearly the same straight line. Both north and south stones are limestone bowlders set flush with the ground and having a cross to mark the exact point. The steeple of the public school building bears 33° 18′.8 west of true north.

St. Martinville, St. Martin Parish.—The station is 60 feet north of the south monument of the meridian line established by Dr. G. D. Harris in front of the Catholic Church.

Shreveport, Caddo Parish.—The station is in the northeastern part of the space inside the Caddo Downs race track, which is about 3 miles southwest of the court-house. The inner fence about the race track is distant from the station 38.1 feet, measuring due north, and 34.4 feet, measuring in the direction of the Mulkaupt House. There is a small pear orchard about 15 rods north and west of the station and across the race track. The station is marked by a Bedford limestone post 5 inches square, projecting 5 inches above the general surface, and having a hole filled with lead to mark the center. Two other similar stones mark the meridian; the south stone being 600 feet south of the magnetic station and 6 feet inside the inner fence of the race track, while the north stone is 940 feet north of the magnetic station and is 6 feet inside the high board fence surrounding the race-track grounds. The spire of the Jewella Christian Church bears 76° 59′.4 west of true south. Declination observations were also made at the south end of the city engineer's range line in the southern part of Shreveport.

Descriptions of stations—Continued.

LOUISIANA—Continued.

Springville, *Livingston Parish.*—The magnetic station is southwest of the court-house, near the southern edge of the court-house grounds. It is 135.7 feet almost south from the southwest corner of the fence around the court-house and 111.3 feet east of the east fence of Mr. L. D. Allen's yard. The station is marked by a large spike in the end of a pine post, 6 inches in diameter and projecting 4 inches above ground. The southeast corner of the jail bears 33° 51′.2 east of true north. The north end of a meridian line 246 feet long is marked in the same manner as the magnetic station. This north monument is just inside the west fence inclosing the court-house and is 59.1 feet from the northwest corner of the north wing of the court-house.

Tallulah, *Madison Parish.*—The station is in the southeastern part of the Parish Farm and about three-fourths of a mile south of Tallulah. It is 31 feet from the fence along the west edge of the road by the bayou and 23.7 feet from a fence to the southwest. The station is marked by the neck of a bottle embedded in a 6-inch tile filled with cement and surrounded by a mass of concrete. A similar monument, 252.5 feet north, marks the meridian line. This north monument is north of a small peach orchard, 63.7 feet from the northwest corner of a small house and 54.5 feet from the southwest corner of a small fenced lot. The south gable of the "Frisco" section house bears 4° 37′.6 east of true north.

Vidalia, *Concordia Parish.*—The magnetic station is in the yard northwest of the jail. It is 30.0 feet from the fence around the court-house yard, 87.0 feet from the fence in the rear of the jail, and 25.6 feet from the center of a large monument lettered U. S. C. S. 1878. The station is marked by a limestone post 6 by 8 by 26 inches, projecting 3 inches above ground and having a cross to mark the exact point. The spire of the Baptist Church in Natchez bears 77° 04′ .3 east of true south. The south end of a meridian line 239.8 feet long is marked in the same manner as the magnetic station. This monument is 52.5 feet from the west corner of the court-house and 16.0 feet from the north corner of the parish office building.

Winnfield, *Winn Parish.*—The station is in the street 2 blocks west and a little more than 2 blocks north of the court-house, and is near the east edge of a small gully. It is 91.3 feet from the northwest corner of the lot owned by J. G. Teagle, and 76 feet almost due north of a large oak tree. The station is marked by a large "Marble Quarry" bowlder, projecting slightly above ground and having a hole filled with lead to mark the precise point. The court-house spire bears 43° 48′ .6 east of true south. The schoolhouse tower bears 3° 24′ .3 west of true south. Two similar bowlders, with the magnetic station, mark the meridian line. One is approximately 1 100 feet south of the magnetic station and the other 1 700 feet; both are in the street.

Winnsboro, *Franklin Parish.*—The station is in the meridian line established by Dr. G. D. Harris across the court-house yard. It is 47.54 feet due north of the monument "N" and is marked by an oak post 2 by 4 inches projecting 1 inch above ground and having a nail driven in the end to mark the exact point. The east gable of Mrs. R. V. Clarke's house bears 46° 33′.0 west of true south.

MAINE.

Kennebunk Port, *York County.*—The station is near the extreme end of Cape Arundel. It is in the open space between the old cemetery, the Episcopal Church, and the earthen breastworks erected during the civil war. It is 61 feet southwest of the southwest corner post and 78 feet southwest from the northwest corner post of the old cemetery. The station is marked by a stone with a hole drilled in its top, which is flush with the ground. The Congregational Church spire at Kennebunk Port bears 10° 18′.1 west of true north.

Portland, *Cumberland County.*—The station is in the northwestern part of the grounds of the old J. B. Brown property, somewhere near the magnetic station of 1895. The middle granite monument of the meridian line in City Park, on Bramhall Hill, bears from the magnetic station 35° 07′.0 west of true north.

Descriptions of stations—Continued.

MARYLAND.

Baltimore, Baltimore City County.—Observations were made near the station of 1903 in the extreme eastern part of Fort McHenry. A second station was established near the center of Patterson Park, in east Baltimore. It is about 200 feet south of the band stand and on the terrace below it. It is 45 feet northwest from the edge of the driveway, 15 feet east of a scrub-oak tree, and 20 feet south of the foot of the sloping bank. The dome of the insane asylum bears 88° 10′.0 east of true north. A church spire bears 62° 49′.2 east of true south.

Cheltenham, Prince George County.—The station is at the Coast and Geodetic Survey magnetic observatory on the grounds of the State Reform School.

Linden, Montgomery County.—The station is in the middle of Prof. M. H. Doolittle's rear garden, 94.1 feet northwest of the northeast corner of the frame dwelling house and 84.1 feet northeast of the northwest corner of the same building. The station is marked by a sandstone post, 6 inches square, projecting 6 inches above the ground. A small hole drilled in the center of the upper surface of the stone marks the point. The primary azimuth mark, the extreme tip of the Chevy Chase standpipe, 3 miles distant, bears 39° 15′.7 west of true south. The secondary azimuth mark, the extreme tip of the tower of Major Lawrence's house, about 200 yards distant, bears 66° 46′.8 west of true south.

MASSACHUSETTS.

Fairhaven, Bristol County.—The station is about 375 feet west from Fort New Bedford and about 10 feet back from the shore line. It is midway between the fort and a large white beacon standing on a rocky ledge of the shore line. The station is on the south edge of a small field, and is about 12 feet northeast from a cedar tree standing on the shore line. The old light-house tower at Clarks Point bears 00° 15′.5 east of true south.

MISSOURI.

Albany, Gentry County.—The station is in the southwestern part of the grounds of the old Central Christian College. It is 141 feet from the west fence, 134.2 feet from the south fence, and 160.3 feet from the southwest corner of the college building. It is marked by a sandstone with a drill hole in the center of its top, which is lettered U. S. C. & G. S., 1903, and is sunk 3 inches below the surface of the ground. The southwest corner of the college building bears 10° 00′.0 east of true north. The north edge of the chimney on the house of E. L. McCurry bears 88° 32′.6 east of true north.

Bolivar, Polk County.—The station is located on the land of J. T. Odor, about three-fourths of a mile east of town. It is 130.1 feet from the east line of the Odor property and about 300 feet southwest from the house of B. M. Johnson. The station is marked by a sandstone post 7 inches square on top and lettered U. S. C. & G. S., 1903, and has a drill hole in the center. The southwest edge of the standpipe bears 55° 13′.6 west of true north.

Bowling Green, Pike County.—The station is in the eastern part of the town, on a hill, and in line with Centennial avenue. It is on the property of G. W. Wallar, 111.6 feet from the west fence and 252.9 feet from the south fence. It is 49.3 feet southwest of a bull hickory tree and 81.3 feet west of a second bull hickory tree. The station is marked by a limestone post 7 inches square on top and lettered U. S. C. & G. S., 1903. The spire of the Presbyterian Church bears 87° 46′.4 west of true north.

Chillicothe, Livingston County.—The station of 1900 was reoccupied. It is on the grounds of a State industrial home for girls. It is 450 feet east of the main building and 91.5 feet south of the fence along Third street. It is marked by a gray limestone post 6 inches square on top and lettered U. S. C. & G. S., extending 2 inches above the ground. The west edge of the standpipe bears 45° 40′.0 east of true south.

Clinton, Henry County.—The station is in the park at White Sulphur Springs. It is in the northern part of the grounds, about 330 feet north of the drive to the Springs Hotel, and 33 feet west of the road to the hitching ground. It is 80.5 feet southeast of a white-oak tree and 73.5 feet a little north of east from a second tree. It is marked by a limestone post projecting 3 inches above ground and

Descriptions of stations—Continued.

MISSOURI—Continued.

lettered on top U. S. C. & G. S., 1903. The southwest edge of the standpipe bears 41° 42′.4 east of true south.

Edina, Knox County.—The station is on the grounds of St. Joseph Parochial School, in the northern part of the town. It is about 240 feet a little north of west from the northwest corner of the school building and 246.4 feet from its southwest corner. It is 113.1 feet from a fence along the south edge of the public road to the north and 154.1 feet from a fence to the south. It is marked by a sandstone post. The southwest corner of the basement wall of the school building bears 63° 38′.2 east of true south. The foot of the cross on the Catholic Church bears 23° 03′.2 east of true south.

Fayette, Howard County.—The station is on the grounds of Central College, which is situated on the hill in the northern part of town. It is 284 feet almost directly north of the northeast corner of Science Hall. It is marked by a limestone post 6 inches square on top, which projects 3 inches above the ground and is lettered U. S. C. & G. S., 1903. The north point of the roof of Howard Payne College bears 37°16′.8 east of true south.

Gallatin, Daviess County.—The station is at the north end of a large orchard on the property of Frank Woodruff, about 1½ miles west of the town. It is in the southeastern corner of the Woodruff property and 143.6 feet from the south fence and about 1 200 feet from the road to town. It is just west of a bog and 268.5 feet southwest of a well. The station is marked by a sandstone post, which is 7 inches square on top, lettered U. S. C. & G. S., with a hole in its center. The pole on the standpipe bears 78°49′.6 east of true north.

Lexington, Lafayette County.—The station is on the old Lexington battle ground on the crest of the hill and overlooking the river. It is about 600 yards north of the standpipe and is northwest from the Central Female College. It is 82.1 feet northeast from a locust tree, 97.1 feet northwest from a second locust tree, 82.4 feet southwest from an elm tree, and 86.4 feet east of an angle in the west fence. It is marked by a sandstone post 6 inches square on top and lettered U. S. C. & G. S., 1903, and projects 3 inches above ground. The spire of the Zion A. M. E. Church bears 21° 17′.6 east of true south.

Marshfield, Webster County.—The station is on a hill in a conspicuous open place surrounded on three sides by a small growth of timber. This hill is 1 mile southeast of town and is the property of the Ozark Plateau Land Company. The station is west from a wagon road running southeast from town about 330 feet and about 825 feet south of a small stream. It is marked by a limestone post 7 inches square on top which is lettered U. S. C. & G. S., 1903, and has a hole in the center. The spire of the M. E. Church South, bears 47° 44′.4 west of true north.

Mexico, Audrain County.—The station is about three-quarters of a mile east of the public square, on the grounds of the Missouri Military Academy. It is 260.5 feet north from the northwest corner of the north dormitory. It is marked by a stone 6 inches square on top and is lettered U. S. C. & G. S., and has a hole in its center. The west post on the cupola of the Reed farmhouse bears 44° 27′.2 east of true north.

Osceola, St. Clair County.—The station is on a high hill southeast of the town on the land of the Johnston Land Company. It is 217 feet west from the south corner of Frank Daniel's land. It is marked by a rough dressed stone 7 inches square at the top, which is lettered U. S. C. & G. S., 1903, and projects 4 inches above ground. The tip of the belfry on the schoolhouse bears 55° 03′.0 west of true north.

Plattsburg, Clinton County.—The station is about 1 mile north of town on the property of Mrs. Anna P. Vance. It is 206.7 feet from the east fence, 108.1 feet from the west hedge fence, and 386.2 feet from the southwest corner of Mrs. A. P. Vance's brick house. The station is marked by a granitoid post about 8 inches square on top, which is lettered U. S. C. & G. S., 1903, and projects 3 inches above ground. The spire of the South Methodist Church bears 3° 41′.2 east of true south.

MONTANA.

Chinook, Choteau County.—The station is in the northeast corner of the public-school yard. It is 57.6 feet from the north fence, 42.7 feet from the east fence, and 167.8 feet from the northeast

Descriptions of stations—Continued.

MONTANA—Continued.

corner of the brick schoolhouse. It is marked by a stone 30 by 4 by 4 inches, with a drill hole in its top, which projects 4 inches above ground. The spire of the Methodist Church bears 27° 25′.9 west of true north. The west spire of Mrs. Parrott's house bears 10° 13′.9 east of true south.

Flathead River, United States and Canada boundary, Flathead County.—The observations were made over a wooden hub set in the boundary line west of the north fork of the Flathead River and about 140 feet east of monument No. 5.

Gateway, Flathead County.—The station is 10 feet south of an iron post on the United States and Canada boundary, which is the south monument of a meridian line. It is about 750 feet west of monument No. 9 and 500 yards east of the top of the second bench. The station is marked by a wooden hub driven in the ground. The Great Northern Railway station at Gateway and the Kootenai River are about 1 500 feet west of the station.

Glasgow, Valley County.—The station is 395 feet almost due south from the southeast corner of the new jail. It is very near the station of 1896, and is marked by an irregular-shaped stone 24 by 6 by 6 inches and projecting 4 inches above ground. The pole on the public school bears 21° 50′.6 east of true north. The court-house spire bears 1° 59′.4 west of true north.

Helena, Lewis and Clarke County.—The station of 1896 was reoccupied. It is located near St. Joseph Catholic Orphan Asylum, about 1 mile north of the city limits. It is 453 feet east of the inner edge of Montana avenue extended, 78 feet north of the plank fence around the asylum grounds and 250 feet northeast of the northeast corner of the asylum building. It is marked by a marble slab 24 by 6 by 6 inches, with a drill hole in its top, which is flush with the ground. The spire on the public school bears 1°59′.6 east of true south. The spire of the statehouse bears 00°38′.6 east of true south.

Monument No. 11, United States and Canada boundary, Flathead County.—Observations were made over a wooden hub set about 6 feet east of monument No. 11 and in the boundary line. This point is 3.6 miles west of Gateway and the Kootenai River.

Phillips ranch, Kootenai River, Flathead County.—Observations were made over a wooden hub set in the ground about 180 feet east of monument No. 8 of the United States and Canada boundary line and about 15 feet south-southwest of an iron post which is in the boundary line and marks the south end of a meridian line. The station is very near the station of 1901.

NEW JERSEY.

Atlantic City, Atlantic County.—The station is on the lawn southwest of the Absecon light-house, near the intersection of Pacific and Rhode Island avenues. It is 43 feet from the Rhode Island avenue sidewalk, 40.6 feet from the Pacific avenue sidewalk and 150.6 feet from the base of the light-house. An auxiliary station B was occupied at a point 100 feet northeast and in line with the azimuth mark. The principal station is marked by a marble post 28 by 6 by 6 inches sunk 4 inches below the ground and lettered on top U. S. C. & G. S., 1903. Station B was not marked. The southwest basement corner of a yellow brick wall of a cottage on Vermont avenue, about 50 feet from Pacific avenue, bears 60° 12′.0 east of true north. The base of the pole on the cupola in line beyond the west corner of the roof of the porch to the light-house keeper's house bears 12° 00′.2 west of true north.

Barnegat Light-house, Ocean County.—The station is on a high sand dune near the northern end of the beach. It is a little east of south from the base of the Barnegat Light-house and is south from the light-house keeper's house. It is 68.6 feet from a crooked cedar tree, 64.1 feet from a second cedar tree, and 248.8 feet from the base of the Barnegat Light-house. It is marked by a marble post 28 by 6 by 6 inches set flush with the ground and lettered on top U. S. C. & G. S., 1903. The west gable of the west tower on the Oceanic Hotel bears 30° 13′.9 east of true south. The gable of the Forked River life-saving station bears 13° 11′.0 east of true north.

Bridgeton, Cumberland County.—The station is in a lane running south from the barn on the county almshouse property and about 2 miles southwest of town. The station is 73 feet a little west of north from an oak tree at the end of the lane where it joins an east and west road. It is 38.9 feet

Descriptions of stations—Continued.

NEW JERSEY—Continued.

northwest of an apple tree and 15.2 feet from the fence on the west side of the lane. The station is marked by a marble post 28 by 6 by 6 inches sunk 3 inches below the ground and lettered on top U. S. C. & G. S., 1903. The right edge of the chimney on a certain house bears 13° 56′.7 east of true north. The gable of a certain farmhouse bears 73° 23′.6 west of true south.

Camden, Camden County.—The station is 2 miles southeast of the center of the city, in Knight Park. It is in the southern part of the park, about 95 feet from the inner edge of a driveway, 34 feet from an evergreen tree to the southwest, 31.3 feet from a sycamore tree to the southeast, and 28.8 feet from a cucumber tree to the east. It is marked by a marble post 28 by 6 by 6 inches set flush with the ground and lettered on top U. S. C. & G. S., 1903. A church spire in Camden bears 41° 46′.8 west of true north. The center of the steel water tower bears 71° 40′.8 east of true north.

Cape May Point, Cape May County.—The station is approximately 650 yards north of the light-house on the east edge of the street or road running north from the light-house and about 42 feet north of the intersection of this road with a second road running around the south end of Lake Lily and thence east to Cape May City. The station is 72 feet from a wild cherry tree to the east and is marked by a marble post 28 by 6 by 6 inches, sunk 4 inches below the ground and lettered on top U. S. C. & G. S., 1903. The Baptist Church spire at Cape May Point bears 76° 35′.0 west of true south. The base of the flag pole on the Shoreham Hotel bears 3° 18′.2 east of true south.

Chatsworth, Burlington County.—The station is 225 feet from the main road or street, in the back part of the Methodist Church lot. It is 103.6 feet from the southeast corner of the church and 48 feet from a pine tree to the northwest. It is marked by a marble post 26 by 6 by 6 inches, set flush with the ground and lettered on top U. S. C. & G. S., 1903. The south gable of Mr. J. L. Applegate's house bears 38° 43′.9 west of true north.

Egg Island Light-house, Cumberland County.—The station is southwest of the light-house on the circular embankment of sod thrown up around the light-house and in the line from the center of the light-house tower through the southwest corner of the house. The station is 84 feet from the southwest corner of the brick foundation of the light-house. It is marked by a marble post 28 by 6 by 6 inches, set flush with the ground and lettered on top U. S. C. & G. S., 1903. The tower of Cross Ledge Light-house bears 78° 40′.2 west of true south. The tower of Morris River Light-house bears 80° 31′.8 east of true north.

Elizabeth, Union County.—The station is in the northeast corner of the athletic field of the Pingry School. It is 69 feet from the east fence, 163.5 feet from the west fence, 106.5 feet from the north fence, and 328 feet north of the school. It is marked by a marble post 30 by 6 by 6 inches, sunk 3 inches below the surface of the ground and lettered on top U. S. C. & G. S., 1903. The tip of the tower on Prosecuting Attorney English's house, at the northeast corner of Westminster avenue and Park lane, bears 32° 04′.8 east of true south. The middle of the top of the tower of the First Baptist Church bears 6° 28′.6 west of true south.

Flemington, Hunterdon County.—The station is in the southwest corner of the Flemington Academy grounds. It is on the athletic field and is 198.2 feet from the southwest corner of the new red-brick primary school building and 236.7 feet from the southeast corner of the same. It is 102 feet from the west fence and 28.3 feet from the south fence. The station is marked by a white marble post 30 by 6 by 6 inches, sunk 3 inches below the surface of the ground and lettered on top U. S. C. & G. S., 1904. The tip of the cupola on the Shields or town-clock building bears 65° 52′.4 east of true north.

Freehold, Monmouth County.—The station is southwest of town, near the center of the oval inclosed by the race track. This ground is a part of the golf links of the Freehold Golf and Country Club. The station is 314.1 feet southeast from the judge's stand, 220.7 feet a little east of north from the quarter-mile post on the race track, and 35 feet west from the northern end of the southernmost of two bunkers. The station is marked by a marble post 30 by 6 by 6 inches, set flush with the ground and lettered on top U. S. C. & G. S., 1903. The west edge of a steel water tower bears 6° 03′.1 east of true north. The spire of the Reform Church bears 69° 02′.7 east of true north. The spire of the Presbyterian Church bears 89° 24′.9 east of true south.

Hackensack, Bergen County.—The station is in a large field owned by the Hackensack Improvement Company and used by the Hackensack Golf Club as golf links. It is a little to the east of north from

Descriptions of stations—Continued.

NEW JERSEY—Continued.

the clubhouse and 21 feet south of the first property line north of this house. The station is about 324 feet east of a small stream flowing north and south through a swamp, and 132 feet west from a lone crab-apple tree on the before-mentioned property line. The station is marked by a marble post 26 by 6 by 6 inches, sunk flush with the ground and lettered U. S. C. & G. S., 1904. The northeast edge of the chimney on Mr. Brown's house bears 27° 02′.8 east of true south. The spire on Mr. Oliver's barn bears 57° 42′.0 east of true south.

Long Beach, Ocean County.—The station is in the central part of the beach and bears south 65° east one-eighth of a mile from Mr. Enoch Grant's house. It is about one-fourth of a mile from Bond's old Long Beach House and 25.3 feet southerly from a granite post which marks the end of Keith's line between east and west Jersey. The station is marked by a marble post 28 by 6 by 6 inches, lettered U. S. C. & G. S., 1903. The tower of Engleside hotel at Beach Haven, 2½ miles away, bears 30° 43′.5 east of true north. A tower of the life-saving station bears 42° 11′.4 east of true north.

Mays Landing, Atlantic County.—The station is on the public school property on the extension of the center line of the street passing to the rear of the court-house. It is 161.3 feet southeast from the southernmost corner of the schoolhouse, 81.4 feet southeast from an oak tree, and 35.4 feet southwest from a cedar tree. It is marked by a marble post 26 by 6 by 6 inches, lettered U. S. C. & G. S., 1903, and set flush with the ground. The gable of Captain Hudson's house bears 16° 42′.3 east of true south. The pole on the cupola of Dr. H. C. James's house bears 44° 51′.1 east of true south. The southeast corner of Morris Taylor's house bears 62° 47′.0 west of true north.

Mount Holly, Burlington County.—The station is opposite the grand stand and on the green inside the race track of the County Fair Association grounds. It is 53.1 feet a little west of north from an elm tree, 50.7 feet northeast of a second elm tree, and 87.6 feet a little north of east from a third elm tree. The station is marked by a marble post 30 by 6 by 6 inches, lettered on top U. S. C. & G. S., 1903, and set 3 inches below the surface of the ground. The higher west gable of Mr. Kester's barn bears 47° 59′.8 east of true south. The cupola on a building in Mr. Martin's barnyard at Woodlane farm bears 64° 17′.2 west of true north.

Mount Rose, Mercer County.—The station is in a field south of Mr. George Stout's house, on the east side of a road leading from the village of Mount Rose to Princeton, and just west of a steep hill (Mount Rose). Station A, an auxiliary station, is at the intersection of two grooves chiseled on a trap-rock bowlder which lies 100 feet from the east side of the field and about 127 yards south of Mr. George Stout's house. U. S. is also chiseled on this stone, which is 3½ by 5 by 1½ feet in its exposed part. Station B, the principal station, is not marked. It is on a line from station A to the northwest corner of Mr. George Stout's house, being 49.1 feet from the bowlder and 107.6 feet from the east fence. From station B the southwest corner of Mr. Ely Connor's house bears 75° 06′.6 west of true north. The northwest corner of Mr. George Stout's house bears 14° 11′.3 west of true north.

Mount Royal, Gloucester County.—The station is about 4 miles from Woodbury and three-fourths of a mile from Mount Royal station on the West Jersey and Seashore Railroad. It is midway between the public road and the almshouse buildings and on the south side of the avenue leading between them. The station is 7 feet north of a fence, 14 feet southwest of a pine tree, 51.9 feet south of a maple tree, and 57.2 feet southeast from a second pine tree. It is marked by a marble post 28 by 6 by 6 inches, sunk 2 inches below the surface and lettered on top U. S. C. & G. S., 1903. The northeast gable of Mrs. Glover's house bears 38° 48′.9 west of true south. The southeast gable of Captain Hoffmann's house bears 15° 50′.5 west of true north.

Newark, Essex County.—The station is on a grassy mound in Branch Brook Park, almost directly west of the front entrance to the Newark High School. The station is 67 feet from the east edge of the park lake, 31.2 feet from the southeastern corner of the most southerly of two decorative walls or abutments of stone, and 41.2 feet from the southwestern corner of the same. The spire of the Presbyterian Church on Roseville avenue bears 68° 11′.6 west of true south. The spire of the Methodist Church on Seventh street bears 53° 13′.9 west of true north.

New Brunswick, Middlesex County.—The station is on the athletic field of Rutger's College. It is somewhat southeast of the center of the oval field inclosed by the running track, being about 60 yards from the southeast end of this field. The station is marked by a marble block 17 by 8 by 7 inches,

Descriptions of stations—Continued.

NEW JERSEY—Continued.

sunk 2 inches below the surface of the ground and lettered on top U. S. C. & G. S., 1903. A church spire about 3 miles away bears 68° 51′.6 east of true north.

Paterson, Passaic County.—The station is in the southeast corner of Eastside Park and northeast of Doctor Marsh's house. The station is between two paths which come to a point toward the south, being 15.1 feet from the western edge of the path to the east and 42.6 feet from the eastern edge of the path to the west. It is 17.7 feet from a small lone pine tree a little south of west and 28.3 feet a little west of north from a second pine tree. The station is marked by a brown stone 26 by 6 by 6 inches, sunk 1 inch below the surface of the ground and lettered U. S. C. & G. S., 1904. The spire on the barn of Doctor Marsh bears 30° 10′.3 west of true south. The west edge of the northwest chimney on the Spenginer House bears 19° 23′.6 east of true south.

Perth Amboy, Middlesex County.—The station is about 2 miles northwest of town on the intended reservoir site, near its northwest corner. This tract of land belongs to the town and lies along the road just beyond the Jewish cemetery. The station is 154.6 feet south of an oak tree in the north fence line of the reservoir site and 94.6 feet northeast of a projecting corner of a large stone. To the road and fence on the west side of the reservoir site is about 90 yards. It is marked by a marble post 36 by 6 by 6 inches projecting 7 inches above ground and lettered on top U. S. C. & G. S., 1903. The northwest corner of a house just beyond the Jewish cemetery bears 0° 23′.9 east of true south. The apex of the Kramer tombstone in the Jewish cemetery bears 1° 02′.1 east of true south.

Port Norris, Cumberland County.—The station is east of the eastern terminus of the main street of the town, in line with the row of maple shade trees to the west and on the north side of the street. The station is 198 feet a little south of east from the old Ogden house, 204.8 feet from the most easterly of one of three maple trees in front of this house, and 38.8 feet a little north of west from a granite post marking the center of the street. The station is south of several gravel pits. A church spire in Mauricetown bears 28° 46′.4 east of true north. A church spire in Leesburg bears 65° 23′.4 east of true north. The south gable of Mr. William B. Lamb's house bears 36° 55′.2 west of true north.

Salem, Salem County.—The station is on the grounds owned by the Salem Presbyterian Church in the east part of town and along Grant street. It is south and east of the brick house now occupied by Charles Rider. The station overlooks the creek and is 14 feet north of the fence along the road, 39.2 feet south of a hickory tree, and 59.2 feet southeast from a butternut tree. It is marked by a marble post 28 by 6 by 6 inches, projecting 2 inches above the ground and lettered U. S. C. & G. S., 1903. The spire of the M. E. Church in Salem bears 84° 36′.7 west of true south. The spire of the Baptist Church in Salem bears 75° 02′.8 west of true north.

Sandy Hook, Monmouth County.—The station is on the Fort Hancock parade ground nearly south of headquarters and about 100 feet south of a cement walk running east across the parade grounds from the commanding officer's quarters. It is 228.8 feet west of a lamp-post. The station is marked by a marble post 26 by 6 by 6 inches, lettered on top U. S. C. & G. S., 1903, set flush with the ground. The apex of the water tower in the woods bears 25° 07′.3 east of true south. The apex of a second water tower bears 0° 50′.5 east of true north.

Sea Isle City, Cape May County.—The station is in a meadow or marsh in the northern part of town. It is on a knoll in line with the Prospect street crossing of the Philadelphia and Reading Railroad and the Sea Isle City Light-house. It is approximately 395 yards from this crossing and 140 yards a little south of east from the old marine laboratory of the University of Pennsylvania. It is marked by a marble post 28 by 6 by 6 inches, projecting 4 inches above ground and lettered U. S. C. & G. S., 1903. The center of Sea Isle City Light-house tower bears 9° 04′.6 west of true south. A church spire in Seaville bears 89° 48′.3 west of true south.

Somerville, Somerset County.—The station is near the entrance to the cemetery on the west side of South Bridge street. It is about 73 feet south of the door to the tool house and 27.5 feet southwest from a pine tree. It is 71.6 feet and 40.8 feet respectively from the southwest and southeast corners of the Arrowsmith lot. The station is marked by a Bedford limestone post 30 by 4 by 5 inches, sunk flush with the ground and lettered on top U. S. C. & G. S., 1904. The east edge of the brick chimney on Mr. Hendrickson's house at the corner of Center and South avenues bears 46° 11′.9 east of true north.

Descriptions of stations—Continued.

NEW JERSEY—Continued.

Toms River, Ocean County.—The station is in the northeast part of town, at the top of a steep hillside in the rear of a house belonging to the Hurry estate and now occupied by Mr. Irons. It is 22.5 feet east of north from a cherry tree, 26 feet west of north from a cedar tree, and 40 feet northwest of a second cherry tree, these three trees standing along an old fence line. The station is marked by a marble post 28 by 6 by 6 inches, projecting 1 inch above ground and lettered on top U. S. C. & G. S., 1903. The north gable on Sheriff Downey's house bears 39°55′.4 west of true south. The Methodist Church spire bears 1°28′.4 west of true south. The northeast gable of Mr. Berrien's house bears 15° 35′.4 west of true north.

Trenton, Mercer County.—The station is on the grounds of the New Jersey State Hospital for the Insane. It is about 450 feet southeast and in front of the central entrance to the main asylum building. The station is on the lawn 113.3 feet southeast of a tulip tree, 146.1 feet northeast of a buttonwood tree, and 165.6 feet northwest of a spruce tree. It is marked by a marble post lettered U. S. C. & G. S., 1903, on top, which is 6 inches square and sunk flush with the ground. The northeast gable of the warden's house bears 11° 20′.0 west of true south.

NORTH CAROLINA

Wadesboro, Anson County.—The station is near the southwest corner of W. B. Little's front yard. It is 22.4 feet from the west fence, 21.4 feet from the south fence, and 82 feet from the southwest corner of W. B. Little's house. It is marked by a brown stone 36 by 10 by 8 inches, projecting 6 inches above the ground and with a drill hole in the top. The cupola of the Pee Dee Institute bears 15° 46′.8 west of true north. The cupola of the public school bears 45° 15′.6 east of true north.

OHIO

Berea, Cuyahoga County.—The station is about 2 miles east of town in section 3 of the Woodlawn Cemetery. It is at the intersection of two paths running between lots 19, 55, and 21, and is marked by a sandstone 36 by 6 by 6 inches, set a little below the surface of the ground and lettered on top U. S. C. & G. S., 1903. The north edge of the large central chimney on the Lovejoy house, 1 mile east, bears 69° 56′.9 east of true south. The west edge of the chimney on the house of the sexton of the cemetery bears 35° 49′.6 west of true south.

Bowling Green, Wood County.—The station is 3½ miles south of the town on the County Infirmary farm. It is in a small open pasture, south of the infirmary building and of a creek flowing eastward. It is 41.5 feet north of the road passing along the south side of the farm and 162 feet from a white ash tree which stands near the south bank of the creek and about 45 feet from an iron bridge. The station is marked by a sandstone 36 by 6 by 6 inches, set flush with the ground and lettered on top U. S. C. & G. S., 1903. The court-house spire at Bowling Green bears 41° 50′.2 west of true north. The Methodist Church bears 46° 36′.4 west of true north.

Bryan, Williams County.—The station is in the park forming the western part of the grounds of the public school. It is distant from the north fence 63.6 feet, in line with the fence separating two residence lots adjoining the school grounds on the north, and is 12.1 feet north of a large oak stump. The station is marked by a syenite rock 27 by 7 by 7 inches set flush with the ground. The spire of the Baptist Church bears 72° 51′.7 east of true north.

Bucyrus, Crawford County.—Observations were made over the south monument of the county meridian line in the southwest quarter of the city cemetery. The meridian line was tested and found correct.

Celina, Mercer County.—The station is about 2½ miles west of town. It is near the southwest corner of the grounds surrounding the fifth district public school, the school grounds being in the northeast corner of the Mercer County Poor Farm. It is 17.0 feet from the south fence, 16.5 feet from the west fence, and about 195 feet south of the brick schoolhouse. The station is marked by a limestone 36 by 6 by 6 inches, projecting 3 inches above the ground and lettered on top U. S. C. & G. S., 1903. The south edge of the standpipe at Celina bears 78° 27′.0 west of true north.

Descriptions of stations—Continued.

OHIO—Continued.

Chardon, Geauga County.—The station is on the farm of H. C. Peas, about 1 mile east of town. It is on a narrow ridge of land in a pasture northeast of a small apple orchard on the east side of Mr. Peas's farm and north of the road to Chardon. It is 71.6 feet from a large bowlder, about 20° east of south, 55.3 feet from a second large bowlder, about 20° east of north, and 142.5 feet from the northeast tree of the small apple orchard. It is marked by a sandstone 28 by 8 by 6 inches, lettered U. S. C. & G. S., 1903, and projecting 2 inches above ground. The spire of the Congregational Church bears 88° 53′.7 west of true south. The court-house spire bears 84° 43′.8 west of true north.

Defiance, Defiance County.—The station is on the campus of Defiance College near its north boundary and about 400 feet northeast of the college building. It is on the east side of the proposed football grounds, 132 feet from the middle of the street to the north and 27.8 feet from a young hickory tree. The station is marked by a marble post 38 by 6 by 6 inches, projecting 3 inches from the ground and lettered on top U. S. C. & G. S., 1903. The west gable of Defiance College bears 56° 51′.0 west of true south.

Delaware, Delaware County.—The station is on the Delaware County Infirmary farm, 5 miles east of the town. It is in a small park and orchard in front of the infirmary building and about halfway between a pond and the fence along the pike to Delaware. The station is 47.7 feet from the south fence and 151 feet from the west fence. It is marked by a sandstone 36 by 6 by 6 inches, projecting 3 inches above ground and lettered on top U. S. C. & G. S., 1903. The east edge of the large west chimney on the infirmary bears 4° 51′.8 east of true north.

Eaton, Preble County.—Mr. Houston's station in the southeast part of the pasture of the Preble County Infirmary was reoccupied. It is marked by a limestone 36 by 6 by 6 inches, projecting 2 inches above ground and lettered on top U. S. C. & G. S., 1903. A small hole in the center of the top marks the exact point. The court-house spire bears 21° 46′.8 east of true south. The tower on the west end of the infirmary bears 65° 12′.2 west of true south.

Elyria, Lorain County.—The station is on the County Infirmary farm, about 2 miles from town. It is in a pasture about 1 200 feet west of the infirmary buildings, 29.5 feet from the south pasture fence, and 57 feet from the east fence. It is marked by a sandstone 36 by 6 by 6 inches, projecting 2 inches from the ground and lettered on top U. S. C. & G. S., 1903. A chimney on a house about one-half mile east bears 80° 12′.4 east of true south. The northwest edge of the main infirmary building bears 88° 08′.7 east of true south.

Findlay, Hancock County.—The station is in the city cemetery, a mile west of town. It is marked by a sandstone 36 by 6 by 6 inches, set 3 inches below the surface of the ground and 18 inches north of the south edge of an extension of the main east and west driveway at a point west of its intersection with a second driveway from the northwest. The station is 52.2 feet east of an oak tree on the north border of this main east and west driveway. The flag pole of the Adams School bears 62° 00′.8 east of true south. The Catholic Church spire bears 55° 30′.2 east of true south.

Forest, Hardin County.—The station is northwest of the center of the Heuston Cemetery, about 2¼ miles north of town. It is marked by a sandstone 36 by 6 by 6 inches, lettered on top U. S. C. & G. S., 1903, and set 2 inches below the surface of the ground near the center of the intersection of two paths running between lots 14 and 15 and between rows 10 and 11, respectively. The Methodist Episcopal Church spire bears 82° 39′.3 east of true south.

Fremont, Sandusky County.—The station is on the Sandusky County Infirmary Farm, in an open space east of the burial grounds and south of a creek. It is 41.9 feet from the north corner and 83.3 feet from the east corner of these grounds. It is marked by a sandstone 36 by 6 by 6 inches, set flush with the ground and lettered on top U. S. C. & G. S., 1903. The Catholic Church spire in Fremont bears 63° 03′.1 west of true south. The schoolhouse belfry, one-quarter mile distant, bears 26° 24′.1 west of true north.

Greenville, Darke County.—The station is about 3½ miles north-northeast of town, on the farm of the Darke County Children's Home, in a 6-acre pasture south of the main building of the Home. It is about 600 feet north of district school No. 6, 192.6 feet from the pasture fence to the north, 202.9 feet from the west pasture fence, about 300 feet from the east pasture fence along the Greenville and

Descriptions of stations—Continued.

OHIO—Continued.

Beamtown pike, and about 350 feet from the Home building. The station is marked by a limestone 36 by 6 by 6 inches, set flush with the ground and lettered U. S. C. & G. S., 1903. The spire of the St. John's Lutheran Church, about 2 miles distant, bears 72° 27'.3 east of true south.

Kelleys Island, Erie County.—The station is in the cemetery near its southwest corner, 36.8 feet from the west line and 89.6 feet from the south line. It is marked by a sandstone 18 by 12 by 4 inches, set 3 inches below the surface and marked on top with a cross. This stone is set at the crossing of two paths. The east edge of the east chimney on the schoolhouse bears 1° 46'.6 west of true south. The east edge of the chimney on the Brown house bears 3° 12'.1 west of true north.

Kenton, Hardin County.—The station is on the infirmary farm, 1½ miles northwest of town. It is near the northwest corner of the farm in a small pasture. It is 46.8 feet from a hedge fence on the north and bordering the pike to Kenton, and 263.3 feet from the west fence. The station is marked by a sandstone 36 by 6 by 6 inches, projecting 2 inches above ground and lettered U. S. C. & G. S., 1903. A marble post, 5 inches square on top with a drill hole in the center, marks the south end of a meridian line 357.6 feet long. This south monument is near the fence separating the pasture from an apple orchard. The court-house bears 67° 12'.1 east of true south. The Presbyterian Church spire bears 66° 25'.0 east of true south.

Lancaster, Fairfield County.—The station is in the Lancaster camp grounds 3 miles west of town. It is in the southeastern part of the grounds between the cottages and the east fence, and is 83.2 feet from the east fence, 9.5 feet south of east from a hard maple tree, and 36.3 feet east of north from a second hard maple tree. The station is marked by a Bedford limestone post 34 by 6 by 5 inches, lettered U. S. C. & G. S., 1903, and projecting 1 inch above ground. The spire of the German Luthern Church bears 67° 52'.0 east of true south. The city hall spire bears 62° 42'.0 east of true south.

Lima, Allen County.—The station is about 3¼ miles east of town, on the grounds of the Allen County Infirmary. The station is placed in line with the east wall of the infirmary building and is 246.8 feet south from the fence on the south side of the pike leading to town and lying between the building and station. It is marked by a limestone 36 by 6 by 6 inches, projecting 3 inches above ground and lettered on top U. S. C. & G. S., 1903. The ventilator tip on George Fetter's barn, about one-half mile distant, bears 86° 02'.7 east of true south.

Mansfield, Richland County.—The station is on the Richland County Infirmary farm northeast of town. It is in the pasture lying southwest of the infirmary buildings and is located near the west end of a narrow ridge of land. It is 71 feet from the picket fence inclosing the lawn and 74 feet from the wire fence on the west. The station is marked by a sandstone 36 by 6 by 6 inches, lettered U. S. C. & G. S., 1903, and projecting 2 inches above the ground. A schoolhouse belfry 1 mile distant bears 29° 32'.8 west of true south.

Marysville, Union County.—The station is in an open grassy plot inside the race track on the fair grounds and 1 mile north of town. It is 48 feet north of the south monument of an old meridian line and is marked by a sandstone 36 by 6 by 6 inches, lettered on top U. S. C. & G. S., 1903, and projecting 2 inches above ground. The German Lutheran Church bears 23° 32'.2 east of true south. The figure on the court-house bears 7° 59'.3 east of true south.

Maumee, Lucas County.—The station is about 1½ miles a little west of south from the town and on the opposite side of Maumee River, in Wood County. It is in Tippecanoe Park, a short distance southeast of the site of Fort Meigs, on Maumee River. It is 74.8 feet from the fence along the Maumee and Perrysburg road on the west side of the park, and is 18.2 feet southwest of a shellbark hickory tree. The station is marked by a sandstone 36 by 6 by 6 inches, projecting 3 inches above ground, and lettered on top U. S. C. & G. S, 1903. The Catholic Church cross in Maumee bears 18° 47'.5 east of true north. The smokestack of the glass factory bears 2° 45'.8 east of true north.

Medina, Medina County.—The station is in the northwest part of Spring Grove Cemetery on the lawn north of the soldiers' memorial monument. It is 105.6 feet from the nearest tree by the drive on the east, 126.8 feet from the north edge of the drive on the south, and 125.6 feet from the road on the northwest. It is marked by a sandstone 36 by 8 by 6 inches set flush with the ground and lettered U. S. C. & G. S., 1903. The Episcopal Church spire bears 85° 36'.0 west of true south.

Descriptions of stations—Continued.

OHIO—Continued.

Mount Gilead, Morrow County.—The station is 1½ miles north of town in a pasture belonging to the Morrow County Infirmary, west of the infirmary buildings and of the road leading to town. The station is on a slight elevation near the northeast corner of the pasture and is distant 166.7 feet and 97 feet from the east fence along the road and the rail fence on the north, respectively. It is marked by a sandstone 36 by 6 by 6 inches, projecting 2 inches above ground and lettered on top U. S. C. & G. S., 1903. The court-house spire bears 45° 8′.3 west of true south. Observations were also made at the north monument of the county meridian line in the city cemetery, 1 mile distant from the magnetic station.

Mount Vernon, Knox County.—The station is in the western part of town in Riverside Park. It is near the center of the park, being south of the baseball grounds, north of a small grove of trees and of an old tennis court. It is 83.7 feet from a willow tree to the southwest, 57 feet from a small hard maple to the south, and 114 feet from a large sycamore tree to the north and west. The station is marked by a stone 36 by 8 by 6 inches, lettered on top U. S. C. & G. S., 1903, and set flush with the ground. The Presbyterian Church spire bears 80° 54′.8 east of true south. The Congregational Church spire bears 84° 6′.2 east of true south.

Napoleon, Henry County.—The station is on the Henry County Poor Farm, 2½ miles north of town. It is in an open field east of the main building about 195 feet from the northeast corner of the barn and on the north side of the lane leading from the barn eastward. A sandstone 39 by 6 by 8 inches is set just north of the fence on the north side of this land, projecting about 3 inches above the ground and lettered on top U. S. C. & G. S., 1903. The magnetic station is 45.7 feet from the center of this stone and in line with it and the center of the water standpipe at Napoleon. The standpipe bears 16° 18′.3 east of true south.

Norwalk, Huron County.—The station is near the northwest corner of the burial grounds of the Huron County Infirmary about 1½ miles southeast of town. It is 12 feet from a rail fence on the west and 19.2 feet from a plank fence on the north. It is marked by a sandstone 40 by 7 by 8 inches, projecting 3 inches above ground and lettered on top U. S. C. & G. S., 1903. The St. Paul's Catholic Church bears 0° 16′.1 west of true north.

Oberlin, Lorain County.—The station is about 3½ miles southwest of town near the northeast corner of the grounds surrounding a small district schoolhouse. It is 12.8 feet from the east fence, 12.9 feet from the north fence, and about 150 feet northeast of the brick schoolhouse. It is marked by a sandstone 36 by 6 by 6 inches, set nearly flush with the ground and lettered on top U. S. C. & G. S., 1903. The west edge of the chimney on Mr. Luther's dwelling bears 25° 12′.8 west of true south.

Ottawa, Putnam County.—The station is about 1½ miles east of town, near the west end of and inside the oval race track on the county fair grounds. The station is 82.6 feet from the inner fence of the race track at its western end. It is marked by a marble post 36 by 6 by 6 inches, the top lettered U. S. C. & G. S., 1903, and projecting 4 inches above ground. The main tower of the new public school, about 1 mile away, bears 59° 13′.2 west of true north. The spire of the Catholic Church bears 63° 21′.4 west of true north.

Paulding, Paulding County.—The station is southwest of town, on the county fair grounds. It is near the west side of the inclosure, surrounded by the race track, 88½ feet from the inner fence on the west side of the race track, and 248 feet north of the judges' stand. It is marked by a marble post 36 by 7 by 7 inches, set flush with the ground and lettered on top U. S. C. & G. S., 1903. The court-house tower bears 29° 12′.4 east of true north. The spire of the Methodist Church bears 20° 48′.4 east of true north.

Port Clinton, Ottawa County.—The station is west of town, in the southwest corner of the cemetery. It is in the middle of a path running north and south, 29.3 feet from the west fence, and 59.9 feet from the south fence. It is marked by a sandstone post 36 by 6 by 6 inches and lettered on top U. S. C. & G. S., 1903. The court-house spire bears 83° 22′.6 east of true south. St. John's German Lutheran Church bears 77° 50′.3 east of true north.

Put in Bay, South Bass Island, Ottawa County.—The station is near the middle of the west side of the grounds belonging to the United States Fish Commission. It is 106.5 feet from the southwest

Descriptions of stations—Continued.

OHIO—Continued.

corner and 101.2 feet from the northwest corner of these grounds. These corners are marked by gas pipe driven in the ground. The station is marked by an irregular piece of granite set flush with the ground and marked on top with a cross. The middle of the chimney of the Hunker residence across the bay bears 84° 47′.0 east of true south. The point of the post on the south gable of the fish hatchery bears 53° 13′.0 east of true north.

Ravenna, Portage County.—The station is three-quarters of a mile north of the town, on the lawn of Maple Grove Cemetery. It is about 200 feet northeast of the small chapel, 35 feet from the board fence on the north, 63.8 feet from a maple tree to the southeast, and 74.5 feet from a second maple tree to the southwest. The station is marked by a sandstone 30 by 8 by 6 inches, roughly lettered U. S. C. S. and set flush with the ground. The court-house spire bears 1° 35′.8 west of true south. The southeast corner of the chapel in the cemetery bears 44° 52′.4 west of true south.

Sandusky, Erie County.—The station is near the light-house on Cedar Point, about 3 miles north of Sandusky, on the northwest end of the long, narrow peninsula. It is on a high, sandy ridge about 100 feet northwest of the light-house, 26 feet southeast of a large cottonwood tree, and about 30 feet from the shore line. It is marked by a sandstone 36 by 6 by 6 inches, set nearly flush with the ground and lettered on top U. S. C. & G. S., 1903. A tall, slender church spire in Sandusky bears 22° 50′.9 west of true south. The Marblehead Light-house bears 15° 47′.7 west of true north.

Sidney, Shelby County.—The station is about 2 miles southeast of town and in the southeast portion of the pasture of the Shelby County Children's Home. It is 22.7 feet southeast of a hard sugar maple and 53.0 feet west of a silver poplar. The station is marked by a limestone 36 by 6 by 6 inches, set flush with the ground and lettered on top U. S. C. & G. S., 1903. The spire of the Catholic Church in Sidney bears 32° 41′.2 west of true north. The court-house cupola bears 28° 30′.2 west of true north.

Tiffin, Seneca County.—The station is southeast of the town, on the Seneca County Infirmary Farm. It is northwest of the infirmary buildings, in an open field near the north boundary of the farm. It is 75.6 feet southwest of a large elm tree and 67.2 feet southeast of a second large elm tree. These two elm trees are on the north line of the farm. The magnetic station is marked by a stone post 36 by 6 by 6 inches, set flush with the ground and lettered on top U. S. C. & G. S., 1903. A second smaller stone with a drill hole in the center of its top is set on the south border of the same field near the orchard and marks the south end of a meridian line about 400 feet long. The Catholic Church spire in Tiffin bears 26° 18′.8 west of true north.

Toledo, Lucas County.—The station is on the farm of Mr. Shepard, near the boundary line separating it from the Case farm. It is on the shore of Maumee Bay, about 5½ miles northeast of the center of the city. The magnetic station is 52.7 feet south of triangulation station Case and in line with the triangulation station West Tower. The magnetic station is in a thickly planted peach orchard. West Tower bears 48° 24′.7 east of true north.

Upper Sandusky, Wyandot County.—The station is in the northwest corner of the Wyandot Mission Cemetery. It is at the center of the crossing of two footpaths 23.4 feet from a picket fence forming the west boundery of the cemetery and 51.1 feet from the north boundary fence. It is marked by a sandstone 36 by 6 by 6 inches sunk flush with the ground and lettered on top U. S. C. & G. S., 1903. The spire of the German Lutheran Church bears 10° 52′.1 west of true south.

Vanwert, Van Wert County.—The station is 1 mile south of town, in the county fair grounds. It is near the middle of the ground, surrounded by the race track, 203.3 feet north of the judge's stand and 92.6 feet from a large elm tree. It is marked by a marble post 36 by 6 by 6 inches projecting 3 inches above ground and lettered on top U. S. C. & G. S., 1903. The court-house tower bears 18° 6′.0 east of true north.

Wapakoneta, Auglaize County.—The station is about 2½ miles north of the town, in a field belonging to the Auglaize Infirmary, and situated on the west side of 2-mile pike, the infirmary buildings being on the east side. A limestone 36 by 6 by 6 inches projecting 3 inches above ground is set near the hedge on the south side of this field and 126 feet from the osage-orange hedge along the 2-mile pike on the east side of this field. The exact point is in the open field 47.2 feet a little west of north of the

Descriptions of stations—Continued.

OHIO—Continued.

center of the stone and exactly in line with the stone and the tower of Auglaize County Court-house which bears 16° 28′.7 east of true south. The center of the schoolhouse chimney about one-third mile north, bears 4° 59′.9 east of true north.

Wauseon, Fulton County.—The station is 4 miles north of town, on the Fulton County Infirmary Farm. It is about 300 feet east of the infirmary building, in line with the south wall of the east (rear) extension, and also in line with the west fence surrounding the little graveyard southeast of the infirmary. The station is 151.2 feet from the northwest corner of this graveyard and 234 feet from the middle of the east and west pike. It is marked by a marble post 26 by 6 by 6 inches, set flush with the ground and lettered U. S. C. & G. S., 1903. The north gable of J. Jones's barn bears 4° 35′.8 west of true south. The center of the cross in the round window in the east gable of the infirmary bears 88° 08′.0 west of true north.

PHILIPPINE ISLANDS.

Albay Gulf, Luzon.—The magnetic station is identical with triangulation station Mont, which is on the easterly end of the largest and easternmost of three rocks north of and off Montugan Point, which is the extreme south and eastern point of Albay Gulf. This rock is about 50 feet long, overhanging the water from 4 to 6 feet all around, and appears somewhat flat on top from a distance, but very jagged and sharp on close inspection. It is about midway between the main shore to the south, which is fringed with mangroves, and the coral reef to the north, which is about 1,000 meters offshore and bare at low water. The station is on the highest part of the rock and is marked by an octagonal steel bar 10 inches long, with its top even with the surface. The mark used was triangulation station Rap, which bears 32° 31′.8 west of true north.

Batan Island, Luzon.—The magnetic station is identical with triangulation station Heat, which is on the point at the northwest entrance to Rapu Rapu Pass, about 150 feet above high-water line. This point is nearly perpendicular on the west side and has a very steep slope on the north and east sides. The station is on a flat place about 40 meters from the steep north slope, 4 meters from the western cliff, and 10 meters from the steep east slope. There is a clump of bushes on the edge of the cliff 6 meters southwest of the station. The mark is triangulation station Cent, which bears 7° 54′.8 west of true south.

Batangas, Luzon.—The magnetic station is about 60 meters south and a little to the west of the astronomic station, which is about 4 meters south of the road leading from Batangas to the beach, about half a mile west of Batangas Plaza and three-fifths of a mile east of the beach. It is just inside the low dikes of a rice field, and is marked by a stone 8½ by 12 inches on top and projecting 8 inches above ground, with a drill hole and letters U. S. cut on its top surface. The magnetic station is marked by a cross cut in the top of a stake, 2 by 1 inches, driven in the ground. The mark is the cross on the church dome and bears 80° 41′.1 east of true south.

Boac, Marinduque.—The magnetic station is identical with the astronomic station. A tree was used as the azimuth mark and bears 6° 25′.9 east of true south.

Calapan, Mindoro.—The magnetic station is identical with West Base of the triangulation and is near the astronomic station. It is nearly north of the northwest corner of the old stone fort and is about halfway between it and the beach. The station is marked by a very hard rock, 12 by 7 by 5 inches, with a drill hole in the top which projects 1 inch above the surface. The mark used was East Base, which bears 88° 55′ east of true north.

Calbayoc, Samar.—The magnetic station is on the beach, about 7 meters back from high-water mark and directly at the foot of the street, which passes in front of the church and cuts the shore at right angles. It is 20.6 meters west from the astronomic station and 27.9 meters southwest of the southwest corner of a large building used as United States military headquarters. The station is marked by a pint bottle, buried 2 feet below the surface of the ground, and by an irregular stone with a cross cut in its upper end, which projects about 1 inch above the surface. The mark used was a glass telegraph wire insulator which was attached to the top of a square frame tower on the west side

Descriptions of stations—Continued.

PHILIPPINE ISLANDS—Continued.

of the river and next to the Warner Barnes & Co. agent's house. This bears 76° 18′.5 west of true north.

Castilla, Luzon.—The magnetic station is identical with triangulation station Free, which is on solid rock on Point Pandanblanay, east of the town of Castilla and is awash at high water. An inch hole inclosed in a triangle was cut in the rock to mark the station. Two other triangular cuts were made in the rock near the station, the one being 3.4 inches west and the other 4 inches northeast from the station. Triangulation station Pool was used as an azimuth mark and bears 13° 55′.3 east of true south.

Catbalogan, Samar.—The magnetic station is situated just below the extreme southern end of the town and is midway between the beach and the road leading south to the cemetery. This road is a continuation of the main street of Catbalogan and is the only road near and parallel to the shore line. The station is in the middle of a long ridge of shell and sand, with low rows of bamboo stakes forming a retaining wall—the whole being an insurgent fortification. It is 15 feet northwest of a large tree, about halfway between the northern and southern ends of this ridge. The station is marked by a quart bottle buried 2 feet below the surface.

Culili, Luzon.—The magnetic station is identical with triangulation station Culili, which is on the highest part of the main portion of Point Culili. It is on a grass-covered, rounded knoll, and is 115 feet from the edge of the cliff to the north and 130 feet from the edge of the cliff to the west. The station is marked by a bottle buried 3 inches below the surface, and there is a small cairn around the foot of the signal pole. The mark is triangulation station San Miguel, and bears 74° 20′.3 east of true north.

Currimao, Luzon.—The magnetic station is identical with the astronomic station, which is in the barrio of Currimao, and is just west of the road running northwest and southeast and parallel to the beach line. Across this road and almost east of the astronomic station is the camarine or warehouse. The mark is triangulation station Gabot, which bears 17° 30′.6 west of true south. The astronomic station is marked by a stone about 6 by 18 by 30 inches, projecting about 6 inches above ground and having a drill hole in its center.

Cuyo, Cuyo.—The magnetic station is in the open common or plain to the west of the old fort, between it and the beach. It is 229.1 meters northwest from the longitude station and 405.9 meters from the top of the pavilion on the boat landing to the south. This was the mark, and bears 11° 26′.5 west of true south. The station is marked by a large rock with a drill hole in its top, which is level with the ground.

Danao, Negros.—The magnetic station is the astronomic station. The mark is triangulation station Stump and bears 72° 36′.4 east of true north.

Gubat, Luzon.—The magnetic station is identical with triangulation station Gubat, which is on the grass bank between the Tribunal building and the beach. The station is 9.7 meters about southeast from the northeast corner and 11.9 meters northeast from the southeast corner of the east wing of the Tribunal building. The station is marked by a bottle resting on solid stone and buried 2 inches below the surface of the ground. The mark, triangulation station River, bears 32° 23′.6 east of true north.

Guiuan, Samar.—The magnetic station is triangulation station Baul. The mark used was triangulation station Bin, which bears 65° 14′ east of true north.

Iligan, Mindanao.—The magnetic station is near the beach and in a cocoanut grove which lies between the town and the sea. It is 101.6 meters from the astronomic station which bears 23° 35′.4 west of true south. The station is about 15 meters back from high water line and is a few feet south of a seldom used wagon road to the beach. The station is marked by a quart bottle buried 2 feet below the surface; three other pint bottles are buried 6 inches below the ground and about 6 inches from the station. The station is further marked by triangles blazed in the trunks of four palms at a height of 1 to 2 feet above ground, the first of which is 4.3 meters southeast, the second 6.8 meters east, the third 10.6 meters northeast, and the fourth 13.7 meters north of the station.

Kanagao Island, Leyte.—The magnetic station is identical with triangulation station Kan. The mark used was triangulation station Tin which bears 40° 37′ west of true south.

Descriptions of stations—Continued.

PHILIPPINE ISLANDS—Continued.

Lagonoy Gulf, Short.—The magnetic station is identical with triangulation station Short, which is on the mainland of Luzon and on the north coast of Lagonoy Gulf. The mark used was signal "Mex," distant about 1 mile. This bears 84° 48′.7 west of true south.

Lagonoy Gulf, Tall.—The magnetic station is identical with triangulation station Tall, which is on Aguiragnan Island. This island is east and just off from Alto or Patag Point on the north coast of Lagonoy Gulf, Luzon. The mark was station Fine, distant about three-quarters of a mile. It bears 74° 23′ west of true north.

Legaspi, Luzon.—The magnetic station is situated on the open sand beach, 42.4 meters south of the southern side of the wharf of Munoz, the northernmost wharf at Legaspi, 113 meters about north-northeast from the astronomic station, and 79.1 meters northeast from the northeast corner of the stone wall surrounding the Warner Barnes warehouses. The station is marked by a diamond-shaped stone, buried 2 inches below the surface of the ground and with a drill hole in its upper surface. The mark was the lower portion of the flagstaff, and bears 8° 51′.6 west of true south.

Mangarin, Mindoro.—The magnetic station is at the South Base of the triangulation. The mark is North Base and bears 4° 38′.7 west of true north. South Base is 1 000 meters southward along the beach from North Base and is on a long sand spit separating the outer bay from a large inside cove known as Crocodile Cove. The station is equidistant from the water on either side of the spit. A nail driven in a peg 4 inches square, sunk in the sand, with its top flush with the surface, marks the station.

Port Batan, Panay.—The magnetic station is on the west side of the entrance to Port Batan and in line with South Base and North Base of the triangulation, being 10 feet north of South Base. The mark, North Base, bears 18° 55′.6 east of true north.

Puerto Galera, Mindoro.—The magnetic station is identical with the astronomic azimuth station which is on the north end of sand spits, connecting the mainland with Panaquin Island. The station is on the Panaquin side of the sand spit, near the sea level and 20 feet from high-water mark. It is 125 meters north of a building on the Mindoro shore, the same distance south of a second building on the Panaquin shore, and 50 meters south from a third building on the same shore. The station is marked by a bottle, sunk in the sand 30 inches below the surface, with a large seashell placed over it and projecting in part above the surface. The mark used was the astronomic azimuth mark, First ⊙, which bears 60° 38′.4 east of true north.

Reef, Luzon.—The magnetic station is 50 feet distant from triangulation station Reef and in the direction of the azimuth mark, which bears 5° 06′.7 west of true north. Triangulation station Reef is on the point east of the town of Barcelona, on the southeast coast of Luzon.

Romblon, Romblon.—The magnetic station is in the grass-covered plaza, a little south of the crosspath which, if projected eastward, would pass south of the governor's new residence, the most pretentious house in Romblon. The station is west of the main avenue through the center of the plaza and is east of a pathway which is a continuation of the road on the west side of the Commandancia. Between this pathway and the magnetic station is a stone-paved drain which extends down to the bay. The magnetic station is 25.6 meters from the astronomic station, which bears 37° 15′.1 west of true north, and is marked by an oak peg with a copper tack in its top. The astronomic station is marked by a coarse marble stone, elliptical in cross-section, which is sunk level with the surface of the ground and has a cross cut in its top.

San Bernardino Light-house, San Bernardino Island.—The magnetic station is 150 feet distant from the San Bernardino Light-house triangulation station and in the direction of the azimuth mark, which bears 19° 51′.3 west of true north.

San José de Buenavista, Panay.—The magnetic station is in the open ground north of the old fort within whose walled inclosure the longitude station was established. The distance between the longitude and magnetic stations is 155.3 meters. The magnetic station is about one-third of a mile southwest from the plaza and is 25 feet north of the Calle Real, leading from the plaza to the beach. The station is marked by a stone post, 10 by 12 by 20 inches, with a drill hole in the upper end which projects 2 inches above ground. The west gable of San José church bears 57° 24′.2 east of true north.

Sorsogon, Luzon.—The magnetic station is identical with the astronomic station, which is situ-

Descriptions of stations—Continued.

PHILIPPINE ISLANDS—Continued.

ated southwest of the town, on the beach, northwest of two piers. The mark used was triangulation station Grove, which bears 0° 30′.9 west of true south.

Surigao, Mindanao.—The magnetic station is in the open lot west of the Provincial building, near its southwest corner, and 40.8 meters from the astronomic station. It is marked by a very hard stone, 14 by 8 by 4 inches, with a drill hole in its top which projects 3 inches above ground. The astronomic station bears from the magnetic station 26° 08′ east of true north.

Valle Hermosa, Negros.—The station is situated in an open field west of the church. It is 319.4 feet from the astronomic station, which bears 59° 42′.7 east of true north. The station is marked by an irregular coral stone, 18 by 6 by 8 inches, with a drill hole in its top which projects 3 inches above ground; below this stone a second piece of coral is buried 2 feet.

Vigan, Luzon.—Magnetic observations were made at the astronomic station situated in the inclosure of the race track, about one-half mile west of south of the center of the town, and about one-third mile due south of the chapel in the town cemetery, the true north line from the station cutting the tower of the chapel near its center. The station is marked by a stone 13 by 3½ inches on top, projecting about 5 inches above ground, having a drill hole on top and lettered U. S. C. G. S. on its north face. It is southwest of two prominent masonry piers, 182 feet from one and 274.6 feet from the other. About 5 feet south of the south wall of the Vigan cemetery a stone was set to mark the true meridian. This stone is 12 by 3 inches, with a drill hole in its top, and projects about 5 inches above ground.

PORTO RICO.

Battle Cay, Culebra Island.—The station is on Battle Cay, Mangrove Harbor, on the southeast side of Culebra Island. It is on the continuation of the line joining Culebrita Light-house and Battle Cay astronomic station and about 15 feet from the latter. The astronomic station is marked by a bowlder capped by a square cement block 15 by 15 by 3 inches, with a half-inch drill hole in the center. From the magnetic station Culebrita Light-house bears 59° 08′.1 east of true north.

Guaniquilla.—The station occupied is on range and between Guaniquilla and Melones triangulation stations, 15 paces from the former. The mark, triangulation station Melones, bears 20° 32′.4 east of true south.

Mayaguez.—The station is in the open field in front of the United States military hospital (1898), 38 paces from the hospital gate, 40 paces from the wire fence on the south, and 24 paces from the hedge fence on the west. The station is marked by a hole drilled in a rock about 1 foot square at the top, which is even with the surface of the ground. The smokestack of the sugar mill bears 52° 59′.0 west of true north.

Obispo Cayo.—The station of 1903 was reoccupied, and is on the northeast shore of Obispo Cayo, about 10 paces from the water and 12 feet from high-water mark. It is about the middle of an opening in the mangroves, which extend for about 60 feet along the beach. All the horizon from Cape San Juan Light-house to Palominos Island is visible from the station. The mark, Cape San Juan Light-house, bears 1° 47′.0 east of true north.

Porto Rico Magnetic Observatory, Vieques Island.—In connection with the establishment of a temporary magnetic observatory in Fort Isabel, a station for absolute observations was established on the hill east of the fort about halfway up.

San Juan South Base.—The station occupied was not marked. It is on range with and between Morro Light-house and South Base triangulation station, 20 paces from the latter. The mark used was Morro Light-house, which bears from the magnetic station 37° 09′.4 east of true north.

Scorpion Point, Culebra Island.—The station is on the extreme end of Scorpion Point, west side of Culebra Island, and on the southeast side of Target Bay. It is about 20 feet from the hydrographic signal "Scorp 2," and is on line from this signal to Soldado triangulation station of 1900. It is on the south side of the point, about 10 feet above sea level, and is nearly identical with the station of 1903. Soldado triangulation station (1900) bears 45° 13′.5 east of true south.

Descriptions of stations—Continued

SOUTH CAROLINA.

Aiken, Aiken County.—Two stations, A and B, marked by tent pegs driven flush with the ground, are located in the park, which is in the middle of the street passing in front of the Immanuel Training School. Station A is northwest from the northwest corner of this school, 68.9 feet from a board fence on the west side of the street and 117.4 feet from the hydrant near the northwest corner of the school building. Station B is 27.4 feet from A, and in line with it and the Ott House cupola. The Baptist Church cupola bears 58° 05′.6 west of true south. The Ott House cupola bears 38° 39′.3 west of true north.

Aiken, Aiken County.—The station is in Eustis Park almost exactly north of the northeast edge of the sanitarium. It is marked by a granite post 28 by 6 by 6 inches projecting 4 inches above ground and with a cross in the top. This post marks the north end of a meridian line 321.7 feet in length. The south monument, similarly marked, is near the center of Richland avenue and in front of the sanitarium. The east center flag on the "Park in Pines" Hotel bears 1° 17′.8 east of true north. The northeast edge of the sanitarium bears 00° 01′.8 east of true south.

Bamberg, Bamberg County.—The station is in the grounds of the Wofford Fitting School, nearly south of and in line with the rear or east side of the building, being 107 feet from its southeast corner. It is marked by an oak peg 1 inch in diameter driven flush with the ground. The cupola of the Presbyterian Church bears 72° 44′.4 west of true north. The water tank of the oil mill bears 69° 56′.1 east of true south.

Barnwell, Barnwell County.—The station is in the public park west of the Confederate soldiers' monument. It is 83.3 feet from the northwest corner of the iron fence around the monument and 18 feet from the west park fence. It is marked by a hickory peg driven flush with the ground. The cupola of the Baptist Church bears 63° 50′.5 west of true north. The south gable of the Colored Baptist Church bears 12° 05′.2 east of true north. The southwest edge of the court-house bears 89° 20′.5 east of true south.

Beaufort, Beaufort County.—The station is west of Wilmington street, two squares north of Bay street. It is 119.7 feet from the southeast corner of the jail and 71 feet from the southeast corner of the board fence surrounding the jail. It is 300 feet more or less north of Assistant Boutelle's station of 1874-75, and is marked by a pine peg driven flush with the ground. The southeast edge of the court-house bears 41° 00′.5 west of true south. The north edge of the Baptist Church cupola bears 76° 37′.4 east of true south. The southeast edge of the standpipe bears 55° 42′.7 west of true south.

Bennettsville, Marlboro County.—The station is in the northeast corner of the public school grounds, 20.4 feet from the east fence, 19.2 feet from the north fence, and is marked by a very hard stone 36 by 14 by 4 inches, with a small drill hole in the top and set flush with the ground. This is the north end of a meridian line 403.3 feet long, the south end of which is similarly marked. The cupola of the Presbyterian Church bears 63° 52′.6 west of true south. The Methodist Church cupola bears 31° 08′.9 east of true north. The water tank of the oil mill bears 13° 39′.7 west of true south.

Conway, Horry County.—The station is on private ground belonging to D. A. Spivy. It is 146.1 feet from the northeast corner of the Horry Hardware Company building and 8.4 feet from the fence on the south side of the grounds around Mr. Spivy's residence. It is marked by a round peg an inch and a half in diameter driven flush with the ground. The chimney of the Burroughs School bears 25° 42′.4 west of true north. The northeast edge of the Horry Hardware Company building bears 30° 05′.8 east of true south. The Methodist Episcopal Church cupola bears 89° 37′.0 west of true north.

Darlington, Darlington County.—The station is in the grounds surrounding the Baptist Church, approximately in line with the rear of the brick tobacco warehouse and 113.6 feet from the northeast corner of the church. It is marked by an oak peg with a small nail in the top, driven flush with the ground. The city hall cupola bears 22° 30′.0 west of true north. The city water tank bears 8° 15′.6 west of true north.

Georgetown, Georgetown County.—The station is on the sidewalk on the east side of Cleland street, north of Highmarket street. It is a few inches west of the line of trees on the sidewalk, and counting from the corner of Cleland and Highmarket streets it is between the fifth and sixth trees,

Descriptions of stations—Continued.

SOUTH CAROLINA—Continued.

being 18.5 feet from the latter and 17.9 feet from the former. It is marked by a hard sandstone 14 inches long with a triangularly-shaped top. The Presbyterian Church cupola, one-half mile distant, bears 75° 41′.5 west of true south. The smokestack on the ice factory bears 5° 19′.8 east of true south.

Kingstree, Williamsburg County.—The station is in the vacant lot north of the residence of Leroy Lee, being 12.4 feet from the east fence and 43.9 feet from the north fence of this lot. It is marked by a fat pine peg driven flush with the ground. The target of the north railroad switch bears 10° 48′.7 east of true north. The south gable of the oil mill bears 29° 17′.8 west of true north.

Manning, Clarendon County.—The station is in the northeast corner of the court-house square, being 102.0 feet from the northeast corner of the court-house and 104.7 feet from the square cement base of the artesian well on the north side of the square. It is marked by a fat pine peg driven flush with the ground. The east gable of Jud. White's house bears 85° 46′.9 west of true north. The southeast edge of Moses Levi's store bears 58° 48′.7 east of true north.

Marion, Marion County.—The station is near the southwest corner of the public square. It is marked by a pine peg, 20 by 2 by 2 inches, with a small nail in the top and driven nearly flush with the ground. The Presbyterian Church cupola bears 22° 11′.4 west of true south. The Colored Presbyterian Church cupola bears 22° 09′.3 east of true south. Two brown stones were set to mark the true meridian, one 29.9 feet due south of the magnetic station and the other due north.

Moncks Corner, Berkeley County.—The station is in front of and east of the railroad depot. It is 54.4 feet from the southeast corner of the chimney of Evans Myers's store and 50.7 feet from the northwest corner of the shoe shop. It is marked by a pine peg driven flush with the ground. The target of the north railroad switch bears 12° 31′.6 east of true north. The southeast edge of the railroad depot bears 89° 29′.8 west of true north.

St. George, Dorchester County.—The station is near the southeast corner of the court-house square, being 67.0 feet from the southeast corner of the court-house. It is marked by a 10-inch terra-cotta pipe projecting 6 inches above ground. This is the south end of a meridian line 335.7 feet long, the north end of which is similarly marked. The railroad water tank bears 65° 58′.1 east of true south. The colored church cupola bears 6° 25′.9 west of true north. The Baptist Church cupola bears 82° 50′.6 east of true north.

Walterboro, Colleton County.—The station is located on private grounds in front of Mrs. A. M. Henderson's house. It is 83.5 feet from the east fence and 74.4 feet from the south fence, and is marked by an oak peg driven flush with the ground. The southeast edge of Mrs. A. M. Henderson's house bears 20° 54′.7 east of true north. The north dormer gable of C. G. Henderson's house bears 56° 11′.1 west of true south.

TENNESSEE.

Athens, McMinn County.—The station is on a hill north of the town, about 800 feet northeast of the railroad station and about 600 feet south of the standpipe. It is 43 feet east of an apple tree and 118 feet southeast of the lower road from Athens to Sweetwater. The spire of the colored public school bears 8° 02′.6 west of true south. The Baptist Church spire bears 35° 06′.3 east of true south. The station is marked by a stone 16 by 3 by 8 inches, lettered U. S. C. & G. S., 1903 on top, in the center of which there is a drill hole.

Benton, Polk County.—The station is on the hill south of the town, about 225 feet northeast of the old brick kiln and 142.5 feet southeast of one of two heavenly bread (local name) trees. The court-house spire bears 3° 11′.7 west of true north. The center of the belfry on the public school bears 1° 26′.8 east of true north. The station is marked by a stone.

Blountville, Sullivan County.—The station is on a hill west of town and on the property of Mr. C. A. Brown. It is 28.8 feet southeast of a twin persimmon tree and 240 feet southwest of the southwest corner of the residence of C. A. Brown. The station is marked by a stone 24 by 6 by 6 inches, projecting 3 inches above ground. A second stone set approximately 300 feet north marks the meridian. The Presbyterian Church spire bears 61° 45′.9 east of true south. The court-house spire bears 57° 40′.4 east of true south.

Descriptions of stations—Continued.

TENNESSEE—Continued.

Cleveland, Bradley County.—The station is in an open field near the prolongation of Central avenue and Highland avenue. It is 78.5 feet from a fence along the south line of Central avenue, 37.7 feet from the north line of Highland avenue, and 14.5 feet southeast of a tree. The station is marked by a stone 30 by 4 by 5 inches, dressed to 3 inches square at the top, which projects 6 inches above ground. The court-house spire bears 47° 53′.4 east of true south. The spire on the public school bears 78° 53′.4 east of true south.

Clinton, Anderson County.—The station is in the east corner of the court-house square, 61.5 feet from the east corner of the court-house, 29.9 feet from the southeast fence, 37.1 feet from the northeast fence, and 370 feet from the southwest corner of the jail. It is marked by a small pine peg. The cupola of the M. E. Church South bears 67° 59′.4 west of true north. The spire on the Baptist Church bears 31° 55′.1 east of true north.

Crossville, Cumberland County.—The station is on the northeast side of the public square, 88.1 feet from the south corner of the telephone office, 59.0 feet from the north meridian stone and 260.6 feet from the south meridian stone. The meridian stones are 30 by 6 by 6 inches, each projecting 6 inches above ground. The cupola on the court-house bears 23° 43′.2 west of true south. The cupola on the Webster Academy bears 78° 08′.2 east of true south.

Dandridge, Jefferson County.—The station is southeast of the town in an open field belonging to J. L. Hedrick. It is 174 feet a little south of east from a hackberry tree at the corner of P. O. alley. The station is marked by a stone with a drill hole in the top which projects about 4 inches above the ground. The steeple of the North Presbyterian Church bears 5° 12′.6 west of true north. The spire on the Masonic Hall bears 69° 40′.4 west of true south.

Dayton, Rhea County.—The station is in the court-house square on the southeast side and about 75 feet from the building. It is marked by a stone about 8 by 15 inches on top; three crosses are cut on it in a north and south line. The middle one at the middle of the stone is the magnetic station. South of the station, and near the southeast fence at the south gate, is a stone about 8 inches square on top projecting 10 inches above ground. This marks the south end of a meridian line established by R. V. Myers in 1903. From the north meridian stone the Baptist Church cupola bears 37° 51′.4 east of true south. The M. E. Church cupola bears 13° 22′.0 east of true south.

Decatur, Meigs County.—The station is located near the northwest corner of the intersection of the first street north with the second street west of the court-house. It is marked by a limestone 26 by 8 by 4 inches, projecting 3 inches above ground. This is the north end of a meridian line about 640 feet long. The south end is a cross cut on the curbstone near the southeast corner of the intersection of the second street west with the second street south of the court-house. The T. V. Blevins monument in the cemetery bears 57° 07′.0 west of true north. The cupola of the Baptist Church bears 55° 32′.1 east of true north.

Dunlap, Sequatchie County.—The station is in the court-house square near the south side, 31.8 feet from the south fence and 46.0 feet from the south end of a meridian line 333.8 feet long. The south meridian stone is 26 by 7 by 7 inches and projects 2 inches above the ground. The north meridian stone is of irregular shape, projects 2 inches above the ground and has a drill hole to mark the exact point. The meridian line passes very near the southwest corner of the court-house; from the magnetic station the south gable of the M. E. Church bears 17°13′.5 east of true north.

Elizabethton, Carter County.—The station is in an open space about 825 feet west of the Virginia and South Western Railroad station. It is marked by a stone 6 inches square on top and projecting 8 inches above ground. North of the magnetic station 327.8 feet and just the other side of the next street is a stone marking the north end of the meridian line. The south stone is 468.4 feet south of the magnetic station and but a few feet south of the plank walk along Elk avenue. The spire of the Baptist Church bears from the magnetic station 63° 12′.8 east of true north.

Erwin, Unicoi County.—The station is in an open lot to the east of the street running south from the west side of the court-house at a point two blocks south. It is 42 feet from the north line of the street to the southeast and 119.6 feet from the north line of the street to the southwest. A stone marking the meridian line was set in the street 69.8 feet south of the magnetic station. The spire of the Baptist Church bears 29° 31′.6 west of true north.

Descriptions of stations—Continued.

TENNESSEE—Continued.

Greeneville, Greene County.—The station is in Terrell field on the west side of town and 165 feet southwest of the northwest corner of the Presbyterian parsonage. It is marked by a stone 30 by 5 by 3 inches projecting 4 inches above ground. The ball on Johnson's monument bears 13° 06′.5 east of true south. The chimney of the Brown Manufacturing Company bears 46° 56′.0 west of true north.

Huntsville, Scott County.—The station is south of the school building on the public school grounds. It is almost in line with the west front of the schoolhouse and is 84.6 feet from the southwest corner and 87.2 feet from the southeast corner of the building. A peg driven flush with the ground marks the station. The cupola of the M. E. Church bears 77° 35′.5 west of true south. The north gable of the old court-house bears 87° 58′.9 west of true south. The north gable of the Baptist Church cupola bears 80° 37′.5 west of true north.

Jamestown, Fentress County.—The magnetic station is north of the approximate center of the north side of Mr. Wood's garden and is 11.2 feet north of the north meridian stone. This stone is 28 feet southwest of a persimmon tree and 57.5 feet west of a second persimmon tree. The north meridian stone is 14 by 14 by 10 inches with a drill hole and cross in the top, which is flush with the ground. The south meridian stone is 309 feet from the north stone and 18 inches from the northeast corner of O. C. Conatser's house. It is 11 by 18 by 6 inches with a drill hole and cross in the top, which is flush with the ground. The east gable of J. Y. Crawley's hotel bears from the magnetic station 88° 24′.4 west of true south. The southwest edge of the Wood Hotel bears 59° 59′.7 east of true south.

Jasper, Marion County.—The station is on vacant ground north of the Lankester Hotel, 110.3 feet from the northeast corner of the hotel, 25.8 feet from the east fence, and 32.7 feet from the north fence. It is marked by a poplar peg driven flush with the ground with a small nail in the top. The cupola of the M. E. Church South bears 49° 05′.9 west of true north. The cupola of the M. E. Church North bears 7° 38′.6 east of true north. The northwest edge of the Sam Houston Academy bears 66° 13′.1 east of true north.

Jonesboro, Washington County.—The station is on a hill south of the town, just beyond and next to the residence of L. R. Clark. It is on the east side of the street running south from the court-house and is 264 feet southeast from the southwest corner of the residence of L. R. Clark. It is marked by a stone projecting 3 inches above ground. The spire of the Baptist Church bears 6° 04′.1 west of true north. The Methodist Church spire bears 60° 27′.1 west of true north.

Kingston, Roane County.—The station is on the north side of the Masonic lot, in line with the north fence of the M. E. Church and about 47 feet from its northwest corner. It is marked by a sandstone 26 by 8 by 8 inches projecting 2 inches above the ground. This is the south end of a meridian line about 825 feet long, the north end of which is marked by a similar stone projecting 8 inches above the surface of the ground. This north stone is 1 foot south of the fence between the Cormany and Staley properties. From the south monument the cupola of the Baptist Church bears 54° 57′.0 east of true north. The court-house cupola bears 89° 19′.0 east of true south.

Knoxville, Knox County.—The station is on the west edge of town at Fort Sanders. It is at the intersection of the west property line of Tenth street with the north line of Prof. W. W. Carson's house. The station is 380.5 feet from the northwest corner of this house and is north of Clinch street. It is marked by a stone 15 by 2 by 6 inches set flush with the ground. The spire on Daniel Briscoe's house bears 79° 54′.2 east of true south. The United States Weather Bureau pole on the University of Tennessee bears 85° 12′.7 east of true south.

Loudon, Loudon County.—The station is northeast of the court-house, in the court-house square, on an established meridian line, 47.4 feet south of the north monument. The south stone is near the south gate. Both stones are 8 inches square on top with drill holes in the center.

Madisonville, Monroe County.—The station is in the open square west of the public school. It is 202.3 feet southeast from the northeast corner of Robert Snider's house. It is marked by a stone 18 by 5 by 5 inches with a cross on top which projects 3 inches above the ground. The court-house spire bears 00° 41′.0 west of true north. The spire of the public school bears 43° 26′.5 east of true south.

Descriptions of stations—Continued.

TENNESSEE—Continued.

Maryville, Blount County.—The station is in the west side of the grounds of Maryville College and is northwest from the college building. It is east of a paved walk at a point where the walk turns off to the southeast. The distance from the station to this walk is 37 feet, and to a cedar tree to the northeast it is 18.8 feet. The station is marked by a stone. The spire on the Twenty-first district public school bears 75° 45′.8 west of true south. The court-house spire bears 56° 32′.7 west of true north.

Maynardville, Union County.—The station is in the northeast corner of a lot belonging to Mr. Carr and is about 300 feet south from the post-office. It is 61.2 feet from the north fence and 59.6 feet from the east fence of this lot. The station is marked by a stone 24 by 8 by 8 inches. A second similar stone was set south of the station to mark the meridian. The spire of the public school bears 87° 48′.5 east of true south. The court-house spire bears 13° 21′.0 west of true north.

Morristown, Hamblen County.—The station is in an open lot on Cumberland avenue belonging to Mrs. O. C. King. It is two blocks south of the railroad. The station is 246.5 feet from the north line of the street to the southwest and 131 feet from the west line of the street to the southeast. It is marked by a marble slab 15 by 4 by 4 inches set flush with the ground. The spire of the Baptist Church bears 24° 33′.1 west of true south. The north gable of E. O. Tate's house bears 83° 38′.6 east of true north.

Mountain City, Johnson County.—The station is west of town, just beyond (west) a small creek, 161 feet south of the south fence line along the Doe road and 424 feet northwest from the southwest corner of the Baptist Church. The station is marked by a wooden stub with four witness posts at right angles thereto; a second peg with witness posts was set about 300 feet south to mark the meridian. The court-house spire bears 89° 05′.3 east of true south.

Newport, Cocke County.—The station is in a field east of Master's Sanitarium at Eastport, which is about three-fourths of a mile east of the railroad station at Newport. The station is 196 feet from a road fence to the northeast. It is marked by a marble slab 24 by 6 by 6 inches projecting 4 inches above ground, with a drill hole in the center of the top which is lettered U. S. C. & G. S., 1903. The spire on Master's Sanitarium bears 32° 29′.3 west of true north. The north gable of Robert Valentine's house bears 78° 55′.3 east of true south.

Pikeville, Bledsoe County.—The station is near the southeast corner of the court-house square, 17.8 feet from the east fence and 30.5 feet from the south fence. It is marked by a hard limestone 24 by 5 by 11 inches projecting 2 inches above ground and with a drill hole in the center of the top. This stone marks the north end of a meridian line 593.3 feet long. The south meridian stone is near the southwest corner of the jail yard, 1.0 foot from the south fence and 8.1 feet from the west fence. It is a hard limestone of irregular shape, sunk a little below the surface and with a drill hole in its top. The cupola of the Christian Church bears from the magnetic station 36° 21′.8 west of true south. The chimney on S. F. Stevens's house, 1 mile distant, bears 48° 42′.3 east of true north.

Rogersville, Hawkins County.—The station is in the south corner of the grounds of the Swift Memorial Institute. It is 187.9 feet a little west of south from the south corner of the institute building, 50.8 feet northeast from the yard fence to the southwest, and 51.2 feet northwest from the yard fence to the southeast. The spire of the Southern Methodist Church bears 71° 48′.2 east of true north. The station is marked by a stone 15 by 3 by 4 inches projecting 3 inches above ground.

Rutledge, Grainger County.—The station is in the southwest corner of the Presbyterian Church yard, 107 feet southwest of the southwest corner of the Presbyterian Church, 77.5 feet from the west yard fence and 79.5 feet from the south yard fence. The station is marked by a stone 14 by 5 by 5 inches projecting 2 inches above ground. The court-house spire bears 86° 13′.8 east of true north. The Methodist Church spire bears 66° 54′.8 east of true north.

Sevierville, Sevier County.—The station is 184.2 feet southwest of the southwest corner of Murphy College and on the campus. It is marked by a stone 48 by 18 by 8 inches bevelled to 6 by 4 inches on top. A similar stone was set just inside the fence on the north side of the campus to mark the meridian. The turret on the Baptist Church bears 00° 55′.8 east of true north. The court-house spire bears 53° 23′.7 west of true north.

Descriptions of stations—Continued.

TENNESSEE—Continned.

Tazewell, Claiborne County.—The station is in a lot belonging to W. C. Parkey and is about 500 feet east of the Parkey residence across the street. It is 19.5 feet west of a north and south fence line and 30.8 feet north of an east and west fence line. It is marked by a stone 24 by 10 by 8 inches projecting 4 inches above ground. The northwest corner of John Margrave's house bears 21° 53'.1 east of true south. The court-house spire bears 52° 15'.4 west of true south.

Wartburg, Morgan County.—The station is in the northwest corner of the court-house square, 47.2 feet from the west fence and 33.6 feet from the north fence. It is marked with a peg driven flush with the ground. The east gable of Judge Risedon's residence bears 12° 57'.1 west of true south. The east gable of Doctor Cooper's house bears 77° 29'.4 west of true north.

WASHINGTON.

Port Angeles, Clallam County.—The station is on the alluvial spit forming the harbor. It is about half a mile west from the light-house, a little nearer the outside than the inside of the spit, and about 25 yards south of the crest. It is northeast of the most easterly bunch of three piles driven along the inner edge of the spit. The station is marked by a fir post about a foot square, with rounded corners and projecting about 10 inches above ground. The Ediz Hook Light-house bears 82° 15'.2 east of true south. The cupola of a church near the wharves bears 22° 05'.8 west of true south.

Port Townsend, Jefferson County.—The station is in the proposed site for a public park on the northern edge of the city. It is 25 feet west of the bluff extending through the city and about the same distance north of the edge of a depression running in an east and west direction. The station is marked by a cedar block 8 inches square and projecting 3 feet above the ground. The spire of Central High School bears 26° 54'.2 west of true south.

Seattle, King County.—The station of 1903 in the grounds of the State University was reoccupied. It is marked by a stone post 8 inches square projecting 5 inches above ground and lettered U. S. C. & G. S., 1903. The east corner of the administration building bears 23° 08'.5 west of true south.

FOREIGN COUNTRIES.

BAHAMA ISLANDS.

Clarence Town, Clarence Harbor, Long Island. The station is in the Government Residency, and is marked by a ¾-inch copper bolt, set in bed rock, between the portico of the residence and the flagstaff. It is about 40 feet from the flagstaff and about 60 feet from the portico of the residence. The mark used was the rod on top of the light staff on Gaspin Point. The true azimuth of this mark was found to be 28° 44'.4 east of true north.

Cockburn Town, Watlings Island.—The station is on the premises of the government residence and hence on Crown land. It is about 40 feet east-southeast from the southeast corner of the residence and is marked by a pint bottle buried in the ground to the depth of 3 or 4 inches. The only available mark was John Macky's house in Sugar Loaf village, distant about 4 miles to the south and across the bay. This house is the largest of a group of three or four dwellings visible from the magnetic station and in the settlement called Sugar Loaf. The location of this station was selected on account of its convenient access from the point of anchorage at Riding Rock Point.

Hope Town, Elbow Cay, Abaco Island.—Magnetic observations were made on a narrow ridge between Little Harbor and the southeast coast of Elbow Cay. The station is about 100 feet northeast of the public schoolhouse and about 100 feet northwest of the Episcopal Church. It is marked by a limestone rock about a foot square and planted in the soil. The mark used was the rod on top of the Elbow Cay Light-house, which is about one-half a mile north-northwest of the station.

Nassau, Hog Island.—Observations to determine the magnetic declination were made at a point about 30 feet west-northwest of the stone monument marking the southwest corner of a former Crown reservation. This is presumably within a few feet of the station occupied by Lieutenant Ackley in

Foreign stations—Continued.

BAHAMA ISLANDS—Continued.

1879, although no evidence of his station was found. The station is approximately 2 200 feet from the front of the Board of Trade yard in Nassau and 5 000 feet east of the Hog Island Light-house. It is just above high tide, on the south shore of Hog Island, and directly opposite the Royal Victoria Hotel in Nassau. The mark used was the obelisk at Fort Charlotte, which is west-southwest from the station.

Nassau, Old Government House.—The station is on the grounds of the old government building built by the first governor of the islands (Lord Dunmore?). The property was until recently used as a government hospital. About six or eight years ago it was purchased by the Catholic Church and is now the residence of the local priest, Father Chrisostum Schreiner. The exact location of the station occupied is marked by means of 5 copper nails driven into the bed rock on the premises, about 75 feet west-northwest from the northwest corner of the building. These nails are covered by means of a slab about 1 foot square, with the inscription "Bahama Expedition, 1903." The location of the station is further fixed by sighting upon three points, Hog Island Light-house to the north, the obelisk to the west, and the northwest edge of the priory building, about 75 feet to the east-southeast. The mark used was the tip of the obelisk at Fort Charlotte. Its true azimuth was found to be 86°47′.4 west of true north.

Nassau, Public Square.—The station is at the southern extremity of the meridian line established by the surveyor-general, Mr. Miller, from north star observations. This point is marked by a bolt in a stone slab a few feet to the north of the abandoned well between the library building and the custom-house. The north end of the meridian line is a bolt in the wall of the custom-house, about 300 feet distant from the south end.

CANADA.

Union, British Columbia.—The station of 1903 was reoccupied. It is on an alluvial spit, about a quarter of a mile north of the Wellington Colliery Company's pier and about half that distance east of the railroad and coke ovens. It is about 10 feet east of the cart path, 100 feet north of a large wooden post, about 18 inches in diameter and 8 feet high, and 75 feet from high-water mark. The station is marked by a fir post about 6 inches in diameter and projecting about 10 inches above ground. The northeast edge of the chimney at the brickkiln bears 19° 50′.4 west of true south. A church spire at Comox bears 18° 44′.8 west of true north.

APPENDIX 4

REPORT 1904

TELEGRAPHIC LONGITUDES

THE PACIFIC ARCS FROM SAN FRANCISCO TO MANILA, 1903-4
COMPLETING THE CIRCUIT OF THE EARTH

By EDWIN SMITH
Assistant, Coast and Geodetic Survey

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ILLUSTRATIONS.

TELEGRAPHIC LONGITUDES: THE PACIFIC ARCS FROM SAN FRANCISCO TO MANILA, 1903–4, COMPLETING THE CIRCUIT OF THE EARTH.

By EDWIN SMITH, *Assistant, Coast and Geodetic Survey.*

GENERAL STATEMENT.

Preparations for the determination of the difference of longitude by telegraphic methods between San Francisco and Manila began in December, 1902, in anticipation of the completion of the trans-Pacific cable, which was announced for the year 1903, and on the 20th of that month the writer began to prepare plans for the work. In February a visit was made to the New York office of the Commercial Pacific Cable Company for the purpose of obtaining information in regard to the best method of recording time signals automatically. A method had been successfully used by the Canadian and English observers in determining the difference of longitude between Greenwich, England, and Montreal, Canada, in 1892, but no description of this method was available. Fortunately, the superintendent of the cable station at Canso, Nova Scotia, Mr. S. S. Dickerson, was in New York, and could describe the apparatus. Based upon the information thus obtained, a simple apparatus for recording automatically time signals sent over cables was designed and constructed at the Coast and Geodetic Survey Office, which proved entirely successful in use in the field.

Mr. G. G. Ward, vice-president and general manager of the Commercial Pacific Cable Company, generously granted the privilege of using the cables of his company in the exchange of time signals and in making the necessary communications between the observers during the progress of the work without charge, and issued instructions to the superintendents of the cable stations at San Francisco, Cal., Honolulu, Hawaii, Midway Island, Guam Island, and Manila, P. I., to do all in their power to facilitate the progress of the work.

The writer arrived in San Francisco on March 17, 1903, fully equipped for the work, and was joined the same day by Assistant Fremont Morse, who was to co-operate in the longitude determinations.

The following plan of operations was adopted:

(1) Testing of apparatus and special observations for relative personal equation at San Francisco.

(2) Determination of difference of longitude on five nights with Smith at Honolulu and Morse at San Francisco.

(3) The same number of determinations with Morse at Honolulu and Smith at San Francisco.

(4) Special observations for relative personal equation at San Francisco.

(5) To take up the other stations when the cables should become available.

The recording apparatus was tested and found to be more satisfactory than was anticipated. Observations for personal equation were made in San Francisco, and on April 14 the observers were ready for observations at San Francisco and Honolulu. Several days of unfavorable weather followed, but the necessary observations were obtained April 20, 22, 26, 27, and 29. Mr. Morse then went to Honolulu and observations for personal equation were made, before the writer left for San Francisco, at which place he arrived on May 19. Unfavorable weather again prevented observations until June 2, when observations were made, and also on June 4, 6, 11, 12, and 13, thus completing the work between San Francisco and Honolulu, the first step in the trans-Pacific longitude work.

In May it became known that the cables between Honolulu and Manila would be completed by the Fourth of July, and it was decided to advance the work as rapidly as possible. There was no regular means of transportation to and from Midway, and it was therefore desirable to leave this station out of the scheme if possible. There seemed to be a possibility of getting signals directly between Honolulu and Guam with the cables joined at Midway, and, the cable company having consented to make the attempt, the writer went to Guam by the first available means of transportation. In accordance with the plan adopted Mr. Morse remained at Honolulu for the purpose of going to Manila upon the completion of the work between Honolulu and Guam. It was intended that the writer should join him at Manila and again make observations for relative personal equation. It will later be seen that this excellent scheme unfortunately could not be carried out.

The writer sailed from San Francisco on the U. S. S. *Solace* June 21 and arrived at Honolulu on the 27th, where he was able to again confer with Mr. Morse, and observations for personal equation were made. The *Solace* sailed from Honlulu July 1 and reached Guam Island July 14. Here the writer met with many unexpected difficulties, but with the very generous and kind assistance of the superintendent of the cable station they were overcome.

The governor of the island, Commander W. E. Sewell, U. S. Navy, offered any assistance he could give, and some very necessary supplies were obtained from the naval station.

The cables were not ready for signals on July 14, but by the time the observatory and instruments were ready, July 27, the cables were at the service of the longitude parties. The tests made on that day failed to give satisfactory signals, and it became evident that no satisfactory signals between Honolulu and Guam with the cables joined at Midway could be obtained, except possibly by the use of a voltage so great that the cables would be endangered. It was quite out of reason to ask the cable company to take, such a risk and the attempt to eliminate Midway as a longitude station was abandoned. The Superintendent of the Survey being informed of these conditions, Mr. Morse proceeded to Manila, arriving there on August 31.

The difference of longitude between Guam and Manila was determined on nights of September 8, 12, 14, 15, and 16.

There is no means of transportation from Manila to Guam except by the navy vessels. The U. S. S. *Solace* makes two trips a year, and occasionally some other vessel stops there on the voyage to the United States. The army transports stop at Guam on the voyage from the United States to Manila, but not on the return voyage. So, whereas it is quite easy to get from Guam to Manila, it is very difficult to get from Manila to Guam. The exchange of observers had, therefore, to be given up. It was learned that the U. S. S. *Iroquois* would sail from Honolulu for Midway about October 16, and in order to reach Honolulu by that date Mr. Morse would have to take the steamer from Hongkong September 26, and that necessitated his leaving Manila on September 19, and so no further determination of the difference of longitude between Guam and Manila could be made. Mr. Morse reached Honolulu October 15, and found the trip of the U. S. S. *Iroquois* had been given up. While Mr. Morse was seeking other means of transportation, there occurred a wreck on the reef at Midway, which led to the *Iroquois* making the trip and taking Mr. Morse and outfit there. He reached Midway on November 3. The difficulties at Midway were even greater than at Guam, as Mr. Morse was entirely dependent upon the cable staff for assistance and their force was limited. Their generous assistance and great interest were most important in advancing the work. Longitude determinations between Midway and Guam were made on nights of November 16–17, 17–18, 18–19, 22–23, 23–24, 26–27; December 1–2, 3–4, 4–5, 5–6.

It now became the question how the writer could most quickly reach Honolulu. An army transport was due at Guam December 22, and would reach Manila December 28, just too late to get to Hongkong in time to take the steamer due to sail January 2. The next steamer would sail January 9 and reach Honolulu January 30. The cable company's ship *Scotia* was expected at Guam January 4, and would probably reach Honolulu about January 23. Transportation on the *Scotia* was secured, and word came from Mr. Ward that she would reach Guam about January 10. This made it desirable to take the army transport *Logan* to Manila, but when she arrived it was found impracticable. On January 8 word came from Mr. Ward that the *Scotia* was still further delayed, and as the U. S. S. *Solace* was due on January 10 it was decided to risk no further delays. The *Solace* sailed on the 10th and reached Manila January 15. A steamer sailed the next day for Hongkong, where the writer caught a Pacific Mail steamer and arrived at Honolulu February 8. It turned out that the *Hongkong Maru*, which sailed from Hongkong January 9, was held up at Yokohama in anticipation of the war.

At this season the weather was very unfavorable at both Honolulu and Midway, but especially at the former place. Determinations of the difference of longitude between these places was made on nights of February 22, 25; March 2, 8, 9, 10, 19, and 24, and further attempts were made up to April 8, but the very cloudy weather prevented success. The failure of the army transport *Buford* to land provisions at Midway March 28 led to a trip of the U. S. S. *Iroquois* to the island, and Mr. Morse returned on her to Honolulu, where he arrived April 16.

Observations for relative personal equation were made before the observers sailed for San Francisco, on April 18 and 21, the only available nights. They reached San Francisco May 2, and made further observations for personal equation on May 6, 7, 8, and 9. This closed the field work for the determination of the difference of longitude between San Francisco and Manila.

It will at once be understood that the chief cause of delay in the prosecution of this work was the difficulty of transportation to and from the islands of Midway and Guam. Mr. Morse was at Midway five months and seven days, while the writer was at Guam six months less four days.

Acknowledgment is made to the cable company and to Mr. G. G. Ward, its vice-president, for the many facilities and courtesies extended to the observers, without which the work would have been impracticable; and also of the assistance rendered by the cable staffs at the several stations, and especially in the cases of the superintendents, Mr. H. F. Harrington at San Francisco, Mr. J. D. Gaines at Honolulu, Mr. B. W. Colley at Midway, Mr. D. Coath at Guam, and Mr. E. Desnouee at Manila.

DESCRIPTIONS OF STATIONS.

SAN FRANCISCO STATION.

The present longitude station in San Francisco is on Drill Plain Knoll, in the Presidio Military Reservation. It is about 130 meters southwest of the terminus of the Union street-car line. The observatory is T-shaped, and contains three rooms. The observing room is in the stem of the T and to the east of the other two. It contains three piers of brick, capped with massive sandstones. A clock is mounted on the west pier. Upon the middle pier was mounted transit No. 3, and this pier is the longitude station. The east pier was built for the zenith telescope. This observatory was built in 1896, under the direction of Assistant A. F. Rodgers, who was in charge of the sub-office at San Francisco. The same year the difference of longitude between this station and the old station at Lafayette Park was determined by Assistants Fremont Morse and O. B. French on ten nights, the observers exchanging stations after the first five nights. The results of this determination will be found on pages 820 and 826 of Special Publication No. 4, U. S. Coast and Geodetic Survey, 1900, "The Transcontinental Triangulation."

Transit No. 19 could not be conveniently mounted on the middle pier, and was therefore mounted on the east pier, which is 1.47 meters, or 0″.063, or $0^{s}.004$, east of the middle pier or longitude station.

This station is about 4 miles from the office of the Commercial Pacific Cable Company, and as signals could not be sent on the cable from the observatory, a break-circuit chronometer was placed at the cable office, and by a land-line connection this chronometer was compared with the break-circuit chronometer at the observatory both before and after the signals were exchanged between San Francisco and Honolulu. A land line already existed between Presidio and the Feland Building under the control of the Army Signal Corps, and this was connected with the observatory by direction of Colonel Allen, the officer in charge. The Postal Telegraph Company very kindly furnished the land connection between the cable office and the Feland Building. The Pacific States Telephone and Telegraph Company also furnished telephone connection between the observatory and cable office.

The latitude of this station was determined in 1896 by Assistant O. B. French, and is 37° 47′ 48″.22±0″.05 N. (See p. 724, Special Publication No. 4, U. S. C. & G. Survey 1900, "The Transcontinental Triangulation.")

HONOLULU STATION.

All former observation stations at Honolulu were unavailable, and a new one was selected. A site at the navy station was finally chosen and permission to occupy it was granted by Lieut. Commander Hugh Rodman, the acting commandant. This is probably the best location within the limits of Honolulu. It is on Government property, and will be preserved.

An excavation was made to the solid coral rock, upon which was built the concrete pier 14 by 26 inches, extending 3 feet above the surface of the ground. This pier is in the center of a wooden observatory 8 by 12 feet. The sides of the building are only 6 feet high and the ridge of the roof is but 2½ feet higher, so the distance between the objective of the transit and the outside air is about as short as it is practicable to have it. The opening in the roof is 14 inches wide.

North of the center of this pier 11.27 feet was placed a mark consisting of an iron pipe 2.5 feet long set in cement, with a copper bolt marking the center. This mark was set by the Territorial Survey, under the direction of Mr. W. E. Wall, and connected with the main triangulation of the island. The latitude of the longitude station was thus found to be—

21° 18′ 23″.7 north.

The station is about one-half mile from the cable office, and was connected with it by a land line and telephone line in the same manner as at San Francisco. The land line was put up by the Territorial government, and the telephone was furnished by the Mutual Telephone Company of Honolulu.

GUAM ISLAND.

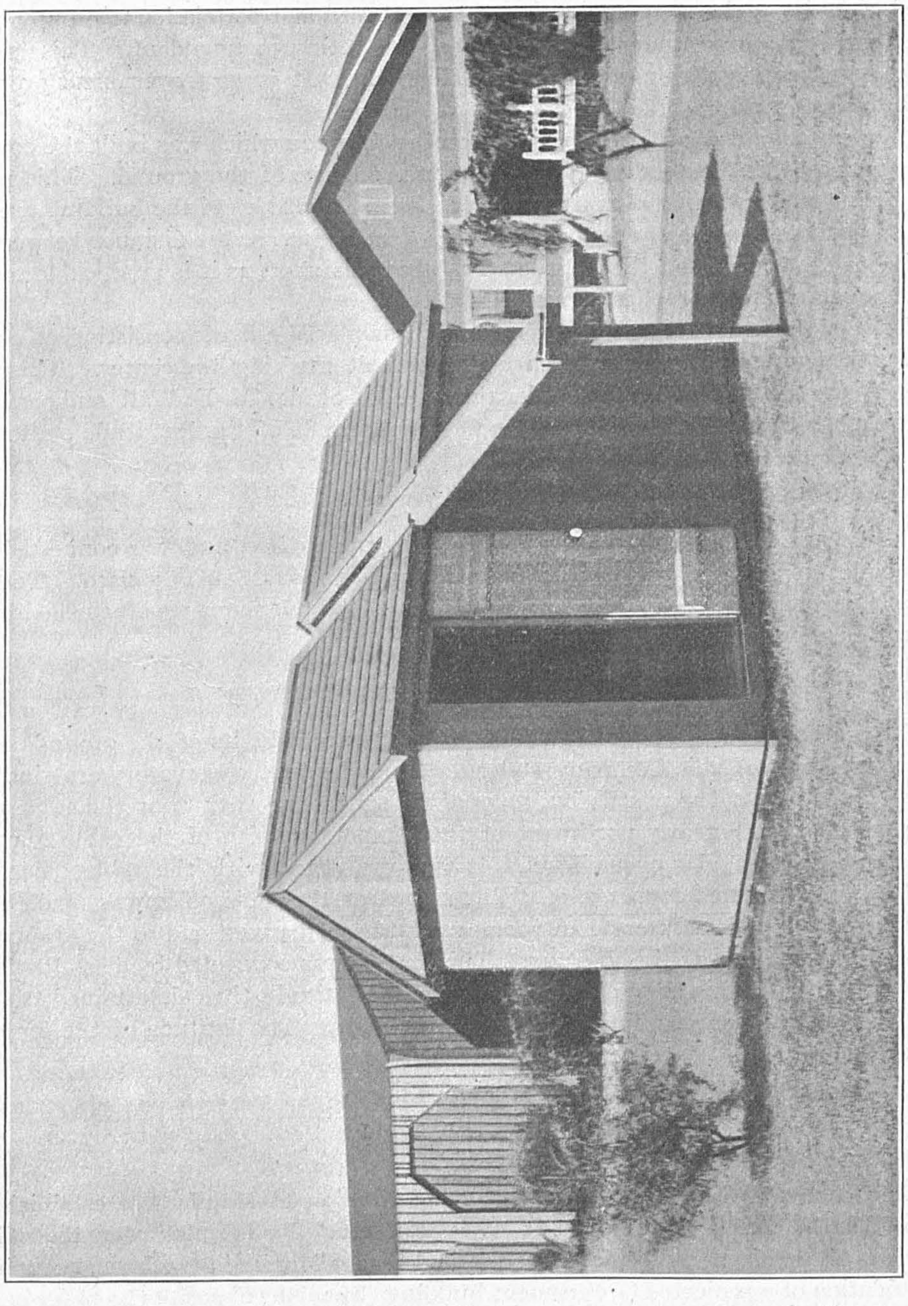
This station is on the Orote Peninsula near the north limits of the grounds of the Commercial Pacific Cable Company station. The pier and observatory are similar to those at Honolulu. The pier is built upon the solid coral rock near the edge of the bluff, about 330 feet nearly northwest of the temporary office of the cable company. It is about 80 feet above sea level. It was connected with the cable office by a loop of No. 12 insulated copper wire. The record at the cable office was made by the chronometer at the observatory. A room was built on the west end of the observatory for the accommodation of the observer. This station was connected by a small triangulation with the Navy Survey of the island and its latitude thus determined from the navy observations made at Fort Santa Cruz in 1899. The latitude of the longitude station is—

13° 26′ 22″.27 north.

MANILA STATION.

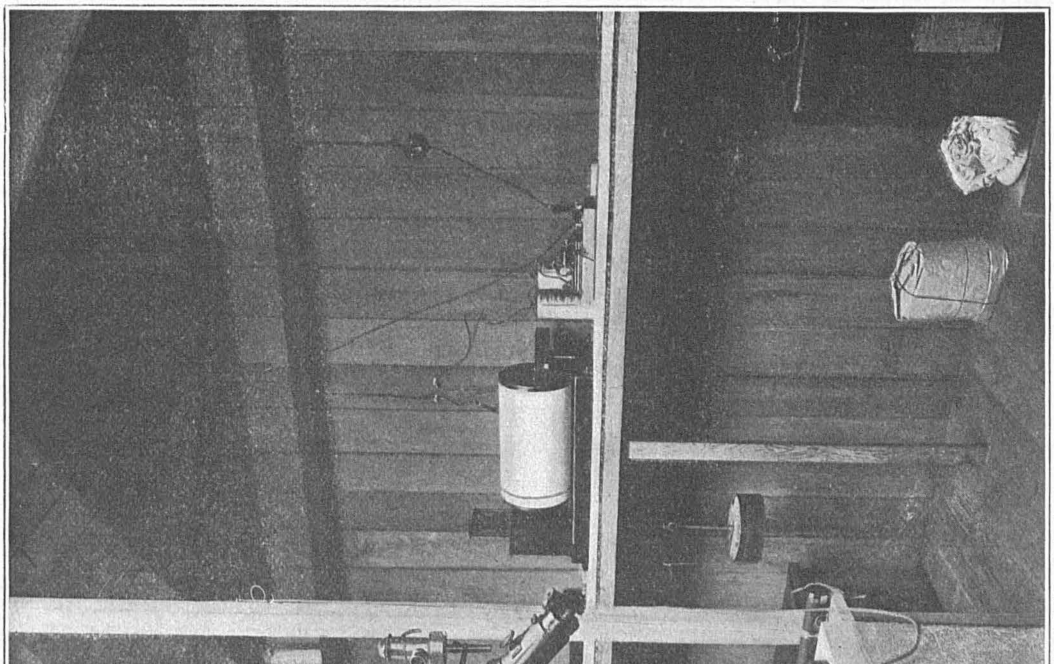
The Coast and Geodetic Survey astronomic station at Manila was established in 1901, under the direction of Assistant G. R. Putnam. By permission of the military authorities the station was located in the walled city of Manila in the block occupied by the foundation of a projected Government building (Spanish) opposite the plaza in front of the principal public building, commonly called the "Palace." In a quadrangle formed by the foundation wall and open toward the plaza a frame observatory building

No. 1.



Observatory at Honolulu.

No. 2.



Observatory at Honolulu. Interior.

10 by 15 feet was erected. Two massive granite blocks were set for the instrument piers, their centers being in an east and west line and 5.5 feet apart. These piers are 19 by 24 inches and were 32 inches in the ground and 28 inches above the ground. The east pier is the longitude station. By triangulation this station was connected with the center of the cathedral dome, which is the point of reference for astronomic work at Manila. The latitude of the astronomic station as observed by the Coast and Geodetic Survey in 1901 is—

$14^\circ\ 35'\ 31''.68$ north.

Cathedral dome is east of the astronomic station 100.67 meters, or $3''.36$ ($0^s.224$), and south 46.98 meters, or $1''.53$. This station is about 1½ miles distant from the cable office and was connected with it by both land telegraph line and telephone, as at San Francisco and Honolulu, for which Mr. Morse states that he was indebted to Major Glassford, Chief Signal Officer, U. S. Army.

MIDWAY ISLAND.

The station is located on a prominent sand dune about 15 feet above high water and about 240 feet northeast from the temporary office of the Commercial Pacific Cable Company. It is marked by a bottle about 3 feet below the surface of the ground. The pier and observatory are similar to those at Honolulu, a room being added to the west end for the accommodation of the observer. The station was connected with the cable office by a loop of No. 12 insulated copper wire, as at Guam.

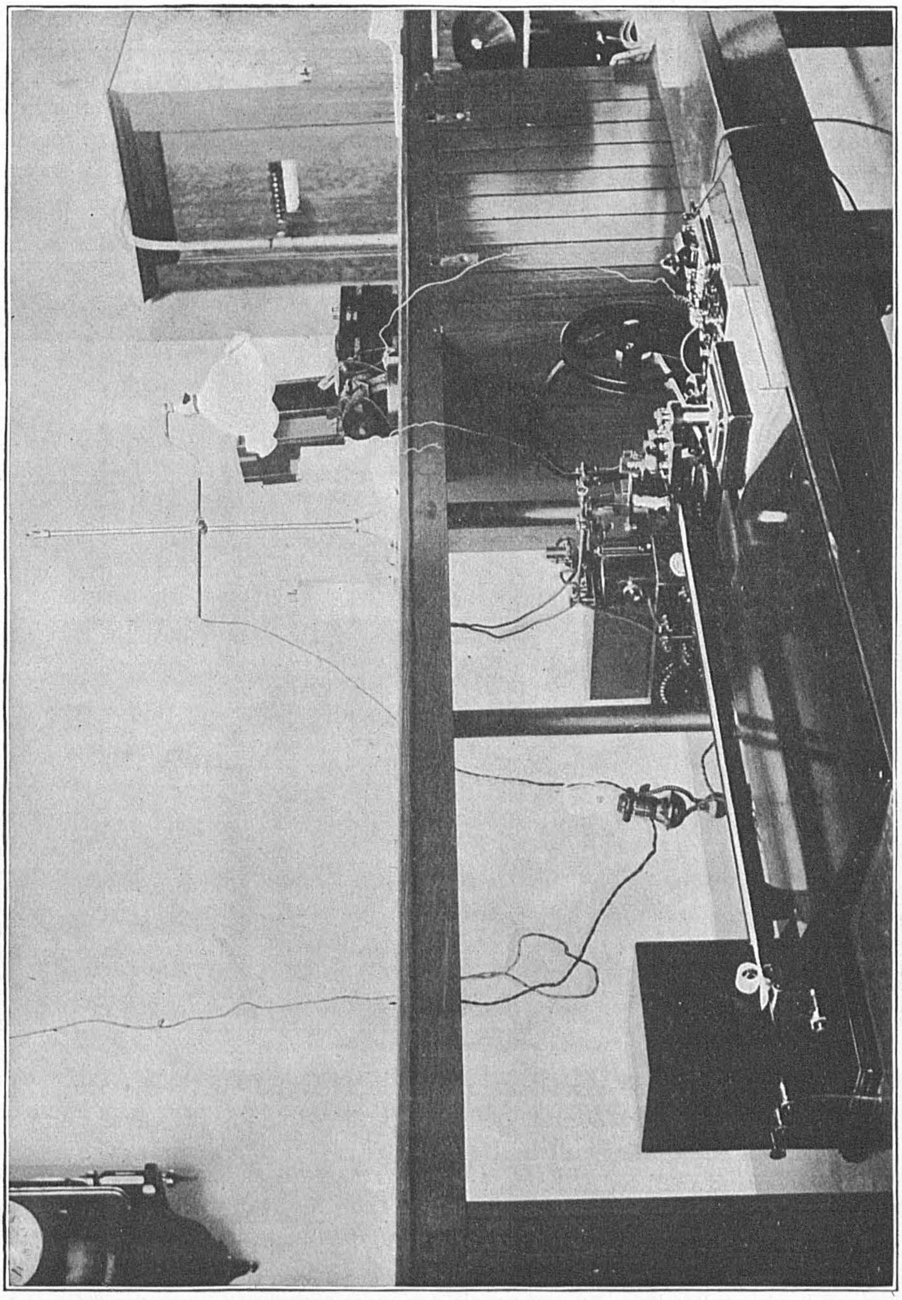
The latitude of the astronomical station at Midway, as determined by Mr. Morse with a sextant and artificial horizon, is—

$28^\circ\ 12'\ 52''.1$ north.

THE AUTOMATIC RECORD OF CABLE SIGNALS.

The five stations of the Commercial Pacific Cable Company are fitted out with the same character of instruments. The Muirhead siphon recorders are exclusively used and a descripton of them can be found in "Submarine Telegraphs," by Charles Bright. The record is made upon a slip of paper by a siphon pen. The slip is made to move by an electric motor at the rate of about 2 centimeters per second. The siphon pen is a very delicate glass tube which is attached to a bit of metal about 1 centimeter square fastened to a horizontal thread held on a horizontal frame in front of the magnet and coil of the receiver. By two threads the bit of metal is attached to the coil of the receiver in such a manner that the turning of the coil by the cable current gives the lower end of the siphon pen a motion parallel to the plane of the paper and at right angles to the direction of motion of the paper. The electric current which is used on the cable is so weak that this siphon pen would not be moved by it if the pen were in contact with the paper, and it is therefore kept in constant vibration at right angles to the plane of the paper. In order that the paper and pen may have the proper relative positions the rollers over which the paper passes are attached to a stand capable of a vertical and two horizontal adjustments. It was necessary that all signals should be received through this instrument and recorded on the slip of paper at the cable office. The end of the cables are brought into the office and no land-line attachment whatever

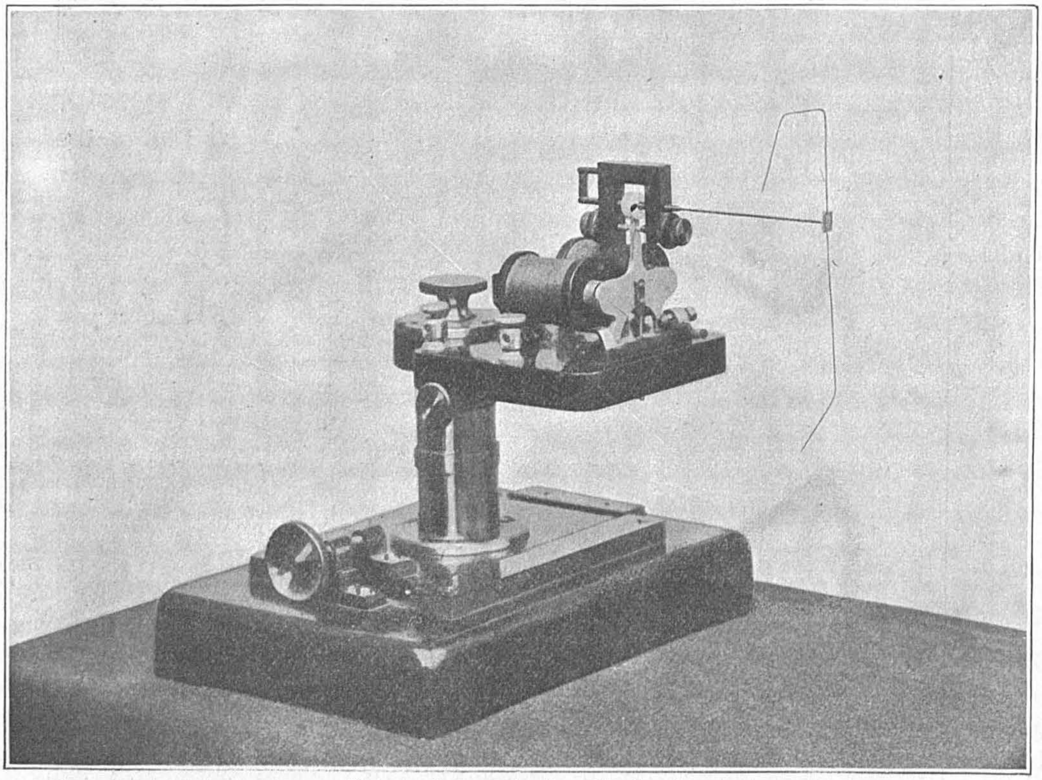
No. 3.



Cable office. Chronometer recorder in position.

is allowed. The problem was to refer the record of a signal received on this slip to the time as recorded by a break-circuit chronometer, and it was solved in the following very simple manner: A magnet as nearly as practicable like the magnets of the chronographs was provided and to the armature was fastened a small horizontal arm of aluminum. This arm carried a siphon pen exactly like the one on the cable receiver. A stand was provided for this magnet having a vertical and two horizontal adjustments so that it could be placed in front of the cable receiver and be adjusted to record on the slip alongside of the cable pen, taking ink from the same well. This is called the chronometer cable recorder. The chronometer and local battery were in circuit with this magnet. The record of the chronometer was made on the slip by the pen attached to this magnet, and that of any signal coming over the cable by the cable pen parallel to it. The record of the cable pen could be brought vertically down to the record of the chronometer pen and read with the ordinary scale. On account of the impracticability of always adjusting the pens exactly opposite each other the cable signal has a correction the determination of which will presently be explained. This chronometer record is made on the slip in exactly the same manner that it is made on a chronograph.

No. 4.

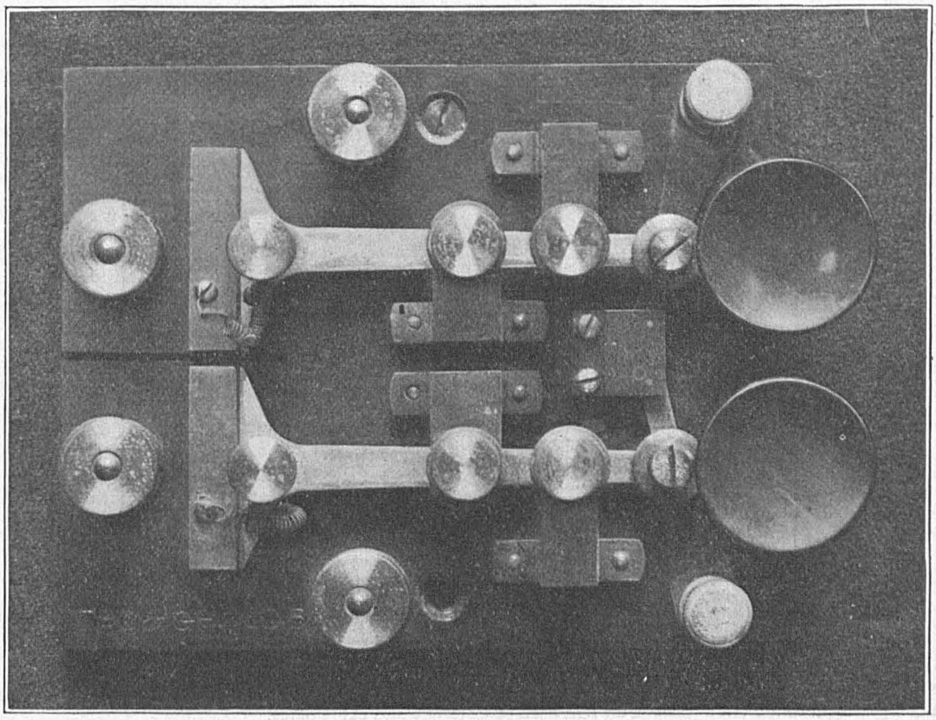


Chronometer recorder for cable signals.

The signals were sent by a key such as is used in correspondence over the cable. In fact, the two keys used were obtained through Mr. Ward from the cable company. They are double keys, by which a positive or negative current can be sent to the cable.

An attachment to these keys was made at the Coast and Geodetic Survey Office by which the circuit through the chronometer recorder would be broken at the instant the current was put on the cable and thus record the chronometer time of the signal sent. When sending signals the local cable receiver was generally disconnected but by so arranging a shunt that a small portion of the sending current would pass through the coil of the local receiver a sharp record was also made by the pen of the cable receiver, and thus the relation of the two siphon pens to each other was obtained from the signals used in the longitude work. This was done in all the work except between San Francisco and Honolulu. This cable is duplexed—that is, it is so connected that messages can be sent in both directions at the same time. The balance of the currents must be so perfect to accomplish this that the equality of the transmission times of signals must be more certain than in any other case. In this particular longitude the balance of the cables was slightly disturbed, both before and after exchanging signals, in order to send special signals to get the double local record to determine the relation of the pens.

No. 5.

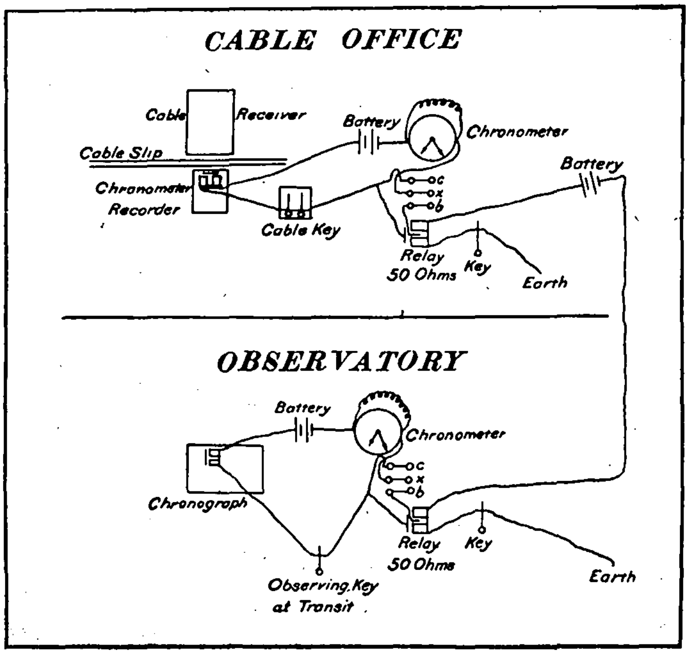


Key for sending time signals over cable.

At the stations San Francisco, Honolulu, and Manila the observatories were so far from the cable stations that the chronometer recorder at the cable office could not be placed in circuit with the chronometer at the observatory. Another chronometer was therefore placed at the cable office to be used in the exchange of cable signals. At these stations the observatories and cable offices were connected by land lines grounded at both ends. These were closed circuits, containing at each end a 50-ohm Morse relay and a Morse key and necessary battery. The chronometers were compared just before and just after the exchange of cable signals, and the method of the comparisons was the same as in a determination of longitude over any land line. Between 20 and 30 signals were sent in each direction, those sent from or received at the cable office being recorded on the cable slip by the siphon pen of the chronometer recorder and those sent from or received at the observatory on the chronograph.

At stations Guam Island and Midway Island the observatories were near enough to the cable office to admit of the chronometer recorder at the cable offices being placed in the observing circuit with the magnet of the chronograph, and so the cable signals were recorded by the same chronometer used in making the time observations. The three sketches show the arrangement of circuits as above stated.

No. 6.



Local circuits at San Francisco, Honolulu, and Manila.

At observatory while observing place switch X on C. At cable office while exchanging cable signals place X on C. When comparing chronometers place X on B at both observatory and cable office.

The plan for exchanging signals was as follows between San Francisco and Honolulu:

(1) The corrections to the cable pens were determined at each station by about 20 signals.

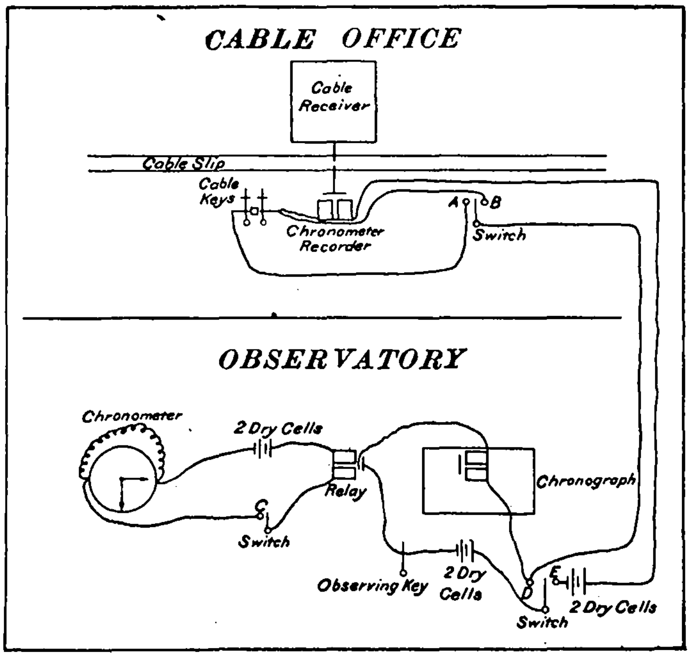
(2) Chronometers at observatories and cable offices were compared by about 20 signals in each direction.

(3) San Francisco sent 40 signals to Honolulu.

(4) Honolulu sent 80 signals to San Francisco.

(5) San Francisco sent 40 signals to Honolulu.

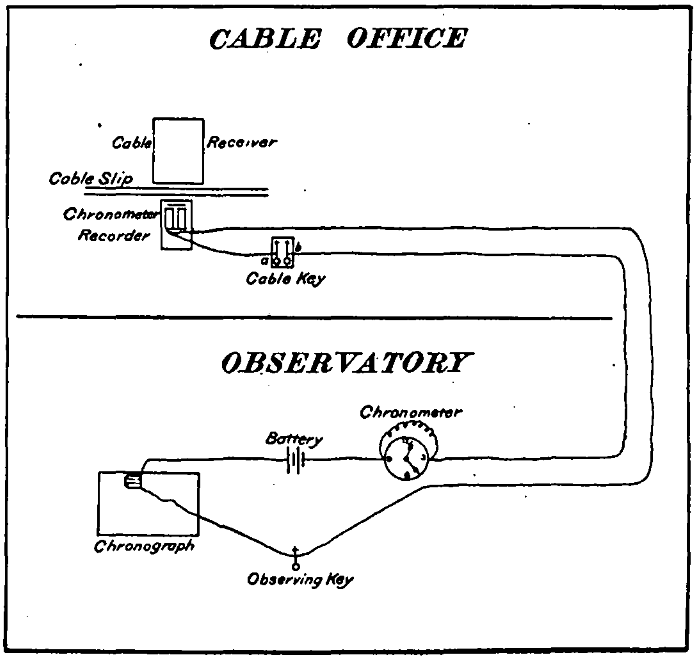
No. 7.



Local circuits at Guam.

Sending or receiving signals place switch on A. During correspondence place switch on B. When observing place switches on C and D. Sending or receiving signals place switch on E.

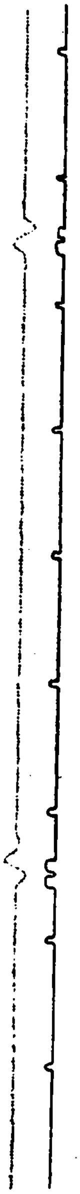
No. 8.



Local circuit at Midway.

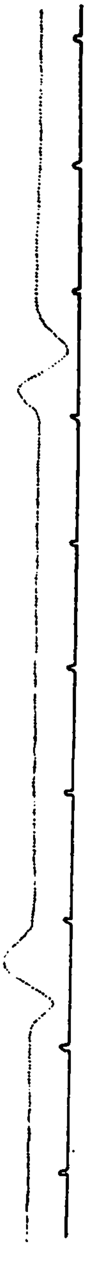
During observations a wire was put around the cable key so correspondence would not interfere and was removed when signals were exchanged.

No. 9.



Example of record of signals sent from Honolulu to San Francisco.

No. 10.



Example of record of signals received at Honolulu from San Francisco.

(6) Chronometers at observatories and cable offices were compared by about 20 signals in each direction.

(7) The corrections to the cable pens were determined at each station by about 20 signals.

It was found that so many signals were unnecessary, and consequently between the other stations only half the number of cable signals were exchanged. After the San Francisco-Honolulu work the corrections to the cable pens were determined from the regular cable signals sent, as previously stated, and no chronometer comparisons were needed at Guam and Midway. The eastern station always sent 20 signals, then the western station sent 40 signals, and again the eastern sent 20. This plan served to eliminate the effect of rate of the chronometers and to determine the transmission times of the cable signals. In the comparison of the chronometers there seems to have been no appreciable transmission time over the short land lines. The transmission time of the cable signals on the several nights in each determination of difference of longitude is more uniform than that derived from previous longitude determinations over cables, and this is undoubtedly due to recording the signals automatically and to the accuracy with which they can be read. Examples of all the signals are shown in illustrations 9 and 10.

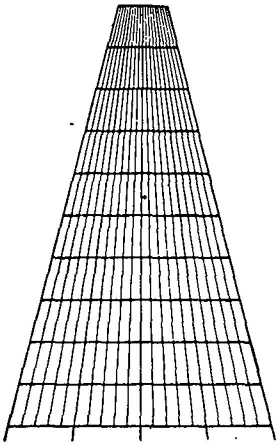
The lower line in these illustrations is the record of the chronometer pen and the upper line of the cable pen.

It would at first appear that there must be a considerable accidental error in reading the record of the cable signals, but the differences of the chronometers determined from these signals indicate that they have been read with as great accuracy as the record of signals over the land lines. It also appears that there might be personal equation between the observers in reading these signals, but there is evidently no such equation between the observers in this work. This has been settled at the office, where the writer has reread many of the signals read by Mr. Morse without developing any personal equation. So far as the exchange of signals is concerned, the errors that affect the several differences of longitude determined over the Pacific cables must be considered to be about the same as those found to affect the differences of longitude determined over the best of land lines where no repeaters are in circuit.

The signals were made by a negative current to cable and then a positive current as soon as possible, and in the next signal the positive current was sent first; and so on. The wave is above the o line for a positive current and below the o line for a negative current. The very first deviation of the signal from the o line is taken for the time of the signal received. In the signal sent the beginning of the first of the two breaks on the lower line is the time of the signal sent, and the difference between this time and that of the corresponding part of the record on the upper line is the correction to be applied to the signals received.

The signals were read with the diagonal scale here illustrated. The reading of the signals sent and recorded on the lower line needs no explanation. In reading the signals received on the upper line the scale was placed so that 2 seconds on lower line were included between the extreme lines of scale, the horizontal line of scale being parallel to the record line, and was then moved horizontally till the middle line of the scale was on the beginning of the signal, and the fraction of a second between this middle line of scale and the adjacent second's mark to the left was read. The accuracy with which these signals were read has already been mentioned. No difference was found between the positive and negative records, and the two kinds of signals were sent to insure a more perfect discharge of the cable and to guard against the possibility of any difference between them.

No. 11.



Scale for reading cable signals.

The following information concerning the four cables between San Francisco and Manila was very kindly furnished by Mr. G. G. Ward, the vice-president and general manager of the Commercial Pacific Cable Company:

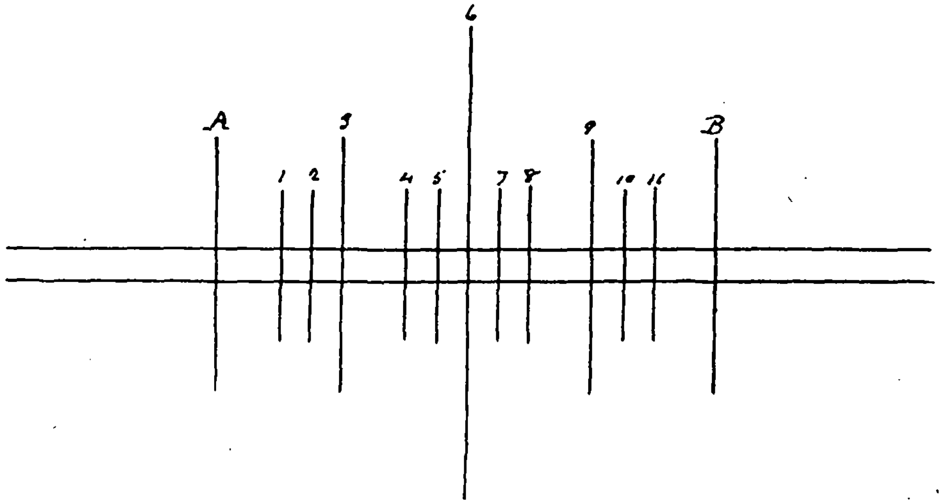
Section	Diameter of copper	Length	Resistance	Electromotive force
	Inch	*Nautical miles*	*Ohms*	*Volts*
San Francisco-Honolulu	0. 1801	2 276. 317	5 043	50
Honolulu-Midway	0. 1122	1 332. 04	6 530	30
Midway-Guam	0. 1830	2 606. 78	4 758	50
Guam-Manila	0. 1183	1 631. 6	7 235	35

Length and resistance refer to sea cable only.
All stations use Fuller cells.

INSTRUMENTAL OUTFIT.

Transit No. 18 was used at Honolulu and No. 19 was used at San Francisco by both observers in the work at these stations. During the rest of the work No. 18 was used by Mr. Morse at Manila and Midway and No. 19 by Mr. Smith at Guam and Honolulu. These two instruments were made at the Office of the Survey in 1887–88, and a detailed description of them can be found in Appendix 9, Coast and Geodetic Survey Report for 1889. They are as nearly alike as it was practicable to make them. The focal length of the telescopes is 94 centimeters (37 inches); the aperture of the objective is 7.6 centimeters (3 inches). The diagonal eyepiece is of the Airy form and gives a magnifying power of 100 diameters. The diaphragms are ruled as follows:

No. 12.



Diaphragm.

Lines 1 to 11 were used in all the time observations. The short intervals are about 2.5 equatorial seconds and the long intervals 5 equatorial seconds. The divisions on the stride levels are 2 millimeters long and have a value of 1″.674 for No. 18 and of 1″.850 for No. 19. The correction for inequality of pivots is $-0^{s}.038$ band west for No. 18 and $0^{s}.000$ for No. 19. Near one end of the axis is a bright band, and the position of the axis is designated by this band.

Chronographs Nos. 784 and 785 were made by Fauth & Co., of Washington, D. C. The former was used in connection with transit No. 18 and the latter with transit No. 19.

Each party was furnished with three chronometers, one for the cable office when necessary, one for an observing chronometer, and one for general use. Four of these chronometers were break-circuit, made by T. S. & J. D. Negus, of New York; one, a break-circuit, made by Frodsham, of London; and the other, not a break-circuit, was made by Parkinson & Frodsham, London. All kept sidereal time. They all had comparatively small rates at the beginning of the work, but their rates gradually increased, though they were uniform at each station. At Honolulu the Frodsham chronometer had to be used for observing, as it was the only one available at the time. It is one of the first break-circuit chronometers made for the Survey, about 1869. The break-circuit apparatus gave trouble, and it finally had to be replaced by one of the Negus chronometers.

PERSONAL EQUATION.

It was known in the beginning that the difficulty of eliminating the effect of personal equation in this work would be the greatest source of error. German observers had settled the fact that the registering micrometer attached to their transits practically eliminated personal equation, and the attachment of such micrometers to the instruments of the Coast and Geodetic Survey was considered. It was found that this would be impracticable in time for this work, and that the instruments on hand would have to be used. The observers could exchange stations between San Francisco and Honolulu, but only by such a sea voyage as might be expected to affect personal equation, and it was not probable such an exchange could take place between the other stations. It was therefore decided, in addition to the exchange of observers between San Francisco and Honolulu, that observations to determine personal equation should be made at the beginning and end of the work and at such other times as possible. It was also intended to so place the observers at the several stations that the personal equation would be eliminated between the extreme stations as well as possible. The observations were made with each instrument by one observer noting the transit of a star over the lines A, 1, 2, 3, 4, and the other observer over lines 8, 9, 10, 11, B. On the next star the order of observers was reversed, and so on. About 20 stars were observed on each of ten nights. The results of all determinations of personal equation are given below.

From the exchange of observers in the determination of the difference of longitude between San Francisco and Honolulu the result is:

April 20–29 and June 2–13, $S.-M.=+0^{s}.062\pm0.008$.

The following are the results from the ten special nights' observations. The plus sign means that S. observes later than M.:

San Francisco,	March 28, 1903,	20 stars	S.—M. = +0ˢ.085±0.017	weight	0.7
" "	April 1, 1903,	20	+0 .092±0.017		0.7
Honolulu,	May 11, 1903,	20	+0 .109±0.010		1.0
"	June 27, 1903,	20	+0 .106±0.012		0.8
"	April 18, 1904,	20	+0 .060±0.009		1.1
"	April 21, 1904,	17	+0 .079±0.007		1.4
San Francisco,	May 6, 1904,	22	+0 .075±0.013		0.8
" "	May 7, 1904,	26	+0 .045±0.012		1.0
" "	May 8, 1904,	22	+0 .043±0.015		0.8
" "	May 9, 1904,	26	+0 .087±0.015		0.8

The weight for each night is the mean of weights derived from the number of stars and the probable errors. The weighted mean is:

$$S.-M.=+0^{s}.077\pm0^{s}.005$$

This result, with an assigned weight of 2.0 combined with that determined from the exchange of observers between San Francisco and Honolulu, with an assigned weight of 1.3, gives

$$S.-M.=+0^{s}.071\pm0^{s}.007$$

This personal equation is applied to the differences of longitude between Honolulu–Midway, Midway–Guam, and Guam–Manila. The difference of longitude between San Francisco and Honolulu is corrected by the personal equation determined from the exchange of observers only. The range of these results is no greater than should be expected from the computed probable errors, and may therefore be due to errors of observation rather than to variation of personal equation. The observers were so placed that personal equation is eliminated in the final longitude of Guam and enters only once in the final longitudes of Midway and Manila, so it does not seem that these longitudes can be seriously in error on account of personal equation.

DETERMINATION OF THE INSTRUMENTAL CONSTANTS AND CHRONOMETER CORRECTIONS.

The difference of longitude between the stations was so great that the same stars could not be observed at both stations without depending upon the rate of the chronometers for a length of time that would probably introduce an error greater than any that would arise from errors of the right ascensions. Each observer, therefore, selected his own lists of stars from the star list given in the Berliner Astronomisches Jahrbuch and supplemented from the American Ephemeris when necessary. A time determination was made at each station before and again after the exchange of cable signals. As far as the weather would permit, each determination depends upon a group of four stars near the zenith and one star about 60° north of the zenith, band east, and a similar group, band west. The level constant was determined four times for each group with the stride level. The collimation and azimuth constants were determined from the time observations. The chronometer times of transit of the stars over the mean of the 11 lines were corrected for aberration, level, and rate, and then each star gave an equation.

$$\Delta T=(\alpha-t)-Aa-Cc$$

The mean of the four zenith star equations was taken, or, in case the far north star was lost, the mean of the equations for the north and for the south stars. For each set of time the four following equations were obtained, in which the ′ indicates the equations of the north star or stars.

$$\begin{array}{lll} \text{East} & \Delta T=(\alpha'-t')-A'a_e-C'c & (1) \\ & \Delta T=(\alpha-t)-A\,a_e-C\,c & (2) \\ \text{West} & \Delta T=(\alpha'-t')-A'a_w-C'c & (3) \\ & \Delta T=(\alpha-t)-A\,a_w-C\,c & (4) \end{array}$$

By subtracting 1–2, 2–4, and 3–4 the middle one of the three new equations contains both a_e and a_w. These equations may be directly solved, but when the coefficients of a_e and a_w are small, which is generally the case, a very close approximation to the true value of c is at once obtained from the middle equation. With this value of c, the values of a_e and a_w are obtained from the other two equations, and if the values of ΔT obtained from the east and west groups do not agree a correction is found for c and new values for a_e and a_w. If in the equations three decimals are used the values of ΔT obtained from the east and west groups will now agree within $0^s.002$. This method of reduction of time observations by Mayer's formula was used by the writer in 1872, and was adopted for the field reduction in the Coast and Geodetic Survey in 1878. Practically nothing is gained by an elaborate least-square reduction, and this method was used in the final reductions of this work. (See p. 285, Appendix 7, Coast and Geodetic Survey Report for 1898, for an example of this method.)

A first computation of all the observations was made in the field by the observers, and a revision or recomputation, where necessary, was made at the Office by the writer, except in the case of the personal equation, which was recomputed in the Computing Division under direction of Assistant J. F. Hayford.

On the following pages are given the results of the cable signals, and of the time determinations and the resulting difference of longitude for each night, the four pieces of work being given in chronological order.

SAN FRANCISCO AND HONOLULU.

Results of cable signals.

Date	Number of signals	Chronometer time		Difference of chronometers	Cable pen correction	Corrected difference of chronometers	Direction of signals	Transmission time
		San Francisco	Honolulu					
1903		*h. m.*	*h. m.*	*h. m. s.*	*s.*	*h. m. s.*		*s.*
Apr. 20	88	14 08.7	11 50.3	2 18 28.442	−0.044	2 18 28.398	W.	
	80	14 08.8	11 50.3	.774	+0.002	.776	E.	0.189
Apr. 22	98	13 50.5	11 32.2	2 18 17.109	0.000	2 18 17.109	W.	
	72	13 50.7	11 32.4	.490	+0.018	.508	E.	0.200
Apr. 26	41	14 16.8	11 58.9	2 17 53.350	−0.042	2 17 53.308	W.	
	36	14 17.7	11 59.8	.671	+0.011	.682	E.	0.187
Apr. 27	92	13 53.4	11 35.6	2 17 47.429	−0.008	2 17 47.421	W.	
	79	13 52.9	11 35.2	.778	+0.020	.798	E.	0.188
Apr. 29	79	14 01.8	11 44.2	2 17 35.419	0.000	2 17 35.419	W.	
	76	14 01.8	11 44.2	.813	−0.019	.794	E.	0.188
June 2	83	16 27.4	14 08.8	2 18 33.774	−0.012	2 18 33.762	W.	
	77	16 27.4	14 08.8	34.132	−0.003	34.129	E.	0.184
June 4	83	16 03.3	13 45.0	2 18 21.238	−0.038	2 18 21.200	W.	
	73	16 02.6	13 44.3	.594	−0.020	.574	E.	0.187
June 6	81	16 01.0	13 42.9	2 18 09.222	−0.036	2 18 09.186	W.	
	76	16 01.0	13 42.8	.570	0.000	.570	E.	0.192
June 11	84	16 17.5	14 00.0	2 17 38.284	+0.037	2 18 38.321	W.	
	78	16 17.6	14 00.0	.697	−0.007	.690	E.	0.184
June 12	89	16 02.1	13 44.6	2 17 32.258	+0.017	2 17 32.275	W.	
	58	16 02.3	13 44.7	.675	−0.024	.651	E.	0.188
June 13	88	16 03.7	13 46.3	2 17 26.149	+0.009	2 17 26.158	W.	
	80	16 03.3	13 45.9	.544	0.000	.544	E.	0.193

The mean of the transmission times is:

$$0^{s}.189 \quad \pm 0^{s}.009$$

The probable error of the transmission time on one night is:

$$\pm 0^{s}.027$$

San Francisco—Result of time observations.

Transit No. 19. Chronometer, Negus No. 1769.
Observer: Fremont Morse, April 20–29; Edwin Smith, June 2–13.

Date	Number of stars	Band	Instrumental constants			Chronometer time		Chronometer correction	Probable error for one star	Probable error of mean	Hourly rate
			Level	Collimation	Azimuth						
1903			*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*s.*	*s.*	*s.*
Apr. 20	5	W	+0. 074	+0.033	—0. 974	13	11. 7	— 9. 529	±0. 058	±0.018	—0.0030
	5	E	+0. 125		—1. 455						
	5	W	+0. 069	—0. 006	—1. 372	15	01. 7	— 9. 534	±0. 045	±0. 014	
	5	E	+0. 113		—1. 430						
Apr. 22	5	E	+0. 241	—0. 007	+0. 038	13	11. 7	—10. 601	±0. 034	±0. 011	+0. 0222
	5	W	+0. 203		—0. 070						
	5	E	+0. 250	—0. 011	—0. 001	14	53. 5	—10. 563	±0. 048	±0. 015	
	5	W	+0. 115		+0. 022						
Apr. 26	4	W	+0. 130	0.000	+0. 307	13	11. 6	—11. 943	±0. 032	±0. 011	+0. 0144
	5	E	+0. 159		+0. 207						
	5	W	+0. 142	0. 000	+0. 292	15	23. 2	—11. 912	±0. 050	±0. 016	
	5	E	+0. 182		+0. 175						
Apr. 27	5	E	+0. 146	—0. 006	+0. 456	13	11. 6	—12. 440	±0. 047	±0. 015	+0. 0438
	5	W	+0. 120		+0. 220						
	5	E	+0. 169	+0. 017	+0. 324	14	53. 5	—12. 366	±0. 042	±0. 013	
	5	W	+0. 113		+0. 400						
Apr. 29	4	W.	+0. 110	—0. 020	—0. 087	13	11. 6	—12. 990	±0. 054	±0. 018	—0. 0126
	5	E	+0. 143		—0. 194						
	5	W	+0. 100	—0. 050	—0. 364	15	01. 6	—13. 013	±0. 037	±0. 012	
	5	E	+0. 144		—0. 244						
June 2	5	W	+0. 028	+0. 010	—0. 484	15	05. 4	—18. 929	±0. 027	±0. 009	—0. 0288
	5	E	+0. 073		—0. 580						
	5	W	+0. 060	+0. 008	—0. 494	16	45. 2	—18. 977	±0. 026	±0. 009	
	4	E	+0. 098		—0. 589						

San Francisco—Result of time observations—Continued.

Date	Number of stars	Band	Instrumental constants			Chronometer time	Chronometer correction	Probable error for one star	Probable error of mean	Hourly rate
			Level	Collimation	Azimuth					
			s.	*s.*	*s.*	*h.* *m.*	*s.*	*s.*	*s.*	*s.*
1903 June 4	5	E	+0.053	—0.013	—0.417	15 05.4	—18.978	±0.040	±0.013	—0.0234
	5	W	+0.016		—0.179					
	5	E	+0.086	—0.045	—0.223	16 47.3	—19.018	±0.044	±0.014	
	5	W	+0.043		—0.297					
June 6	5	E	+0.022	—0.056	—0.529	15 05.4	—18.330	±0.041	±0.013	+0.0258
	5	W	—0.020		—0.639					
	5	E	+0.031	—0.053	—0.526	16 47.3	—18.286	±0.061	±0.019	
	5	W	+0.013		—0.431					
June 11	5	W	—0.025	—0.063	—0.220	15 05.4	—16.390	±0.025	±0.008	—0.0168
	5	E	+0.019		—0.154					
	5	W	—0.009	—0.016	—0.061	16 47.4	—16.418	±0.028	±0.009	
	5	E	+0.031		—0.173					
June 12	5	E	0.000	+0.004	—0.514	15 05.5	—15.990	±0.048	±0.015	+0.0306
	5	W	—0.022		—0.301					
	5	E	+0.036	—0.068	—0.327	16 47.4	—15.938	±0.024	±0.008	
	5	W	+0.008		—0.343					
June 13	5	W	—0.016	—0.044	—0.420	15 05.5	—15.590	±0.017	±0.006	—0.0132
	5	E	+0.036		—0.376					
	5	W	+0.009	—0.028	—0.237	16 47.4	—15.612	±0.055	±0.017	
	5	E	+0.039		—0.483					

San Francisco—Comparison of chronometers.

Chronometer Negus 1769 at observatory.
Chronometer Negus 1823 at cable office.

Date	Chronometer time		Difference of chronometers, 1879–1823	Number of signals	Chronometer correction, 1769	Chronometer correction, 1823	Hourly rate, 1823
	1769	1823					
1903	h. m.	h. m.	m. s.		s.	m. s.	s.
Apr. 20	13 50.7	13 48.8	+1 51.002	65	−9.530	+1 41.472	
	14 16.5	14 14.7	+1 51.070	62	−9.532	+1 41.538	+0.1530
Apr. 22	13 47.3	13 45.3	+1 58.802	63	−10.588	+1 48.214	
	13 57.6	13 55.6	+1 58.831	61	−10.584	+1 48.247	+0.1944
Apr. 26	14 05.5	14 03.3	+2 14.549	62	−11.930	+2 02.619	
	14 27.6	14 25.4	+2 14.620	65	−11.925	+2 02.695	+0.2064
Apr. 27	13 45.5	13 43.2	+2 18.784	61	−12.415	+2 06.369	
	14 04.6	14 02.3	+2 18.833	57	−12.402	+2 06.431	+0.1950
Apr. 29	13 46.2	13 43.8	+2 26.731	62	−12.997	+2 13.734	
	14 12.7	14 10.2	+2 26.833	61	−13.003	+2 13.830	+0.2184
June 2	16 19.0	16 18.6	+0 23.802	47	−18.965	+0 04.837	
	16 40.0	16 39.6	+0 23.864	46	−18.975	+0 04.889	+0.1488
June 4	15 54.7	15 54.1	+0 32.390	59	−18.997	+0 13.393	
	16 13.1	16 12.5	+0 32.434	42	−19.001	+0 13.433	+0.1306
June 6	15 53.0	15 52.4	+0 39.644	51	−18.310	+0 21.334	
	16 12.6	16 11.9	+0 39.696	48	−18.301	+0 21.395	+0.1878
June 11	16 08.3	16 07.3	+0 58.890	50	−16.407	+0 42.483	
	16 27.9	16 26.9	+0 58.932	47	−16.413	+0 42.519	+0.1104
June 12	15 55.4	15 54.4	+1 02.612	56	−15.965	+0 46.647	
	16 10.9	16 09.9	+1 02.644	43	−15:957	+0 46.687	+0.1548
June 13	15 55.4	15 54.3	+1 06.401	52	−15.601	+0 50.800	
	16 13.8	16 12.7	+1 06.450	57	−15.605	+0 50.845	+0.1464

Honolulu—Results of time observations.

Transit No. 18. Chronometer, Frodsham No. 3462.

Observer: Edwin Smith, April 20–29; Fremont Morse, June 2–13.

Date	Number of stars	Band	Instrumental constants			Chronometer time	Chronometer correction	Probable error for one star	Probable error of mean	Hourly rate
			Level	Collimation	Azimuth					
1903			*s.*	*s.*	*s.*	*h.* *m.*	*s.*	*s.*	*s.*	*s.*
Apr. 20	5	W	—0.013	—0.290	—0.703	10 53.5	+15.418	±0.024	±0.008	—0.0624
	5	E	—0.056		—0.730					
	5	W	—0.030	—0.261	—0.661	12 32.1	+15.315	±0.022	±0.007	
	5	E	—0.068		—0.741					
Apr. 22	5	E	—0.164	—0.205	—0.442	10 53.5	+18.487	±0.028	±0.009	—0.0654
	5	W	—0.074		—0.421					
	5	E	—0.180	—0.190	—0.547	12 32.2	+18.379	±0.018	±0.006	
	5	W	—0.122		+0.451					
Apr. 26	5	W	—0.097	+0.046	—0.781	10 53.7	+28.006	±0.029	±0.009	—0.0348
	5	E	—0.248		—0.692					
	5	W	+0.087	+0.102	—0.745	12 34.1	+27.948	±0.030	±0.009	
	5	E	—0.028		—0.763					
Apr. 27	5	E	—0.026	+0.068	—0.302	10 53.8	+31.538	±0.022	±0.007	—0.0744
	5	W	+0.070		—0.339					
	5	E	—0.001	+0.095	—0.649	12 32.4	+31.416	±0.030	±0.009	
	5	W	+0.032		—0.664					
Apr. 29	5	W	+0.010	+0.100	—0.330	10 53.9	+37.019	±0.012	±0.004	—0.0690
	5	E	—0.038		—0.380					
	5	W	+0.000	+0.109	—0.328	12 32.5	+36.906	±0.018	±0.006	
	5	E	—0.059		—0.363					
June 2	5	W	+0.022	+0.136	+0.462	12 55.3	+ 4.074	±0.056	±0.018	—0.7542
	5	E	—0.026		+0.410					
	5	W	—0.024	+0.079	+0.435	14 47.0	+ 2.670	±0.026	±0.008	
	5	E	—0.100		+0.544					

Honolulu—Results of time observations—Continued.

Date	Number of stars	Band	Instrumental constants			Chronometer time	Chronometer correction	Probable error for one star	Probable error of mean	Hourly rate
			Level	Collimation	Azimuth					
			s.	*s.*	*s.*	*h.* *m.*	*s.*	*s.*	*s.*	*s.*
1903 June 4	5	E	−0.049	+0.083	+0.451	12 54.2	−19.054	±0.067	±0.021	+0.1872
	5	W	+0.017		+0.243					
	5	E	−0.080	+0.097	+0.230	14 26.2	−18.767	±0.019	±0.006	
	5	W	−0.071		+0.252					
June 6	5	W	−0.092	+0.122	+0.495	12 54.3	−13.202	±0.042	±0.013	+0.2628
	5	E	−0.133		+0.375					
	4	W	−0.112	+0.094	+0.233	14 26.3	−12.799	±0.029	±0.010	
	5	E	−0.137		+0.159					
June 11	5	E	−0.183	+0.094	+0.123	13 12.7	+15.794	±0.020	±0.007	+0.2172
	4	W	−0.123		−0.002					
	4	W	−0.123	+0.098	+0.018	13 57.2	+15.955	±0.026	±0.010	
	3	E	−0.193		−0.123					
June 12	5	E	−0.150	+0.050	+0.867	12 58.1	+19.841	±0.039	±0.012	+0.2622
	5	W	−0.127		+0.824					
	5	E	−0.235	+0.097	+0.879	14 36.8	+20.272	±0.025	±0.008	
	5	W	−0.210		+0.736					
June 13	5	W	−0.079	+0.110	+0.265	13 03.0	+26.238	±0.035	±0.011	+0.3450
	5	E	−0.208		+0.268					
	5	W	−0.158	+0.078	+0.273	14 59.9	−26.910	±0.030	±0.010	
	5	E	−0.222		+0.401					

The change of rate June 2 and 4 is due to repairs and adjustment by a chronometer maker at Honolulu.

Honolulu—Comparison of chronometers.

Chronometer Frodsham No. 3462, at Observatory.
Chronometer Negus No. 1836, in Cable Office.

Date		Chronometer time			Difference of chronometers, 3462–1836		Number of signals	Chronometer correction, 3462	Chronometer correction, 1836		Hourly rate, 1836
		3462		1836							
1903	*h.*	*m.*	*h.*	*m.*	*m.*	*s.*		*s.*	*m.*	*s.*	*s.*
Apr. 20	11	34.3	11	36.1	−1	44.212	43	+15.375	−1	28.857	
	11	54.4	11	56.1	−1	44.218	38	+15.354	−1	28.864	−0.0810
Apr. 22	11	27.2	11	29.0	−1	51.929	40	+18.450	−1	33.479	
	11	35.4	11	37.2	−1	51.937	42	+18.441	−1	33.496	−0.1242
Apr. 26	11	50.1	11	52.2	−2	10.704	42	+27.973	−1	42.731	
	12	12.0	12	14.3	−2	10.712	37	+27.961	−1	42.751	−0.0546
Apr. 27	11	24.9	11	27.2	−2	16.491	41	+31.500	−1	44.991	
	11	42.2	11	44.5	−2	16.508	41	+31.478	−1	45.030	−0.1350
Apr. 29	11	33.7	11	36.2	−2	26.548	30	+36.973	−1	49.575	
	11	50.2	11	52.7	−2	26.548	40	+36.955	−1	49.593	−0.0654
June 2	13	45.5	13	48.6	−3	03.502	49	+ 3.443	−3	00.059	
	14	14.2	14	17.2	−3	03.186	49	+ 3.082	−3	00.104	−0.0942
June 4	13	31.7	13	34.5	−2	45.109	52	−18.937	−3	04.046	
	13	51.8	13	54.6	−2	45.214	51	−18.874	−3	04.088	−0.1254
June 6	13	30.6	13	33.6	−2	55.004	50	−13.043	−3	08.047	
	13	49.1	13	52.0	−2	55.124	49	−12.962	−3	08.086	−0.1206
June 11	13	48.0	13	51.5	−3	33.755	45	+15.922	−3	17.833	
	14	04.9	14	08.5	−3	33.850	49	+15.983	−3	17.867	−0.1200
June 12	13	33.0	13	36.7	−3	39.727	38	+19.993	−3	19.734	
	13	48.9	13	52.6	−3	39.818	49	+20.063	−3	19.755	−0.0798
June 13	13	33.4	13	37.2	−3	48.077	41	+26.413	−3	21.664	
	13	51.5	13	55.8	−3	48.222	39	+26.517	−3	21.705	−0.1362

The mean probable error for a single star is as follows:

Transit No. 19 at San Francisco,	Morse,	$\pm 0^{s}.045$.
Transit No. 19 at San Francisco,	Smith,	$\pm 0^{s}.036$.
Transit No. 18 at Honolulu,	Smith,	$\pm 0^{s}.023$.
Transit No. 18 at Honolulu,	Morse,	$\pm 0^{s}.034$.

The weights given to the following results for difference of longitude are the means of two weights. One is computed from the number of stars observed at both stations by the formula—

$$p = \frac{2}{n} \cdot \frac{a.b}{a+b}$$

where n is 20 and a and b the number of stars observed at the eastern and western stations on a night. The other is computed from the mean of the probable errors of the chronometer corrections at both stations.

Results for difference of longitude.

Date	Difference of chronometers	Correction to chronometers		Observed difference of longitude	Final difference of longitude	Difference from mean	Weight
		San Francisco	Honolulu				
1903	*h. m. s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*s.*	
Apr. 20	2 18 28.587	+101.523	− 88.856	2 21 38.966	2 21 38.905	+0.018	0.8
22	17.308	+108.231	− 93.486	39.025	.964	−0.041	1.0
26	17 53.495	+122.667	−102.737	38.899	.838	+0.085	0.8
27	47.610	+126.401	−105.009	39.020	.959	−0.036	0.9
29	35.606	+133.800	−109.584	38.990	.929	−0.006	1.0
			Exchange of observers.				
June 2	18 33.946	+ 4.859	−180.091	38.896	.957	−0.034	1.0
4	21.387	+ 13.412	−184.067	38.866	.927	−0.004	0.8
6	09.378	+ 21.361	−188.066	38.805	.866	+0.057	0.7
11	17 38.506	+ 42.502	−197.850	38.858	.919	+0.004	1.0
12	32.463	+ 46.667	−199.745	38.875	.936	−0.013	0.9
13	26.351	+ 50.823	−201.684	38.858	.919	−0.004	0.9

Weighted mean first five nights	$2^h\ 21^m\ 38^s.983$
Weighted mean last six nights	2 21 38 .862
Difference	0 .121
Personal equation S.—M.	$+0\ .061 \pm 0^s.008$

The above final results have been corrected for this personal equation.

Weighted mean of the eleven nights is $2^h\ 21^m\ 38^s.923 \pm 0^s.008$

The probable error of a result for difference of longitude for one night, weight unity, is

$\pm 0^s.024$

GUAM ISLAND AND MANILA.

Results of cable signals.

Date.	Number of signals	Chronometer time		Difference of chronometers	Cable pen correction	Corrected difference of chronometers	Direction of signals	Transmission time
		San Francisco	Honolulu					
1903		*h. m.*	*h. m.*	*h. m. s.*	*s.*	*h. m. s.*		*s.*
Sept. 8	40	22 15.8	20 40.8	1 35 04.369	+0.026	1 35 04.395	W.	
	39	22 15.8	20 40.8	.704	−0.001	.703	E.	0.154
Sept. 12	39	22 08.9	20 34.3	1 34 38.895	−0.013	1 34 38.882	W.	
	31	22 09.2	20 34.6	39.250	−0.056	39.194	E.	0.156
Sept. 14	40	22 15.4	20 41.0	1 34 25.983	+0.005	1 34 25.988	W.	
	39	22 15.9	20 41.5	26.265	+0.014	26.279	E.	0.146
Sept. 15	40	22 08.6	20 34.3	1 34 19.539	+0.005	1 34 19.544	W.	
	38	22 08.6	20 34.3	.900	−0.020	.880	E.	0.168
Sept. 16	40	22 16.5	20 42.3	1 34 13.092	+0.012	1 24 13.104	W.	
	36	22 16.9	20 42.2	.420	000	.420	E.	0.158

The mean of the transmission times is

$$0^s.156 \pm 0^s.0024$$

The probable error of the transmission time on one night is

$$\pm 0^s.0054$$

Guam Island—Results of time observations.

Transit No. 19. Chronometer Negus No. 1823.

Observer: Edwin Smith.

Date	Number of stars	Band	Instrumental constants			Chronometer time	Chronometer correction	Probable error for one star	Probable error of mean	Hourly rate
			Level	Collimation	Azimuth					
			s.	s.	s.	h. m.	s.	s.	s.	s.
1903 Sept. 8	3	W	—0.011	—0.032	—1.142	20 59.9	—21.080	±0.016	±0.006	+0.1950
	5	E	+0.018		—1.408					
	4	W	—0.007	—0.072	—1.275	22 55.1	—20.706	±0.042	±0.014	
	5	E	+0.019		—1.095					
Sept. 12	5	E	+0.036	—0.076	+0.687	20 57.0	— 3.526	±0.041	±0.013	+0.1854
	5	W	—0.055		+0.577					
	5	E	+0.003	—0.027	+0.081	22 55.3	— 3.160	±0.021	±0.007	
	5	W	—0.049		+0.389					
Sept. 14	4	W	+0.015	—0.034	—0.412	20 57.1	+ 5.378	±0.047	±0.015	+0.1804
	4	E	+0.058		—0.535					
	4	W	+0.090	—0.078	—0.588	22 55.5	+ 5.734	±0.014	±0.005	
	5	E	+0.038		—0.338					
Sept. 15	5	E	+0.008	—0.056	—0.592	21 26.0	+ 9.908	±0.035	±0.011	+0.1968
	5	W	—0.029		—0.462					
	5	E	+0.000	—0.050	—0.684	22 56.6	+10.205	±0.018	±0.006	
	5	W	—0.042		—0.383					
Sept. 16	5	W	+0.003	—0.075	—0.205	21 25.0	+14.322	±0.047	±0.015	+0.1962
	5	E	+0.019		—0.352					
	5	W	—0.013	—0.072	—0.340	22 55.6	+14.618	±0.021	±0.007	
	5	E	+0.015		—0.302					

Manila—Results of time observations.

Transit No. 18. Chronometer Negus No. 1828.

Observer: Fremont Morse.

Date.	Number of stars	Band	Instrumental constants			Chronometer time		Chronometer correction	Probable error for one star	Probable error of mean	Hourly rate
			Level	Collimation	Azimuth						
			s.	*s.*	*s.*	*h.*	*m.*	*s.*	*s.*	*s.*	*s.*
1903 Sept. 8	5	E	−0.014	−0.160	−1.424	19	18.4	+ 6.442	±0.041	±0.013	−0.2898
	5	W	+0.040		−1.466						
	5	E	−0.008	−0.154	−1.389	21	19.8	+ 5.856	±0.038	±0.012	
	5	W	+0.100		−1.287						
Sept. 12	5	W	+0.063	−0.163	+1.634	19	16.3	−20.537	±0.025	±0.008	−0.2646
	5	E	−0.012		+1.632						
	5	W	+0.062	−0.164	+1.705	21	18.3	−21.075	±0.032	±0.010	
	5	E	−0.023		+1.802						
Sept. 14	5	E	−0.023	−0.160	−0.872	19	54.0	−33.588	±0.044	±0.016	−0.2424
	5	W	+0.065		−0.800						
	5	E	−0.026	−0.190	−0.830	21	23.2	−33.948	±0.022	±0.007	
	5	W	+0.063		−0.863						
Sept. 15	5	W	+0.049	−0.176	−0.932	19	53.6	−39.712	±0.024	±0.008	−0.2292
	5	E	−0.034		−0.839						
	5	W	+0.079	−0.165	−0.818	21	16.8	−40.030	±0.029	±0.009	
	5	E	−0.034		−0.870						
Sept. 16	5	E	−0.027	−0.155	−0.663	20	28.4	−46.120	±0.043	±0.014	−0.2424
	5	W	+0.062		−0.882						
	5	E	+0.008	−0.163	−0.916	22	13.6	−46.545	±0.018	±0.006	
	5	W	+0.076		−0.865						

Manila—Comparison of chronometers.

Chronometer Negus No. 1828 at Observatory.
Chronometer Negus No. 1836 at Cable Office.

Date	Chronometer time		Difference of chronometers, 1828–1836	Number of signals	Chronometer correction		Hourly rate, 1836
	1828	1836			1828	1836	
1903	*h.* *m.*	*h.* *m.*	*s.*		*s.*	*s.*	*s.*
Sept. 8	20 35.9	20 36.0	− 5.523	40	+ 6.068	+ 0.545	
	20 46.2	20 46.3	− 5.490	52	+ 6.018	+ 0.528	−0.0990
Sept. 12	20 29.0	20 28.8	+13.436	41	−20.858	− 7.422	
	20 39.7	20 39.4	+13.470	33	−20.905	− 7.435	−0.0738
Sept. 14	20 36.3	20 35.9	+22.312	40	−33.759	−11.447	
	20 46.8	20 46.4	+22.340	40	−33.801	−11.461	−0.0798
Sept. 15	20 30.2	20 29.7	+26.418	40	−39.852	−13.434	
	20 39.3	20 38.9	+26.446	40	−39.887	−13.441	−0.0456
Sept. 16	20 38.5	20 38.0	+30.694	40	−46.161	−15.467	
	20 47.3	20 46.8	+30.726	41	−46.196	−15.470	−0.0204

The mean probable error for a single star is:

Transit No. 19 at Guam, Smith, $\pm 0^s.030$.
Transit No. 18 at Manila, Morse, $\pm 0^s.031$.

Results for difference of longitude.

Date	Difference of chronometers	Correction to chronometers		Observed difference of longitude	Difference from mean	Weight
		Guam	Manila			
1903	*h.* *m.* *s.*	*s.*	*s.*	*h.* *m.* *s.*	*s.*	
Sept. 8	1 35 04.549	−20.834	+ 0.537	1 34 43.178	+0.015	0.9
12	34 39.038	− 3.303	− 7.429	.164	+0.029	1.0
14	26.134	+ 5.614	−11.454	.202	−0.009	0.9
15	19.712	+10.048	−13.438	.198	−0.005	1.3
16	13.262	14.491	−15.469	.222	−0.029	1.0

The weighted mean of the five nights is $1^h\ 34^m\ 43^s.193 \pm 0^s.007$
Personal equation S.—M. $+\ 0\ .071 \pm 0\ .007$
Manila Transit west of Guam Transit $1^h\ 34^m\ 43^s.264 \pm 0^s.010$

The probable error of a result for difference of longitude for one night, weight unity, is $\pm 0^s.016$

MIDWAY ISLAND AND GUAM ISLAND.

Results of cable signals.

Date	Number of signals	Chronometer time				Difference of chronometers			Cable pen correction	Corrected difference of chronometers			Direction of signals	Transmission time
		Midway		Guam										
1903		*h.*	*m.*	*h.*	*m.*	*h.*	*m.*	*s.*	*s.*	*h.*	*m.*	*s.*		*s.*
Nov. 16–17	36	2	51.6	0	20.0	2	31	35.725	−0.015	2	31	35.710	W	
	40	2	50.8	0	20.2			36.146	−0.066			36.079	E	0.184
Nov. 17–18	40	2	54.7	0	22.9	2	31	46.703	+0.002	2	31	46.705	W	
	40	2	54.8	0	23.0			47.095	−0.025			47.070	E	0.182
Nov. 18–19	41	2	58.4	0	26.5	2	31	57.560	−0.096	2	31	57.464	W	
	40	2	58.6	0	26.6			57.876	−0.029			57.847	E	0.192
Nov. 22–23	36	3	19.1	0	46.4	2	32	40.558	000	2	32	40.558	W	
	45	3	19.1	0	46.4			40.964	−0.024			40.940	E	0.191
Nov. 23–24	39	3	20.9	0	48.1	2	32	51.090	+0.022	2	32	51.112	W	
	40	3	20.9	0	48.1			51.490	−0.005			51.485	E	0.186
Nov. 26–27	40	3	35.3	1	02.0	2	33	22.504	+0.002	2	33	22.506	W	
	38	3	35.4	1	02.0			22.865	+0.004			22.869	E	0.182
Dec. 1–2	36	3	48.0	1	13.8	2	34	14.099	+0.038	2	34	14.137	W	
	38	3	48.3	1	14.0			14.563	−0.074			14.489	E	0.176
Dec. 3–4	39	3	54.6	1	20.1	2	35	35.018	+0.002	2	35	35.020	W	
	40	3	54.7	1	20.1			35.396	−0.004			35.392	E	0.186
Dec. 4–5	40	4	00.9	1	26.1	2	34	45.645	+0.012	2	34	45.657	W	
	40	4	00.9	1	26.1			46.018	+0.006			46.024	E	0.183
Dec. 5–6	40	3	50.8	1	15.8	2	34	56.124	+0.045	2	34	56.169	W	
	40	3	50.8	1	15.9			56.530	+0.008			56.538	E	0.184

The mean of the transmission times is

$$0^{s}.185 \pm 0^{s}.0011$$

The probable error of the transmission time on one night is

$$\pm 0^{s}.0034$$

Midway Island—Results of time observations.

Transit No. 18. Chronometer Negus No. 1828.

Observer: Fremont Morse.

Date	Number of stars	Band	Instrumental constants			Chronometer time	Chronometer correction	Probable error for one star	Probable error of mean	Hourly rate
			Level	Collimation	Azimuth					
1903			*s.*	*s.*	*s.*	*h. m.*	*s.*	*s.*	*s.*	*s.*
Nov. 16	5	W	+0.091	+0.007	—0.487	1 02.3	—11.610	±0.022	±0.007	—0.2718
	5	E	+0.025		—0.490					
	5	E	+0.050	+0.002	—0.523	3 46.9	—12.356	±0.027	±0.009	
	5	W	+0.075		—0.284					
Nov. 17	5	W	+0.133	—0.025	—0.348	2 01.9	—18.765	±0.029	±0.009	—0.2562
	5	E	+0.042		—0.401					
	5	W	+0.133	—0.032	—0.341	3 47.0	—19.213	±0.038	±0.012	
	5	E	+0.034		—0.370					
Nov. 18	5	E	+0.088	—0.010	—0.627	2 02.0	—25.487	±0.025	±0.008	—0.2598
	5	W	+0.141		—0.531					
	5	E	+0.058	—0.032	—0.624	3 47.1	—25.942	±0.013	±0.004	
	5	W	+0.122		—0.600					
Nov. 22	5	W	+0.343	—0.061	—0.136	2 36.8	— 52.632	±0.047	±0.017	—0.2556
	4	E	+0.240		—0.052					
	5	W	+0.320	—0.030	—0.149	5 14.0	— 53.342	±0.016	±0.005	
	5	E	+0.247		—0.141					
Nov. 23	4	E	—0.055	—0.035	—0.805	2 17.6	— 58.987	±0.021	±0.007	—0.2922
	5	W	+0.041		—0.728					
	5	W	+0.041	—0.037	—0.724	3 16.1	— 59.272	±0.028	±0.009	
	4	E	—0.037		—0.860					
Nov. 26	5	W	+0.094	—0.028	—1.330	2 39.9	—1 18.566	±0.020	±0.006	—0.2754
	5	E	+0.008		—1.364					
	5	W	+0.080	—0.020	—1.404	4 11.6	—1 18.987	±0.021	±0.007	
	5	E	—0.007		—1.306					
Dec. 1	5	E	+0.018	—0.025	—1.467	3 02.0	—1 50.512	±0.035	±0.011	—0.2814
	5	W	+0.085		—1.485					
	5	E	+0.027	—0.023	—1.484	4 40.0	—1 50.972	±0.029	±0.009	
	5	W	—0.131		—1.467					

Midway Island—Results of time observations—Continued.

Date	Number of stars	Band	Instrumental constants			Chronometer time	Chronometer correction	Probable error for one star	Probable error of mean	Hourly rate
			Level	Collimation	Azimuth					
1903 Dec. 3	5	W	+0.047	-0.037	+0.562	3 01.9	-2 03.548	±0.032	±0.010	-0.2520
	5	E	-0.060		+0.602					
	5	W	-0.012	-0.026	+0.483	4 35.4	-2 03.940	±0.027	±0.009	
	5	E	-0.087		+0.504					
Dec. 4	5	E	-0.051	-0.035	+0.503	2 59.5	-2 10.159	±0.036	±0.011	-0.2442
	4	W	-0.001		+0.466					
	5	E	-0.050	-0.013	-0.474	4 35.5	-2 10.550	±0.022	±0.007	
	5	W	-0.011		-0.493					
Dec. 5	5	W	-0.007	-0.011	+0.387	3 03.3	-2 16.746	±0.030	±0.009	-0.2202
	5	E	-0.058		+0.390					
	4	W	-0.013	-0.015	+0.005	4 35.6	-2 17.085	±0.030	±0.010	
	4	E	-0.065		+0.006					

Guam Island—Results of time observations.

Transit No. 19. Chronometer Negus No. 1823.

Observer: Edwin Smith.

Date	Number of stars.	Band	Instrumental constants			Chronometer time	Chronometer correction	Probable error for one star	Probable error of mean	Hourly rate
			Level	Collimation	Azimuth					
			s.	*s.*	*s.*	*h.* *m.*	*s.*	*s.*	*s.*	
1903 Nov. 17	3	W	+0.053	-0.080	-0.003	23 28.7	-29.981			+0.1464
	2	E	+0.093		-0.132					
	5	W	+0.041	-0.130	-0.201	1 25.4	-29.696	±0.039	±0.014	
	4	E	-0.088		-0.434					
Nov. 18	5	E	-0.042	-0.107	-0.310	23 33.4	-25.866	±0.058	±0.021	+0.1350
	4	W	-0.102		-0.243					
	5	E	-0.050	-0.123	-0.321	1 25.5	-25.614	±0.043	±0.016	
	5	W	-0.107		-0.278					
Nov. 19	5	W	+0.016	-0.110	-0.631	23 31.3	-21.832	±0.028	±0.010	+0.1584
	5	E	+0.071		-0.681					
	4	W	+0.009	-0.116	-0.726	1 25.5	-21.530	±0.018	±0.007	
	4	E	+0.041		-0.678					

Guam Island—Results of time observations—Continued.

Date	Number of stars	Band	Instrumental constants.			Chronometer time	Chronometer correction	Probable error for one star	Probable error of mean	Hourly rate
			Level	Collimation	Azimuth					
1903			*s.*	*s.*	*s.*	*h.* *m.*	*s.*	*s.*	*s.*	*s.*
Nov. 23	5	E	+0.056	−0.130	−0.449	23 31.6	− 5.871	±0.055	±0.020	+0.1368
	5	W	−0.019		−0.331					
	4	E	+0.053	−0.100	−0.551	1 25.8	− 5.611	±0.019	±0.007	
	4	W	+0.003		−0.626					
Nov. 24	5	W	+0.006	−0.085	−0.035	0 11.8	− 1.752	±0.063	±0.022	+0.1524
	5	E	+0.046		−0.515					
	5	W	+0.005	−0.116	−0.427	2 15.2	− 1.439	±0.034	±0.013	
	5	E	+0.046		−0.433					
Nov. 27	5	E	−0.006	−0.121	−0.559	0 16.3	+10.060	±0.029	±0.011	+0.1788
	5	W	−0.019		−0.472					
	5	E	−0.019	−0.159	−0.478	2 13.7	+10.409	±0.025	±0.009	
	5	W	−0.065		−0.517					
Dec. 2	4	W	+0.027	−0.122	−0.841	0 35.5	+29.792	±0.038	±0.014	+0.1644
	4	E	+0.065		−0.666					
	5	W	+0.019	−0.119	−0.600	2 14.8	+30.064	±0.009	±0.003	
	4	E	+0.036		−0.642					
Dec. 4	5	E	+0.012	−0.119	−0.024	0 35.6	+37.684	±0.042	±0.015	+0.1776
	5	W	−0.050		+0.180					
	4	E	0.000	−0.190	−0.171	2 14.8	+37.978	±0.031	±0.011	
	5	W	−0.037		−0.201					
Dec. 5	5	W	−0.003	−0.109	−0.418	0 35.7	+41.625	±0.040	±0.014	+0.1524
	5	E	+0.057		−0.422					
	5	W	−0.012	−0.110	−0.402	2 14.2	+41.875	±0.022	±0.008	
	5	E	+0.011		−0.417					
Dec. 6	3	E	+0.022	−0.102	−0.982	0 36.9	+45.634	±0.086	±0.032	+0.1668
	4	W	−0.022		−1.055					
	5	E	+0.025	−0.100	−0.748	2 14.3	+45.905	±0.040	±0.014	
	5	W	−0.025		−0.550					

The mean probable error for a single star, weight unity, is:

Transit No. 18 at Midway, Morse, ±$0^{s}.028$

Transit No. 19 at Guam, Smith, ±$0^{s}.038$

Results for difference of longitude.

Date	Difference of chronometers	Correction to chronometers		Observed difference of longitude	Difference from mean	Weight
		Midway	Guam			
1903	h. m. s.	s.	s.	h. m. s.	s.	
Nov. 16–17	2 31 35.894	− 12.104	−29.855	2 31 53.645	+0.008	0.8
17–18	46.888	− 18.991	−25.755	.652	+0.001	0.8
18–19	57.656	− 25.732	−21.686	.610	+0.043	1.5
22–23	32 40.749	− 52.823	− 5.701	.622	+0.026	0.8
23–24	51.298	− 59.295	− 1.660	.663	−0.010	0.7
26–27	33 22.688	− 78.822	+10.196	.670	−0.017	1.3
Dec. 1– 2	34 14.313	−110.728	+29.897	.688	−0.035	1.1
3– 4	35.206	−123.769	+37.816	.621	+0.033	0.8
4– 5	45.840	−130.409	+41.753	.678	−0.025	1.0
5– 6	56.354	−136.921	+45.743	.690	−0.037	0.6

Weighted mean of the 10 nights, $2^h\ 31^m\ 53^s.653 \pm 0^s.007$

Personal equation M.—S. $-0\ .071 \pm 0\ .007$

Guam transit west of Midway transit, $2\ \ 31\ \ 53\ .582 \pm 0\ .010$

The probable error of a result for difference of longitude for one night, weight unity, is $\pm 0^s.022$.

HONOLULU AND MIDWAY ISLAND.

Results of cable signals.

Date	Number of signals	Chronometer time				Difference of chronometers			Cable pen correction	Corrected difference of chronometers.			Direction of signals	Transmission time
		Honolulu		Midway Island										
1903		h.	m.	h.	m.	h.	m.	s.	s.	h.	m.	s.		s.
Feb. 22	..	.	....	.	....	.	..	......	.....	.	..	......	W.	
	41	8	13.2	6	56.7	1	16	30.382	+0.006	1	16	30.388	E.	.....
Feb. 25	38	8	23.7	7	06.5	1	17	12.571	+0.058	1	17	12.629	W.	
	40	8	23.7	7	06.5			12.874	−0.006			12.868	E.	0.120
Mar. 2	41	8	16.0	6	59.3	1	16	40.593	+0.064	1	16	40.657	W.	
	37	8	16.0	6	59.4			40.905	−0.004			40.901	E.	0.122
Mar. 8	40	8	04.0	6	47.8	1	16	10.046	0.000	1	16	10.046	W.	
	40	8	03.9	6	47.7			10.342	−0.070			10.272	E.	0.113
Mar. 9	40	8	01.9	6	45.8	1	16	04.906	+0.026	1	16	04.932	W.	
	38	8	01.9	6	45.9			05.185	−0.027			05.158	E.	0.113
Mar. 10	39	8	06.6	6	50.6	1	15	59.471	+0.063	1	15	59.534	W.	
	40	8	06.9	8	50.9			59.810	−0.035			59.775	E.	0.120
Mar. 19	40	8	58.6	7	43.4	1	15	13.113	+0.036	1	15	13.149	W.	
	40	8	58.5	7	43.3			13.436	−0.050			13.386	E.	0.118
Mar. 24	42	9	00.9	7	46.1	1	14	48.196	+0.022	1	14	48.218	W.	
	38	9	01.0	7	46.2			48.487	−0.030			48.457	E.	0.120

The mean of the transmission times is:

$$0^s.118 \pm 0^s.0009$$

The probable error of the transmission time on one night is:

$$\pm 0^s.0024$$

Honolulu—Results of time observations.

Transit No. 19. Chonometer Negus No. 1769.

Observer: Edwin Smith.

Date	Number of stars	Band	Instrumental constants			Chronometer time	Chronometer correction	Probable error for one star	Probable error of mean	Hourly rate
			Level	Collimation	Azimuth					
1903			*s.*	*s.*	*s.*	*h. m.*	*m. s.*	*s.*	*s.*	*s.*
Feb. 22	6	W	—0.040	+0.060	+0.041	7 31.0	—0 52.549	±0.020	±0.007	+0.1914
	3	E	—0.036		—0.412					
	5	W	—0.064	+0.100	—0.002	8 45.9	—0 52.310	±0.017	±0.006	
	4	E	—0.019		—0.088					
Feb. 25	5	E	—0.095	+0.010	+0.334	7 31.3	—0 36.336	±0.030	±0.010	+0.1704
	5	W	—0.127		—0.164					
	4	E	—0.112	—0.025	—0.392	8 45.5	—0 36.125	±0.028	±0.011	
	4	W	—0.172		+0.095					
Mar. 2	4	W	+0.028	0.000	+0.487	7 54.8	—0 2.211	±0.037	±0.014	+0.2016
	4	E	+0.067		—0.229					
	5	W	+0.025	—0.040	—0.169	8 43.3	—0 2.048	±0.026	±0.009	
	5	E	+0.047		—0.309					
Mar. 8	4	E	+0.025	—0.060	—0.170	7 25.9	+0 32.562	±0.072	±0.025	+0.2406
	5	W	—0.025		—0.540					
	5	E	+0.014	—0.040	—0.895	8 46.7	+0 32.886	±0.052	±0.017	
	5	W	—0.051		+0.117					
Mar. 9	5	W	+0.053	—0.030	+0.320	7 25.8	+0 38.496	±0.043	±0.017	+0.2772
	4	E	+0.071		+0.229					
	7	W	—0.001	—0.045	—0.072	8 37.0	—0 38.825	±0.030	±0.011	
	4	E	+0.025		—0.541					
Mar. 10	5	E	—0.044	—0.064	—0.378	7 26.6	+0 44.462	±0.026	±0.009	+0.3012
	4	W	—0.130		—0.289					
	4	E	—0.096	—0.034	—0.063	8 27.9	+0 44.770	±0.020	±0.007	
	4	W	—0.158		+0.008					

Honolulu—Results of time observations—Continued.

Date	Number of stars	Band	Instrumental constants			Chronometer time	Chronometer correction	Probable error for one star	Probable error of mean	Hourly rate
			Level	Collimation	Azimuth					
1903			*s.*	*s.*	*s.*	*h.* *m.*	*m.* *s.*	*s.*	*s.*	*s.*
Mar. 19	5	W	−0.064	−0.025	−0.051	8 46.6	+1 37.308	±0.019	±0.006	+0.2736
	6	E	−0.034		−0.620					
	6	E	−0.034	−0.040	−0.586	9 21.5	+1 37.467	±0.034	±0.011	
	5	W	−0.087		−0.135					
Mar. 24	5	E	+0.061	0.000	−0.993	8 45.4	+2 05.702	±0.028	±0.010	+0.2574
	5	W	−0.025		−1.005					
	5	E	+0.006	−0.040	−1.016	9 29.2	+2 05.890	±0.042	±0.016	
	4	W	−0.051		−0.781					

Honolulu—Comparison of chronometers.

Chronometer Negus No. 1769 at observatory.
Chronometer Negus No. 1823 at cable office.

Date	Chronometer time		Difference of chronometers, 1769–1823	Number of signals	Chronometer correction		Hourly rate, 1823
	1769	1823			1769	1823	
1904	*h.* *m.*	*h.* *m.*	*m.* *s.*		*m.* *s.*	*m.* *s.*	*s.*
Feb. 22	7 55.8	7 54.2	+1 39.855	43	−0 52.470	+0 47.385	
	8 25.7	8 24.1	+1 39.815	40	−0 52.375	+0 47.440	+0.1104
Feb. 25	8 20.7	8 19.4	+1 32.896	44	−0 36.196	+0 56.700	
	8 31.1	8 29.6	+1 32.886	41	−0 36.166	+0 56.720	+0.1176
Mar. 2	8 12.6	8 11.3	+1 18.052	43	−0 2.151	+1 15.901	
	8 22.9	8 21.6	+1 18.025	43	−0 2.117	+1 15.908	+0.0408
Mar. 8	7 59.9	7 58.8	+1 01.970	43	+0 32.698	+1 34.668	
	8 09.8	8 08.7	+1 01.943	40	+0 32.738	+1 34.681	+0.0786
Mar. 9	7 58.3	7 57.3	+0 59.320	37	+0 38.646	+1 37.966	
	8 19.2	8 18.2	+0 59.280	39	+0 38.743	+1 38.023	+0.1638
Mar. 10	8 02.2	8 01.3	+0 56.536	42	+0 44.641	+1 41.177	
	8 12.5	8 11.6	+0 56.504	42	+0 44.692	+1 41.196	+0.1104
Mar. 19	8 54.7	8 54.2	+0 31.830	42	+1 37.345	+2 09.175	
	9 04.2	9 03.7	+0 31.804	39	+1 37.388	+2 09.192	+0.1074
Mar. 24	8 56.8	8 56.5	+0 18.924	45	+2 05.751	+2 24.675	
	9 05.9	9 05.6	+0 18.914	38	+2 05.790	+2 24.704	+0.1914

Midway Island—Results of time observations.

Transit No. 18. Chronometer Negus No. 1828 on Feb. 22. Chronometer Negus No. 1836 after Feb. 22.

Observer: Fremont Morse.

Date	Number of stars	Band	Instrumental constants			Chronometer time	Chronometer correction	Probable error for one star	Probable error of mean	Hourly rate
			Level	Collimation	Azimuth					
			s.	*s.*	*s.*	*h. m.*	*s.*	*s.*	*s.*	*s.*
1903 Feb. 22	5	E	−0.020	−0.086	−0.223	5 57.5	−45.217	±0.027	±0.009	−0.3258
	5	W	+0.057		−0.236					
	5	E	−0.022	−0.065	−0.187	7 45.2	−45.802	±0.059	±0.019	
	5	W	+0.063		−0.228					
Feb. 25	5	W	+0.133	−0.106	−0.488	6 03.2	+ 6.428	±0.024	±0.008	−0.0978
	5	E	−0.001		−0.408					
	5	W	+0.094	−0.065	−0.351	7 48.2	+ 6.257	±0.020	±0.006	
	5	E	+0.030		−0.369					
Mar. 2	4	W	+0.216	−0.150	−0.019	6 03.8	− 6.520	±0.034	±0.011	−0.0564
	5	E	+0.082		+0.077					
	5	W	+0.082	−0.147	+0.078	6 51.6	− 6.565	±0.046	±0.014	
	5	E	+0.159		−0.080					
Mar. 8	5	E	−0.103	−0.083	+0.746	5 58.1	−18.176	±0.043	±0.014	−0.0564
	5	W	−0.065		+0.807					
	5	E	−0.146	−0.110	+0.632	7 32.8	−18.265	±0.031	±0.010	
	5	W	−0.075		+0.750					
Mar. 9	5	E	−0.013	−0.108	−0.085	5 58.3	−20.046	±0.023	±0.007	−0.0732
	4	W	+0.086		−0.060					
	5	E	−0.036	−0.120	−0.159	7 30.4	−20.158	±0.028	±0.007	
	5	W	+0.077		−0.007					
Mar. 10	5	W	+0.088	−0.140	−0.237	6 06.8	−22.226	±0.022	±0.007	−0.0720
	5	E	+0.011		−0.251					
	5	W	+0.068	−0.134	−0.295	7 33.7	−22.330	±0.020	±0.006	
	5	E	+0.004		−0.241					

Midway Island—Results of Time observations—Continued.

Date	Number of stars	Band	Instrumental constants.			Chronometer time	Chronometer correction	Probable error for one star	Probable error of mean	Hourly rate
			Level	Collimation	Azimuth					
			s.	*s.*	*s.*	*h.* *m.*	*s.*	*s.*	*s.*	*s.*
1903 Mar. 19	5	E	−0. 109	−0. 132	−0. 131	6 43. 9	−40. 600	±0. 026	±0. 008	−0. 1170
	5	W	−0. 011		−0. 210					
	5	E	−0. 092	−0. 117	−0. 238	8 40. 8	−40. 828	±0. 037	±0. 012	
	5	W	−0. 001		−0. 183					
Mar. 24	5	W	+0. 021	−0. 145	−0. 333	6 59. 8	−50. 065	±0. 026	±0. 008	−0. 0800
	5	E	−0. 049		−0. 285					
	5	W	−0. 016	−0. 097	−0. 159	8 22. 7	−50. 176	±0. 025	±0. 008	
	5	E	−0. 101		−0. 290					

The mean probable error for a single star is:

Transit No. 19 at Honolulu, Smith, $\pm 0^s.033$
Transit No. 18 at Midway, Morse, $\pm 0 .031$

Results for difference of longitude.

Date	Difference of chronometers	Correction to chronometers		Observed difference of longitude	Difference from mean	Weight
		Honolulu	Midway			
1904	*h.* *m.* *s.*	*s.*	*s.*	*h.* *m.* *s.*	*s.*	
Feb. 22	1 16 30. 270	+ 47. 420	−45. 539	1 18 03. 229	−0. 080	0. 7
25	17 12. 748	+ 56. 708	+ 6. 325	. 131	+0. 018	1. 3
Mar. 2	16 40. 779	+ 75. 904	− 6. 572	. 255	−0. 106	0. 7
8	10. 159	+ 94. 675	−18. 222	. 056	+0. 093	0. 7
9	05. 045	+ 97. 978	−20. 104	. 127	+0. 022	1. 0
10	15 59. 654	+101. 187	−22. 279	. 120	+0. 029	1. 5
19	13. 268	+129. 183	−40. 716	. 167	−0. 018	1. 1
24	14 48. 338	+144. 689	−50. 127	. 154	+0. 005	1. 0

Weighted mean of the eight nights,	$1^h\ 18^m\ 03^s.149 \pm 0^s.013$
Personal equation S.—M.	$0\ .071 \pm 0\ .007$
Midway transit west of Honolulu transit,	$1\ \ 18\ \ 03\ .220 \pm 0\ .015$

The probable error of a result for difference of longitude for one night, weight unity, is $\pm 0^s.037$.

RESULTING LONGITUDES.

	h.	m.	s.	s.
San Francisco (Presidio) west of Greenwich	*8	09	48.813	±0.055
San Francisco transit (1903) east of Presidio			0.004	
Honolulu transit west of San Francisco transit	2	21	38.923	±0.008
Midway transit west of Honolulu transit	1	18	03.220	±0.015
Guam transit west of Midway transit	2	31	53.582	±0.010
Manila transit west of Guam transit	1	34	43.264	±0.010
Manila Cathedral dome east of Manila transit			0.224	

From the above the following longitudes result:

	h.	m.	s.	s.
Honolulu transit west of Greenwich	10	31	27.732	±0.056
Midway transit west of Greenwich	11	49	30.952	±0.057
Guam transit west of Greenwich	14	21	24.534	±0.058
Guam transit east of Greenwich	9	38	35.466	±0.058
Manila transit west of Greenwich	15	56	07.798	±0.059
Manila transit east of Greenwich	8	03	52.202	±0.059
Manila Cathedral dome east of Greenwich	8	03	52.426	±0.059

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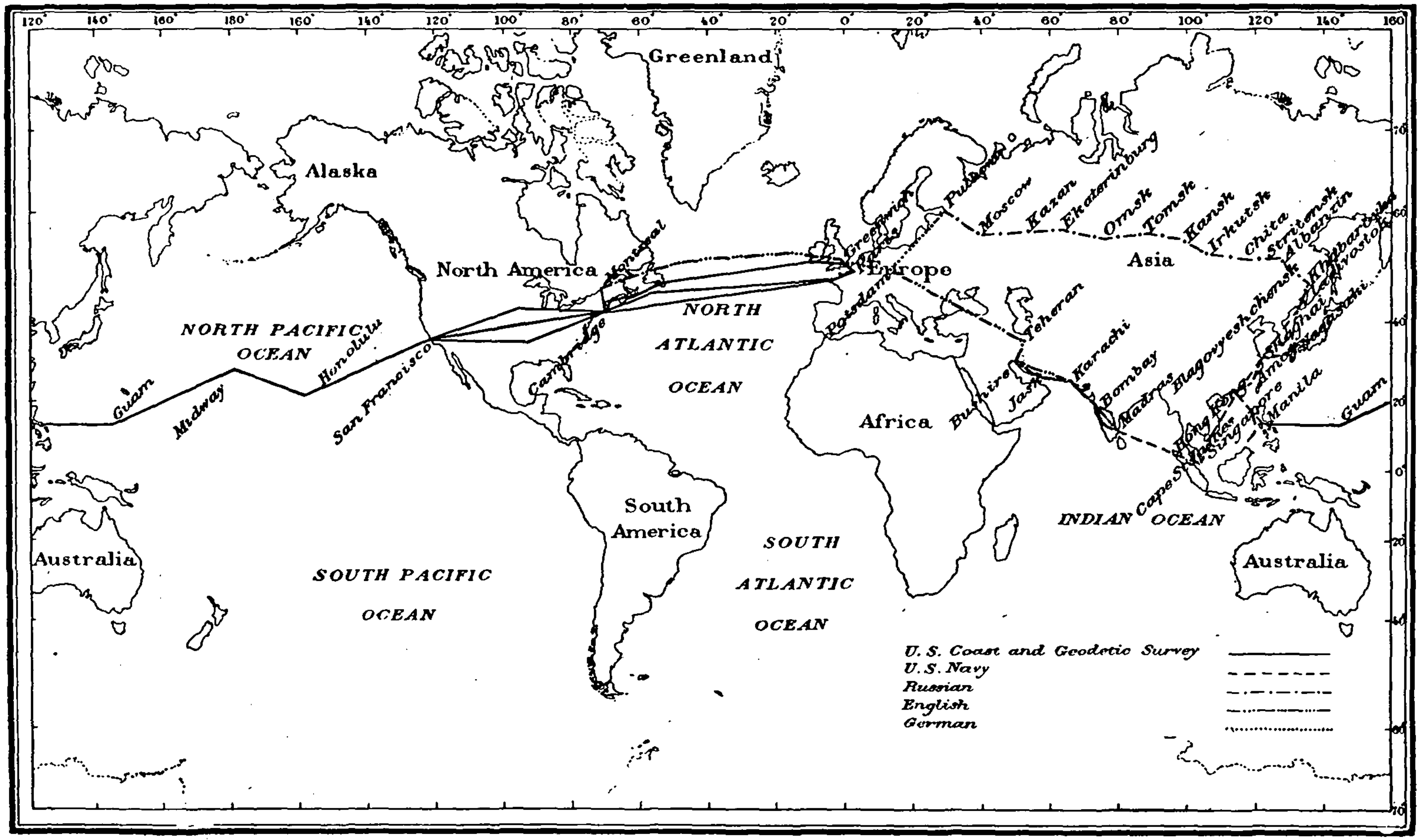
* For this longitude of San Francisco see "The Longitude Net of the United States and its Connection with that of Europe, 1866–1896," Appendix 2, C. & G. Survey Report for 1897, and also "The Trans-continental Triangulation," pp. 820 and 826, C. & G. Survey Special Publication No. 4, 1900.

No. 13.



Telegraphic longitude connections around the earth.

PREVIOUS DETERMINATIONS OF LONGITUDE.

Manila.

In 1881–82 officers of the United States Navy determined a number of differences of longitude between Vladivostok and Madras, including Manila. The results can be found in a publication of the Hydrographic Office of the United States Navy, No. 65b, "Telegraphic Determination of Longitude in the East Indies, China, and Japan, 1891–92."

The observers were Lieut. Commanders F. M. Green and C. H. Davis and Lieut. J. A. Norris. No personal equation was applied to the differences of longitude, and on page 18 of the publication it is stated:

> By means of the repeated use of the personal-equation machine of Professor Eastman at the Naval Observatory it was found that the habitual errors of the observers engaged in this measurement had all the same sign; that is, they habitually observed the transit of a star a few hundredths of a second after its occurrence, but their respective differences were so small that it seemed evident that to introduce results so minute as corrections would not increase the trustworthiness of the result.
>
> In order to avoid as far as practicable the errors arising from difference of personal habit in observing, it was sought to place each observer, in making the long chain of measurements, alternately east and west of the other.

In the results taken from the publication and given below it will be seen that the difference of longitude, Vladivostok–Manila, remains uncorrected for the personal equation (N.–G.), and the difference of longitude, Manila–Madras, remains uncorrected for twice the personal equation (N.–G.).

For a determination of personal equation by Davis and Norris at a later date, see page 29, "Telegraphic Determination of Longitude in Mexico and Central America and on the West Coast of South America, 1883–84."

By Eastman machine eight days N.–D. $= +0^s.130$
By star transits eight nights N.–D. $= +0\ .284$

The personal equation between these two observers is eliminated in the results given below. The personal equation between Norris and Green was not determined.

		Number of nights	Observed difference of longitude			Probable error	Unknown personal equation
			h.	m.	s.	s.	
1	Vladivostok-Nagasaki	2	0	08	01.900	±0.034	+ (N.-D.)
2	Nagasaki-Shanghai	4	0	33	32.850	±0.025	+ (D.-G.)
1-2	Vladivostok-Shanghai		0	41	34.75	±0.042	+ (N.-G.)
3	" "	2	0	41	34.82	±0.034	+ (N.-G.)
Mean	" "		0	41	34.785	±0.038	+ (N.-G.)
4	Shanghai-Amoy	2	0	13	40.87	±0.034	+ (D.-N.)
5	Amoy-Hongkong	4	0	15	36.42	±0.022	+ (N.-G.)
4-5	Shanghai-Hongkong		0	29	17.29	±0.042	+ (D.-G.)
6	" "	2	0	29	17.28	±0.034	+ (D.-G.)
Mean	" "		0	29	17.285	±0.038	+ (D.-G.)
7	Manila-Hongkong	3	0	27	13.36	±0.024	+ (D.-G.)
8	Hongkong-Cape St. James	4	0	28	21.43	±0.027	+ (N.-D.)
9	Cape St. James-Singapore	4	0	12	52.42	±0.034	+ (D.-G.)
10	Singapore-Madras	5	1	34	25.58	±0.028	+ (N.-D.)
	From the above the following are deduced:						
1 to 7	Vladivostok-Manila		0	43	38.710	±0.059	+ (N.-G.)
	Reduction to Cathedral dome				−0.21		
	Vladivostok-Manila Cathedral dome		0	43	38.500	±0.059	+ (N.-G.)
7 to 10	Manila-Madras		2	42	52.790	±0.057	+2(N.-G.)
	Reduction to cathedral dome				+0.21		
	Manila Cathedral dome-Madras		2	42	53.000	±0.057	+2(N.-G.)

In "Telegraphic Determinations of the Difference of Longitude," by Norman Pogson, Madras, 1884, and in the Astronomische Nachrichten, No. 2486, of 1883, are given accounts of a determination of the difference of longitude between Singapore and Madras in 1871 by Doctor Oudemans and Mr. Pogson. No personal equation was determined, and Doctor Oudemans has himself accepted the result of the United States Navy observers. This determination is therefore not used in this discussion. The above results must necessarily be used at present to connect Vladivostok and Madras with Manila.

The longitude of Madras has been determined by five independent series of observations, and a résumé of all of them is given by Captain Burrard in Appendix No. 2, Vol. XVII, of the Great Trigonometrical Survey of India. They are as follows:

	h.	m.	s.	s.	
Series A	5	20	59.750	±0.155	1874-5 and 1881-2
B	5	20	59.010	±0.163	1874
C	5	20	59.137	±0.022	1876, 1881, 1892-4-5
D	5	20	59.223	±0.127	1874-77
E	5	20	59.421	±0.123	1874-77

Series A is by the way of Moscow and Vladivostok, and thence by the work of the United States Navy officers. As this series is used for the direct determination of the longitude of Manila, it will not here be considered in determining the longitude of Madras.

Series B is by way of Berlin, Teheran, Isfahan, Karachi, and Madras. The following is taken from the appendix above mentioned:

An account, written by General Addison, of series B is to be found in Vol. XXXVIII of the Monthly Notices of the Royal Astronomical Society, and the resulting longitude of Madras is there given as $5^h\ 20^m\ 59^s.65$. But in Die Venus-Durchgange 1874 and 1882, published at Berlin in 1896, Doctor Auwers discusses this series of longitudes and considerably modifies General Addison's results, decreasing the value of every arc. [The result given above is that of Doctor Auwers.]

A constant error of about ten seconds of time runs throughout the observations at Karachi. Mr. Pogson writes "an error of exactly ten seconds in General Addison's time determination is the only possible explanation," but Doctor Auwers states the error to be "nearly eleven seconds." General Addison, the observer, attributes it to his neglect to obtain the pivot error of his transit instrument, and is of opinion, though the resulting longitude of Karachi may be wrong, that "the difference between Isfahan and Madras remains unaffected, the errors on the east and west sides of Karachi correcting each other." Mr. Pogson considers that "no conceivable pivot correction nor any other instrumental error could account for so large a difference," but, on the supposition that the observer mistook the time by ten seconds, he agrees with General Addison that the effect would be reversed east and west of Karachi, and would therefore be eliminated in the final difference between Greenwich and Madras.

In this series no determination of personal equation was made between Madras and Isfahan observers.

Series D is by way of Berlin, Malta, Alexandria, Suez, Aden, Bombay, Bellary, and Madras. Captain Burrard states in regard to this series:

> This series is discussed by Doctor Copeland in Vol. III, Chapter XXIII, of the Dunecht Observatory Publications, and by Doctor Auwers in a paper on "The longitude of Aden," published in the Astronomische Nachrichten, No. 3180, dated August 15, 1893. Doctor Auwers's discussion is reprinted in Die Venus-Durchgange, 1874 and 1882. [The result given above is by Doctor Auwers.]
>
> In vol. I of the Annals of the Cape Observatory, Mr. David Gill, who was one of the observers of this series, writes: "In case of Lord Lindsay's expedition (i. e., of series D) the observers lay no claim to high refinement. They were made throughout in the open air with small portable instruments, which, in the case of Alexandria, were placed on the roof of a hotel, where the observer had to abstain from movement during each complete observation; otherwise the level was disturbed by the change of his position. At Aden and Alexandria the chronometers had to be carried a long distance between the observing station and the telegraph office. The observers were without personal assistance, and the crucial observations for time had often to be made under conditions of extreme fatigue, amounting on one or two occasions nearly to exhaustion on the part of the observers engaged. In fact, the character of the work was only such as it was possible to organize and execute en route, and the results fully realized the accuracy expected from them."

Series E is by way of Mokattam, Suez, Aden, Bombay, Bellary, and Madras. Of this series Captain Burrard says:

> In the Annals of the Cape Observatory Mr. Gill points out that this series E was not executed with such refinements or precautions as are necessary for the determination of fundamental longitudes, and Mr. Hunter, the Suez observer, in his report to Sir George Airy, states that the micrometer screw was "decidedly drunken" and that he had to abandon its use, and "to trust to observing the pole-star in both positions of the instrument over the fixed wires for collimation" (p. 322 of the Account of Observations of the Transit of Venus, 1874, by Sir George Airy). The personal equation of the Greenwich and Mokattam observers varied from $0^s.025$ to $0^s.655$ (p. 288, Transit of Venus, 1874).

From the above statements it will be seen that the three series, B, D, and E, can scarcely be considered in deriving the fundamental longitude of Madras, though they served their purpose at the time they were made.

Series C was executed by the English with the greatest care, and at present must be considered the only reliable determination of the longitude of Madras. Nine differences of longitude enter into it and will be given in a table later. The observers were Captains Burrard and Lenox-Conyngham in 1892-4-5, and Captains Campbell and Heaviside in 1876-1881. On the arc Potsdam-Greenwich the personal equation of the observers was eliminated by an exchange of observers. On the other arcs there was no exchange of observers, but their personal equations were determined by special observations, and the observers were so placed at the several stations that in the final longitude of Madras personal equation would be eliminated as well as possible. In the table the differences of longitude 1 to 6 are taken from Vol. XVII, Great Trigonometrical Survey of India, and the full details of the work will be found in that volume. The differences of longitude 7, 8, and 9 are taken from Table IX, pages 440 and 441, Vol. XV, Great Trigonometrical Survey of India. These three differences are in the longitude net of India, and the values given are the adjusted values. The details of the difference Bolarum–Bombay will be found in Vol. XV and of differences Bombay–Karachi and Madras–Bolarum in Vol. IX of Great Trigonometrical Survey of India.

The arcs Berlin–Greenwich 1876 and Berlin–Potsdam 1901 give the difference of longitude Potsdam–Greenwich $0^{s}.236$ in excess of the difference given in the table. In 1903 the Geodetic Institute undertook a new determination of this arc and the full details of the work will be found in the publications of Des Königl. Preuszisschen Geodätischen Institutes, Neue Folge No. 15, "Bestimmung der Längendifferenz Potsdam–Greenwich im Jahre 1903." The work was conducted by Doctor Albrecht. In the observations the Repsold registering micrometer was used. On each evening three complete time sets were observed and four independent exchanges of signals. The star programme was so arranged as to eliminate to the greatest possible extent any uncertainty in the right ascensions of the stars. Midway in the determination a change of position of observers and instruments took place. This determination with a probable error of only $\pm 0^{s}.003$ will supersede all previous ones. It gives the difference of longitude Potsdam–Greenwich $0^{s}.098$ in excess of the difference given in the table for series C, and this amount will be added to the longitude of Madras from this series for a final result.

Series C.

		Year of observation	Nights	Difference of longitude			Probable error	Observers
				h.	*m.*	*s.*	*s.*	
1	Potsdam–Greenwich	1895	10	0	52	15.953	±0.006	(B–C)
2	Teheran–Potsdam	1895	10	2	33	24.228	±0.007	(C–B)
3	Teheran–Bushire,	1896	8	0	02	21.443	±0.008	(C–B)
4	Jask–Bushire	1894	6	0	27	45.057	±0.010	(C–B)
5	Karachi–Jask	1895	8	0	36	59.697	±0.006	(B–C)
6	Karachi–Bushire	1894	5	1	04	44.812	±0.010	(B–C)
	Karachi–Bushire adjusted			1	04	44.790	±0.011	(B–C)
7	Bombay–Karachi	1881	6	0	23	12.196	±0.008	(H–Ca)
8	Bolarum–Bombay*	1892	6	0	22	48.801	±0.008	(C–B)
9	Madras–Bolarum	1876	6	0	06	54.615	±0.008	(Ca–H)
	Madras–Greenwich			5	20	59.140	±0.022	
	Reduction to determination of Potsdam–Greenwich, 1903					+0.098		
	Madras–Greenwich, 1903			5	20	59.238	±0.022	

The difference of longitude between Valdivostok and Moscow was determined in 1874–75 by Generals Scharnhorst and Kuhlberg of the Russian army. It includes 12 arcs. The difference of longitude Moscow–Pulkowa was determined 1872 by Kortozzi, Kuhlberg, Bonsdorf, and Switzki. These thirteen differences of longitude can be found in vols. 35 and 37 of Mémoirs de la Section Topographique de l'État Major Général de la Russie, and the results given below have been taken therefrom. The difference of longitude Pulkowa-Greenwich given by Captain Burrard in his report is superseded by more recent determination 1901–1903 by the Germans in two arcs Pulkowa–Potsdam and Potsdam–Greenwich. The latter arc is the one used in deriving the longitude of Madras. The former was also determined by Doctor Albrecht with the same instruments and methods, and can be found in the publications of Des Königl. Preuszischen Geodätischen Institutes, Neue Folge No. 7. "Bestimmung der Längendifferenz Potsdam–Pulkowa im Jahre 1901". The following table gives all the results used to determine the longitude of Vladivostok.

		h.	m.	s.	s.	
1	Potsdam–Greenwich	0	52	16.051	±0.003	German observers
2	Pulkowa–Potsdam	1	09	02.493	±0.003	German observers
3	Moscow–Pulkowa	0	28	58.450	±0.010	Russian observers
4	Kazan–Moscow	0	46	11.970	±0.030	Russian observers
5	Ekaterinburg–Kazan	0	45	59.637	±0.043	Russian observers
6	Omsk–Ekaterinburg	0	51	01.511	±0.043	Russian observers
7	Tomsk–Omsk	0	46	18.614	±0.043	Russian observers
8	Kansk–Tomsk	0	43	01.189	±0.043	Russian observers
9	Irkutsk–Kansk	0	33	18.090	±0.043	Rnssian observers
10	Chita–Irkutsk	0	36	52.067	±0.043	Russian observers
11	Stritensk–Chita	0	16	45.539	±0.043	Russian observers
12	Albazin–Stritensk	0	25	31.674	±0.043	Russian observers
13	Blagovyeshchensk–Albanzin	0	13	45.992	±0.043	Russian observers
14	Khabarovka–Blagovyeshchensk	0	30	10.962	±0.043	Russian observers
15	Khabarovka–Vladivostok	0	12	43.042	±0.043	Russian observers
	Vladivostok–Greenwich	8	47	31.197	±0.146	Russian observers

The longitude of Manila results as follows:

	h.	m.	s.	s.
Manila Cathedral dome–Madras, United States Navy	2	42	53.000	±0.057+2(N.–G.)
Madras–Greenwich, English and Germans	5	20	59.238	±0.022
Manila Cathedral dome–Greenwich	8	03	52.238	±0.061+2(N.–G.)
Vladivostok–Manila Cathedral dome, United States Navy	0	43	38.500	±0.059+(N.–G.)
Vladivostok–Greenwich, Russians and Germans	8	47	31.197	±0.146
Manila Cathedral dome–Greenwich	8	03	52.697	±0.157−(N.–G.)

In 1881–82 the United States Navy accepted the longitude of Madras to be:

$$5^h\ 20^m\ 59^s.42 \quad \text{(Series E.)}$$

which gave for the longitude of the Cathedral dome at Manila

$$8^h\ 03^m\ 52^s.42$$

and that value has been used since that date. It differs only $0^s.006$ from the determination of the Coast and Geodetic Survey.

On account of the differences of longitude of Manila–Madras and Vladivostok–Manila not being freed from personal equation, proper weights can not be given the values for the longitude of Manila derived from them, to combine them with the Coast and Geodetic Survey determination.

The strength of the determination of the difference of longitude between San Francisco and Manila may be judged from the results given in this appendix. The longitude of San Francisco depends upon the Longitude Net of the United States and its connection with that of Europe, which includes 72 differences of longitude between 45 points. Four of these differences of longitude are trans-Atlantic, three by the Coast and Geodetic Survey, and one recent result, 1892 (not yet published), by the English and Canadians.

Honolulu.

In September, 1874, Capt. G. L. Tupman, Royal Marine Artillery, in charge of the British Transit of Venus Expedition of that year, arrived in Honolulu and established an observatory on Punchbowl street, near the shore. No pains were spared to ascertain the longitude, by lunar observations, and the latitude, by zenith distances of stars measured with an altazimuth, and the accuracy of the work has since been fully confirmed.

The observations for longitude were continued through the months of October, November, December, and January. During this time were obtained 7 results from occultations of stars by the moon, 52 results from the observations of moon culminations, and 60 results from the observations of zenith distances of the moon combined with the observed culminations and zenith distances of well-known stars.

The result officially communicated to the Hawaiian Government Survey was 10 h. 31 m. 27.2 s., and upon this all the L. M. Z. computations and maps since then have been based.

In March, 1875, Captain Tupman made an attempt to connect Honolulu with San Francisco by transportation of chronometers. Accordingly twenty chronometers were carried by H. B. M. S. *Reindeer*, Commander C. V. Anson, from Honolulu to the United States navy-yard, Mare Island, and compared with the local time at both stations. Unfortunately the *Reindeer* was blown out of her course by a northerly gale, which lengthened her voyage seven or eight days and lowered the temperature in the chronometer boxes as much as 15° F. Hence the resulting determination of the longitude of Honolulu, viz, 10 h. 31 m. 33.2 s. ± 3.0 s. W., has very little value.

Again, in August and September, 1884, an attempt was made by the Hawaiian Government Survey, with the cooperation of Professor George Davidson and Mr. Fremont Morse in San Francisco, to determine the longitude of Honolulu by comparing the chronometers on board the Oceanic Steamship Company steamer *Mariposa* with the local time at each end. This was done for two round trips, giving a mean result of 10 h. 31 m. 25.8 s.

In view of the above facts the Hawaiian Government adopted 10 h. 31 m. 26.0 s. as the most probable value, in rating chronometers and furnishing standard time, until the recent telegraphic determination made by the Coast and Geodetic Survey.

As it was impossible to connect the Coast and Geodetic Survey observatory at the naval station directly with the transit of Venus station, which is now a lumber yard, the Territorial Survey connected it with the Harbor Light-house and three principal trigonometrical stations by triangulation, which gave for the new longitude of the transit of Venus station

$10^h\ 31^m\ 27^s.236$ W.

differing from Captain Tupman's value only $0^s.036$, a remarkably close agreement.

The Harbor Light-house is $1^s.166$ west of the Coast and Geodetic Survey station, which gives for its longitude

$10^h\ 31^m\ 28^s.90$

Midway Island.

In 1900 a survey was made of the island by officers of the United States Navy on board the *Iroquois*, under the command of Lieut. Commander C. F. Pond. The Hydrographic Office Chart No. 1951 is based upon this survey. The position given for the point marked Observation Spot is

Lat. 28° 13′ 15″ N.
Long. 177 21 30 W.
$11^h\ 49^m\ 26^s$ W.

This Observation Spot is 192.4 feet west of the longitude station of the Coast and Geodetic Survey, which makes its longitude, based upon the work of the Coast and Geodetic Survey,

Long. 177 22 46 .4 W.
$11^h\ 49^m\ 31^s.091$ W.

Guam Island.

In 1899 the officers of the U. S. S. *Yosemite* made a survey of the harbor of San Luis d'Apara. A concrete pier was built on Fort Santa Cruz and its geographic position determined. Near the town of Soumaye a base was measured and a triangulation of the harbor was made. In 1901 the officers of the United States Navy extended the triangulation over the island.

The following is taken from notes furnished by the Hydrographic Office of the United States Navy:

"The geographical position of the observatory, as obtained by meridian-transit observations and the transportation of eight chronometers back and forth from Yokosuka, Japan, is

*Lat. 13° 26′ 22″.28 North
Long. 144 39 21 .45 East"
$9^h\ 38^m\ 37^s.43$

The position of the North Base is given as

Lat. 13° 26′ 20″.35 North
Long. 144 38 40 .28 East
$9^h\ 38^m\ 34^s.69$ East

---

*Zenith Telescope Method.

The mark at North Base was found by the Coast and Geodetic Survey longitude party in 1903 and was connected with the longitude station by triangulation. The Coast and Geodetic Survey longitude station is 59.09 meters north and 276.27 meters west of the North Base. Hence the longitude of North Base derived from the Coast and Geodetic Survey longitude station is

$9^h\ 38^m\ 36^s.07$ East,

giving a correction of $1^s.38$ to the longitude of the pier in Fort Santa Cruz given above, or longitude of Observation Spot is

$9^h\ 38^m\ 38^s.81$ East.

APPENDIX 5

REPORT 1904

MANUAL OF TIDES—PART IV B

COTIDAL LINES FOR THE WORLD

By ROLLIN A. HARRIS

PREFACE

Part IV A, "Outlines of Tidal Theory," appeared as Appendix 7, Coast and Geodetic Survey Report for 1900. The aim of that appendix is to obtain through theoretical considerations, rational so far as they go, a first approximation to the times of the principal ocean tides.

Part IV B aims at a system of cotidal lines which, while conforming to all reliable data, shall reasonably well meet the requirements of the theory alluded to, and so, for most regions, constitute an essentially true representation of the tides.

The labor involved in the construction of these lines has been so great that many matters relating to the subject have, of necessity, either remained undeveloped or, if appearing in the accompanying text, have been but scantily treated.

CONTENTS

CHAPTER I.—*On the Combination of Long Waves.*

CHAPTER II.—*Additional Lemmas.*

CHAPTER III.—*Matters Concerning Amphidromic Regions.*

CHAPTER IV.—*Cotidal Lines.*

CHAPTER V.—*The Semidiurnal Tides in the Indian Ocean.*

CHAPTER VI.—*The Semidiurnal Tides in the Atlantic Ocean.*

CHAPTER VII.—*The Semidiurnal Tides in the Arctic Ocean.*

CHAPTER VIII.—*Tides in the Pacific Ocean.*

ILLUSTRATIONS

MANUAL OF TIDES—PART IV B. COTIDAL LINES FOR THE WORLD.

By Rollin A. Harris.

CHAPTER I.

ON THE COMBINATION OF LONG WAVES.

1. The combination of long waves under several conditions has been briefly considered in Chapters III and VIII, Part IV A, and some similar questions for ordinary waves have been treated in Chapter II, Part I, and Chapter IV, Part IV A. A few questions relating to this subject and which have important bearings upon the construction of cotidal lines will be considered in this chapter.

2. *The combination of two progressive waves.*

Suppose the space origin to be situated at any convenient point and suppose one progressive wave to move toward $+x$ and the other, at some angle to this direction. Suppose the time to be reckoned from Greenwich or any other given meridian. Let T' denote the time of high water of the first wave at $x=0$ and T'' that of the second wave at the origin. Then the vertical displacement may be written

$$\begin{aligned}\zeta&=A'\cos(at-lx-aT')+A''\cos(at-ly-aT'')\\&=A'\cos(\theta-lx-\epsilon')+A''\cos(\theta-ly-\epsilon'')\end{aligned}\qquad(1)$$

where the axis of y is generally oblique to the axis of x. When the direction of the second system is the same as the first, or opposite to it, y should be replaced by x or by $-x$.

If $A''=A'$ the lines of no tide are given by the equation

$$lx+\epsilon'=ly+\epsilon''\pm(2\nu+1)\pi.$$

If $A''\not=A'$, then there must be some rise and fall at every point of the surface covered by either or both of these wave systems.

From $\frac{\partial\zeta}{\partial\theta}=0$ we have for finding the time of the resultant high or low water

$$\tan\theta=\frac{A'\sin(lx+\epsilon')+A''\sin(ly+\epsilon'')}{A'\cos(lx+\epsilon')+A''\cos(ly+\epsilon'')}\qquad(2)$$

If y coincides with x, we then have from $\frac{\partial\zeta}{\partial\theta}=0$,

$$\tan lx=\frac{A' \sin (\theta-\epsilon')+A'' \sin (\theta-\epsilon'')}{A' \cos (\theta-\epsilon')+A'' \cos (\theta-\epsilon'')}, \tag{3}$$

which determines the position of high or low water for this case at any given time.

The time is referred to the time of high water of the first wave at $x=0$ if $\epsilon'=0$, and to the time of high water of the second wave at $y=0$ if $\epsilon''=0$. The amplitude of the tide at any point x, y is obtained by substituting for θ in (1) its value from (2).

3. *The combination of a stationary and a progressive wave, both lying in the same direction.*

Suppose the space origin to be situated at a loop of the stationary wave and suppose the progressive wave to move toward $+x$. Suppose the time to be reckoned from Greenwich or any other given meridian. Let T' denote the time of high water of the stationary wave at $x=0$ and T'' that of the progressive wave at $x=0$. Then the vertical displacement may be written

$$\begin{aligned}\zeta&=A' \cos lx \cos (at-aT')+A'' \cos (at-lx-aT'')\\&=A' \cos lx \cos (\theta-\epsilon')+A'' \cos (\theta-lx-\epsilon'')\end{aligned} \tag{4}$$

From $\frac{\partial\zeta}{\partial\theta}=0$ we have for finding the time of the resultant high or low water

$$\tan \theta=\frac{A' \cos lx \sin \epsilon'+A'' \sin (lx+\epsilon'')}{A' \cos lx \cos \epsilon'+A'' \cos (lx+\epsilon'')} \tag{5}$$

and for the position of high or low water at any given time

$$\tan lx=\tan (\theta-\epsilon'')+\frac{A' \sin (\theta-\epsilon')}{A'' \cos (\theta-\epsilon'')}. \tag{6}$$

The time is referred to the time of high water of the stationary wave at $x=0$ if $\epsilon'=0$, and of the progressive wave at $x=0$, if $\epsilon''=0$. The amplitude of the tide at any point x is obtained by substituting for θ in (4) its value from (5).*

In case the progression is toward $-x$, replace $l\,x$ by $-l\,x$.

Since for natural bodies of water the end boundaries at the loops of a stationary wave are seldom such as to turn back the approaching particles simultaneously because of irregularities in the shore line, extensive shoaling, or more especially breaks in the walls, it is evident that progressive waves must often accompany stationary ones.† Here no attempt will be made to determine what the relative positions and amplitudes of the two waves must be. In fact it must generally happen that the amplitude of the progressive wave diminishes as we go from the locality giving rise to it, to points from which it appears to come (Cf. § 8). Although such combinations are quite common in the oceans, waves from other causes frequently so obscure them that it is seldom worth while to actually perform the computations necessary for making the combination.

Some fairly good instances may be cited and which will be referred to in the description of the cotidal lines of the several localities: The northeastern corner of the Indian Ocean, the Red Sea, the Gulf of Suez, the Pacific Ocean west of the South

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*The angle $l\,x$ can be found by aid of Table 15, in Part III.

†Cf. lemmas 14 and 21, § 70, Part IV A.

Shetland Islands. See Figs. 6, 7, and 28, also Fig. 23 of Part IV A. Other instances are the Bay of Bengal, Adriatic Sea, English Channel, Irish Channel, Baffin Bay, Long Island Sound, Gulf of California, and Gulf of Georgia. In most of these cases the progressive wave is rather small, it being due to the shoaling and irregularities of the body of water and not to an opening in an end boundary. But, as will be noted in Chapter III, the earth's rotation often sensibly modifies the tide in the vicinity of a nodal line, apparently increasing the range of the progressive wave on one side of the channel and diminishing it upon the other.

The general tendency of the progressive wave is to obliterate the nodal line of the stationary one; the larger its amplitude, the less crowding up there generally is of the cotidal lines at the nodal line.

This combination of waves applies only to regions of water where the oscillatory motion is nearly rectilinear. Progressive waves in the ocean are generally directed toward openings in the shore line, especially if the rise and fall of the tide be there considerable. Consequently it seldom happens that in the ocean the particles oscillate in the same direction in both stationary and progressive waves.

4. *The combination of one stationary wave with another lying transversely to it.*

Suppose the space origin to be situated at a loop of each wave. Suppose the time to be reckoned from Greenwich or any other given meridian. Let T' denote the time of high water, at $x=0$, of the stationary wave whose motion is parallel to x, and T'' the time of high water, at $y=0$, of the stationary wave whose motion is parallel to y. Then the vertical displacement may be written

$$\begin{aligned}\zeta &= \mathrm{A}' \cos lx \cos (at-aT')+A'' \cos ly \cos (at-aT'') \\ &= A' \cos lx \cos (\theta-\varepsilon')+A'' \cos ly \cos (\theta-\varepsilon'')\end{aligned} \tag{7}$$

From $\frac{\partial\zeta}{\partial\theta}=0$ we have for finding the time of the resultant high or low water

$$\tan \theta=\frac{A' \cos lx \sin \varepsilon'+A'' \cos ly \sin \varepsilon''}{A' \cos lx \cos \varepsilon'+A'' \cos ly \cos \varepsilon''} \tag{8}$$

[If both stationary waves lie in the same direction, replace y by x in (7) and (8). The amplitude of the tide at any point x is then obtained by substituting for θ in (7) its value from (8).]

By assigning a value to θ (i. e., to at), this equation gives a relation between x and y which is the equation of the cotidal line for the assumed time.

From (8) we have

$$\frac{dy}{dx}=\frac{\tan \theta\, (A' \sin lx \cos \varepsilon')-A' \sin lx \sin \varepsilon'}{-\tan \theta\, (A'' \sin ly \cos \varepsilon'')+A'' \sin ly \sin \varepsilon''} \tag{9}$$

which gives the direction of the cotidal line whose characteristic is θ at any permissible point x, y. This ratio appears indeterminate at $x=0, y=0$ and of course at such points as $x=\mu\pi$, $y=\nu\pi$, μ and ν denoting integers. The value is, however, ± 1. For the lines $x=0$ or $x=\mu\pi$, $\frac{dy}{dx}$ becomes zero, and for $y=\nu$ or $y=\nu\pi$ it becomes infinite. Hence:

The cotidal lines are normal to the real or virtual boundaries of a square oscillating area excepting the two lines which coincide with the diagonals of the square.

Upon substituting in (9) the value (8) of tan θ we have

$$\frac{dy}{dx}=\frac{\tan lx}{\tan ly}\;\frac{\sin(\varepsilon''-\varepsilon')}{\sin(\varepsilon''-\varepsilon')}=\frac{\tan lx}{\tan ly} \qquad (10)$$

which gives the direction of the cotidal line through *any* point in the area. This does not depend upon the amplitudes or the phases of the two waves. Hence if we have a drawing covering the square completely with cotidal lines based upon a simple assumption like $A''=A'=1$ and $\varepsilon''-\varepsilon'=\pm 90°$, ε' or $\varepsilon''=0$, the cotidal lines for any other assumptions can be immediately traced therefrom as soon as we have identified or computed one point in each line.

At the center of the square, where $lx=90°$, $ly=90°$, there is no rise and fall and so all cotidal lines must radiate from this point. The value of $\frac{dy}{dx}$ at this point is

$$\frac{A'}{A''}\;\frac{\tan\theta\cos\varepsilon'-\sin\varepsilon'}{-\tan\theta\cos\varepsilon''+\sin\varepsilon''} \qquad (11)$$

The fact that two stationary waves of different phases are combined together shows that high water must occur at the middle points of the sides of the square area at times given by the waves when considered separately. And it is readily seen that the times of high water change successively through all values of a period as we proceed around the square. The distribution of the radiating cotidal lines will, however, be quite uneven, as expression (10) shows.

Cotidal lines, whose numbers progress through all hours (i. e., form a complete cycle of values) around a no-tide point, may be called *amphidromic*, or the locality concerned may be said to be amphidromic.

It has already been noted that the center of gravity of the surface of a deep lake is a no-tide point, and that around this point the cotidal lines are what is here called amphidromic. For a more extended body of water the corrected equilibrium theory still gives a no-tide point, about which the cotidal lines are amphidromic. But the determination of the point and the radiating lines is more difficult than in the case of a small, deep body of water. See § 40, Part I; §§ 49, 50, Part II; and §§ 3, 4, 92, Part IV A.

If a large island lie near the theoretical no-tide point of a body having equilibrium tides the cotidal lines will, because some wave motion is always present, probably radiate from its shores rather than from the exact theoretical point. E. g., the island of Crete, Fig. 19.

Amphidromic cotidal lines depending upon still other causes will be noted in §§ 5, 12, 13, 15, and in the description of cotidal maps.

From expressions (3), (4) Part I, we see that the amplitude of the resultant oscillation (7) is

$$\sqrt{A'^2\cos^2 lx+A''^2\cos^2 ly+2A'\,A''\cos lx\cos ly\cos(\varepsilon'\sim\varepsilon'')} \qquad (12)$$

and the angle (or negative phase) corresponding to ε is

$$\tan^{-1}\frac{A'\cos lx\,\sin\,\varepsilon'+A''\cos ly\,\sin\,\varepsilon''}{A'\cos lx\,\cos\,\varepsilon'+A''\cos ly\,\cos\,\varepsilon''} \qquad (13)$$

The amplitude squared and equated to a constant R^2 is the equation of a line of equal range. Its direction is given by the equation

$$\frac{dy}{dx}=-\frac{A' \sin lx}{A'' \sin ly}\,\frac{A' \cos lx+A'' \cos ly \cos(\varepsilon'\sim\varepsilon'')}{A'' \cos ly+A' \cos lx \cos(\varepsilon'\sim\varepsilon'')} \qquad (14)$$

For $x=0$ or $x=\mu\pi$, this ratio becomes zero, and for $y=0$ or $y=\nu\pi$, it becomes infinite. Hence: The lines of equal rise and fall are normal to the real or virtual boundaries of a square oscillating area. Cf. § 26, Part IV B, where $\varepsilon'\sim\varepsilon''=60°$, and § 26, Part IV A, where $\varepsilon'=\varepsilon''$.

5. *The combination of a progressive wave with a stationary wave lying transversely to it.*

Suppose the space origin is so taken that $x=0$ at a loop of the stationary wave and suppose the progressive wave to move toward $+y$, a direction transverse to the motion in the stationary wave. Suppose the time to be reckoned from Greenwich or any other given meridian. Let T' denote the time of high water of the stationary wave at $x=0$, and T'' that of the progressive wave at $y=0$. Then the vertical displacement may be written

$$\begin{aligned}\zeta&=A' \cos lx \cos(at-aT')+A'' \cos(at-ly-aT''),\\ &=A' \cos lx \cos(\theta-\varepsilon')+A'' \cos(\theta-ly-\varepsilon''). \end{aligned} \qquad (15)$$

From $\frac{\partial\zeta}{\partial\theta}=0$ we have, for finding the time of the resultant high or low water.

$$\tan\theta=\frac{A' \cos lx \sin\varepsilon'+A'' \sin(ly+\varepsilon'')}{A' \cos lx \cos\varepsilon'+A'' \cos(ly+\varepsilon'')} \qquad (16)$$

The time is referred to the time of high water of the stationary wave at $x=0$ if $\varepsilon'=0$; and of the progressive wave at $y=0$ if $\varepsilon''=0$.

By assigning a value to θ (i. e. to $a\,t$), this equation gives a relation between x and y, which is the equation of the cotidal line for the assumed time.

From (16) we have

$$\frac{dy}{dx}=\frac{-\tan\theta\,(A' \sin lx \cos\varepsilon')+A' \sin lx \sin\varepsilon'}{\tan\theta\,(A'' \sin ly+\varepsilon'')+A'' \cos(ly+\varepsilon'')} \qquad (17)$$

which gives the direction of the cotidal line whose characteristic is θ at any permissible point x, y.

∴ All cotidal lines intersect the line $x=0$ or $x=\mu\pi$ perpendicularly.

At a point defined by the equations

$$A' \cos lx=\pm A''. \qquad (18)$$

$$\varepsilon'=ly+\varepsilon''+\begin{pmatrix}2\nu+1\\ \text{or } 2\nu\end{pmatrix}\pi \qquad (19)$$

there is no rise and fall of tide because ζ then becomes zero. At this point $\tan\theta$ is indeterminate, and all cotidal lines radiate from it. Along the nodal line of the stationary wave the tide is due to the progressive wave alone; therefore the cotidal lines divide the nodal line into equal parts or segments whose lengths each represent the distance over which the progressive wave moves in one hour. Along the line

$$A' \cos lx = \pm A''$$

the value of the cotidal hour at any point (y) is the arithmetical mean between the hour there given by the progressive wave and the hour of the stationary wave at $x=0$; the times at the given point are always so taken as to not differ more than 6 hours from each other.

Referring to the coordinates of the no-tide point, it will be seen that such a point can not exist unless the amplitude of the stationary wave at the loop exceeds the amplitude of the progressive wave.

CHAPTER II.

ADDITIONAL LEMMAS.

6. In Chapter VII, Part IV A, a number of lemmas are given which seemed to be of chief importance in attempting a partial explanation of the tides. It is convenient to here lay down other lemmas more or less related to those there given, assigning to them numbers which shall form a continuation of those already used.

(26) Two areas which have a considerable stretch of latent or imaginary boundary in common will generally oscillate together and form parts of one and the same system. (See § 29, Part IV A.)

Many of the areas forming parts of the systems shown in Fig. 23, Part IV A, will serve as illustrations.

If, however, the dimensions and locations of the areas are such that the virtual work of the tidal forces upon the system is always small, no considerable tides will result even if the free periods of the areas agree well with the period of the forces; e. g., a short and shallow canal one wave length long (two half-wave lengths placed end-to-end).

(27) If two hypothetical systems, each capable of independent oscillation in a period of 12 hours, overlap, the two motions will generally coexist with little interference; but if their individual periods differ from 12 hours more than does the period of the two when combined together, synchronization will generally take place.

This lack of interference is evident in the case of two systems in a square area whose edges are ½ λ in length. (§ 26, Part IV A.)

Consider next an L-shaped figure whose extreme length in either direction is ½ λ.

Now if the ⊥ is slender, it is probable that the two oscillations will synchronize because the free period of both branches of the L differs but little from the free period of either branch. To see this, imagine it to be high water at the angle of the L on account of an oscillation in one branch, and suppose little or no oscillation exists in the other branch. This implies a slope, and so acceleration, along the direction of the second branch (eq. (92), Part IV A); that is, when it is high water in the angle of the L the surface slopes away from the angle in both directions. After several periods the whole body will oscillate as one system. Of course a better oscillation would be obtained by taking the extreme dimensions of the L-shaped figure a little greater than ½ λ so that the virtual lengths of the two trapezoidal areas would each be ½ λ in length. (Cf. § 43, Part IV A.)

If the L is no longer slender but broad, then although the oscillation in one branch produces a simultaneous slope, and so acceleration, in the other branch, yet if we draw such lines of motion as a synchronization of the two systems into one would imply, it becomes evident that the periods of the resulting trapezoidal areas will be sensibly less than the period of the forces. Since the surface slope belonging to the oscillation in one branch produces a simultaneous slope in the other branch, the resulting stationary oscillation in the second branch, if there be any, must synchronize with that in the first branch. But, by hypothesis, the dimensions are such that one system can not be formed out of these two branches. The transverse acceleration due to the first branch may affect an existing and sustained oscillation in the second branch, especially if the width of the first branch approaches the value ¼ λ.

Synchronization may therefore generally be expected in a slender L-shaped figure provided either its external dimensions or virtual lengths equal ½ λ, but in a broad L-shaped region only when its external dimensions exceed ½ λ by such an amount that the virtual length of either arm equals ½ λ.

Other cases of overlapping systems can be studied in a somewhat similar manner.

Examples of overlapping areas are shown in Fig. 23, Part IV A. It is probable that the North Indian system does slightly accelerate the half-wave area extending from Mozambique Channel to Báluchistán and India, also that the South Atlantic system accelerates the North Atlantic system. In each of these two cases the effect of the smaller system upon the larger may be safely neglected. The two Pacific systems must be practically independent of each other, and the same is true of the South Atlantic and South Indian systems.

7. (28) High water occurs remarkably late along the inner side of capes which guard the entrance to a bay or broad passage.

Several cases in which an inner body of water derives its tides through a strait from an outer body have been briefly considered in §§ 102–113, Part IV A. In most of these cases it can be readily seen that in the strait and in its immediate vicinity the time of tide must change rapidly, and so the time of high water on the inner side of capes partially inclosing the bay or broad passage must occur remarkably late.

It is here proposed to call attention to the lateness of the tide at the inner side of the capes in comparison with the time of tide in the near-by channel or axis, the bay being broad enough or so situated with reference to the incoming water that transverse propagation is possible near the capes.

In the first place it may be noted that if the distance between the capes is so great that a wave can be transmitted at approximately the rate due to depth, the crest of the wave will be convex inward and retarded at the capes on account of the lesser depths at and off the capes than in mid-channel. In this connection see § 36, Part IV A.

But even if the depth were as great at the capes as in mid-channel, the tide would still be retarded. At the time of high water between the capes, the neighboring inner waters are at a less elevation. Now, whatever these inward accelerations and resulting velocities may be, the phase of the horizontal velocity in the direction taken by the incoming flood must be in advance of the phase of the horizontal velocity in the transverse direction. For, the longitudinal velocity is generally near its maximum value at the time of high water between the capes, because of the assumed motion transmitted from without, whereas the transverse velocity depending upon the transverse slope or acceleration can hardly have begun—provided the bay is large enough to permit of transverse progressive wave motion. As a matter of fact the incoming flood streams are not all directed parallel to the axis of the bay, but spread out considerably toward either shore of the bay. But high water along the inner side of the cape can not occur until the flood current along this shore reaches its maximum velocity. Hence we may expect delays of various amounts according to the sharpness of the capes and trend of the shores.

Examples: Cape Chidley, Labrador, Fig. 12; Cape Charles, Virginia, Fig. 14; northern part of New Zealand, Fig. 40.

In most bays, even if wide and shallow, there is no great opportunity for transverse progressions because the shores generally are such that transverse stationary waves would be formed. In such case no considerable delay will occur.

The most conspicuous delays, however, are due to incomplete wave eddies, § 14. Examples are Shantung Promontory and each end of Formosa Island.

8. (29) If a progressive wave is developed at an opening in a rigid boundary of an oscillating area or over a submerged boundary, an *antecedent wave* is necessitated; that is, there must exist a progressive wave moving toward the opening or shoal.

For, the periodic, horizontal, and vertical displacements of water in the opening or over the shoal will entrain displacements far out at sea, whose phases must agree with those in the opening or over the shoal as this part of the coast is approached; e. g., the waters south of the Sunda Islands, and west of Cape Horn.

(30) A stationary wave in a strait involves no antecedent wave.

Three cases of stationary wave motion may be noticed. See §§ 35, 102, 103, Part IV A.

Case 1.—Where one of the bodies connected by the strait has no tide.

At the end of the strait joining the tided body, high water occurs at the time of elongation of the particles in the strait toward that body. Hence no progressive antecedent wave can partake of this motion; e. g., no progressive wave approaches the strait of Gibraltar from the west.

Case 2.—Where the two connected bodies have tides of opposite phase.

At the time of high water in either body the particles in the strait will be at elongation toward that body. For example, no considerable progressive wave approaches the strait between the Färöe Islands and Iceland from the south; the same is true for North Channel.

Case 3.—Where the two connected bodies have tides of like phases.

At the time of high water in either body, as well as throughout the strait, the particles in the strait will be at their elongations toward the middle of the strait, or, rather away from the tided bodies. Many narrow channels between islands are examples of this.

9. (31) If the lines of motion of the water particles off a given part of the shore can be seen to be normal to and directed toward this part of the shore while the lines of motion off a neighboring stretch of shore are parallel with or oblique to the shore line, then, other things being equal, high water will occur earlier in the first-mentioned locality than in the second.

From the first locality a stationary wave will extend seaward, and this, combined with whatever local progression there may be, causes the tide to occur remarkably early as judged from its time of occurrence at neighboring places where the motion of the off-lying particles is oblique or parallel to the shore line. (Cf. lemmas 12, 15, and 16.) Several cases may be noticed.

Case 1.—Stationary wave connected with an oscillating area.

Instances of stationary waves along the shore line are very numerous. In fact, they almost always exist to a greater or less degree immediately at the shore line. They, however, become conspicuous in localities where they cause the tide to occur not only earlier than would otherwise have been expected, but nearly simultaneously over a considerable stretch of coast because the offshore deep-water tide is very nearly simultaneous over an extended region. (Cf. lemma 15 and § § 99, 112, Part IV A.)

Examples: The northwestern coast of Australia, the outer coast of Scotland north of Ireland, the Atlantic coast of the United States from Rhode Island to Florida, and the eastern coast of Nova Scotia. For many miles out from any of these shores the water is less than 100 fathoms deep, and yet no great amount of progression occurs.

Case 2.—Tide wave progressing toward a large island or a corner of a continent.

As the wave approaches the land the tidal streams will no longer be normal to the direction of its crest at an earlier epoch; but will be deflected as soon as the shore line is felt. In one limited locality, however, the streams may have the direction normal to the crest. This point is therefore characterized by earlier tides. Examples: On the eastern coast of Madagascar, southwestern coast of Sumatra, southeastern coast of Kiusiu, and eastern coast of Formosa, Figs. 7, 36.

Lemma 22 should now be dispensed with.

Case 3.—On and just off the open coast not far from the mouth of an estuary or bay up which the tide progresses.

Consider first a point on the coast some distance from the tidal inlet: High water will occur early on account of the stationary character of the wave, the flood setting shoreward and slack water occurring soon after the time of high water.

As the inlet is approached, the flood just offshore is not directed normally to the shore line of the inlet, but gradually approaches parallelism therewith; hence, the incoming particles are not reflected back from the shore line and do not produce any considerable stationary wave, and so the hastening of the time of tide from this cause does not occur to the extent that it occurred at a point of the coast farther away from the inlet.

This explains why the cotidal lines may be somewhat convex outward off the mouths of tidal rivers, estuaries, etc. In some instances shoals and channels among islands may resemble a tidal estuary or bay in delaying the time of tide at a near-by point of the shore line, the essential thing being a transmitting medium. Examples: The mouth of the Gulf of Cambay, the mouth of Delaware Bay, of Rio de la Plata, off the Golden Gate, off the Loo Choo Islands, and off Spencer Gulf.

Case 4.—At the capes or mouth of an estuary or bay up which body the tide progresses. The set of the currents in the main or outside tidal wave is supposed to be parallel to the general shore line.

Suppose that two capes or bends in the shore line mark the mouth of the tidal estuary or bay. By placing flood arrows just off these capes, the one following the general direction of the outer coast and the other that of the bank of the estuary, the resultant arrow will show that the flood stream must be directed toward the cape on the far side of the estuary and away from the cape on the near side. High water will occur unexpectedly early on the far cape or unexpectedly late on the near one.

The maps of cotidal lines for the North Sea show several instances where the cotidal lines are suddenly broken or recurved at or off the far capes or forelands. The coast south of the Gulf of Cambay, India, and in the neighborhood of Point Arena, California; the eastern coast of Kiusiu, Japan, and of Basilan, Philippine Islands, are other examples.

Case 5.—A broad reflective bay the direction of whose axis is transverse to the direction of the currents in the main body.

In a broad reflective bay leading off abruptly from the general shore line parallel to which the off-shore tidal currents set, high water may occur earlier along the axis of the bay than at certain shore points nearer to the mouth.

For, the off-shore flood has the general direction of the shore line, and the flood well in the bay must be comparatively weak and be directed toward the head of the bay. The wave being practically stationary along the axis, it will be high water at the head of the bay as early as at its mouth. This tongue of water, having remarkably early tide, gradually produces high water along the shores of the bay in the same manner as a stationary wave in off-shore deep water generally controls the tide at the shore. These small delays may be due to the trend of the shore line of the bay, to shoals, to tidal rivers branching from it, etc. The fact that the off-shore tidal current is supposed to set in the general direction of the shore prevents the water at and outside of the mouth of the bay from all flowing toward the bay and filling it practically instantaneously as a perfectly stationary off-shore wave would have done. That is, the paths of these particles differ somewhat from what the paths would have been had the tide in the bay been simply a stationary wave connected with some oscillating area of the ocean whose direction of motion coincided with the direction of the axis of the bay. Cf. lemmas 9, 28.

The Bay of Biscay tide occurs earlier at the eastern part of the northern coast of Spain than at the western part of the coast. High water occurs earlier at Cadiz than at Cape St. Vincent. It occurs earlier in the Cromarty Firth than along the coast extending eastward. The locality of earliest tide on Cape Cod Peninsula is about the middle of the western coast. See Figs. 15, 18, and 21.

10. (32) In going up a tidal river the rate of propagation at any point is usually somewhat less than that given by Lagrange's formula $\sqrt{gh}$, where h denotes the mean depth of the cross section.

Reasons for this will be considered in Part V.

CHAPTER III.

MATTERS CONCERNING AMPHIDROMIC REGIONS.

11. *The deflecting force of the earth's rotation.*

From equations (116), (117), Part IV A, we have as the components of the force which a unit particle moving on the earth's surface is capable of exerting because of the earth's rotation,

$$\begin{aligned} \text{Southward force} &= 2k_1 v_e \cos\theta = -2k_1 v_w \cos\theta && (20) \\ \text{Eastward force} &= -2k_1 v_s \cos\theta = 2k_1 v_n \cos\theta && (21) \end{aligned}$$

$$\therefore \quad \text{Total force} = 2k_1 v \cos\theta. \qquad (22)$$

The direction (from the south via east) of action of this force is given by the equation

$$\tan\psi = -\frac{v_s}{v_e} = \frac{v_s}{v_w} \qquad (23)$$

and the direction (x) of the path of the moving particles by

$$\tan\chi = -\frac{v_e}{v_n} = \frac{v_e}{v_s}. \qquad (24)$$

The force therefore acts at right angles to the instantaneous path of the particle and is therefore a deflecting force. The moving unit particle has a tendency to crowd, or slightly move relatively to the earth's surface, to the right in the northern hemisphere and to the left in the southern, the force representing this tendency being $2k_1 v \cos\theta$.

This deduction from Laplace's equations of motion is known as Ferrel's law. It was demonstrated and published by Ferrel in 1859, in Runkle's Mathematical Monthly. The paper containing the demonstration has been republished by the Signal Service of the United States Army in Professional Paper No. VIII.

In order to show that the earth's axial rotation must affect the tides, recourse is often had to the case of a body moving in a north-and-south direction at a given latitude but gradually altering its local direction as other latitudes are reached. However, this restriction to north-and-south motions is wholly unnecessary, as equation (22) shows; and, moreover, the results of even these motions are not always understood and correctly presented.

Ferrel thus states the law, and comments upon it:

> Hence *in whatever direction a body moves on the surface of the earth, there is a force arising from the earth's rotation, which deflects it to the right in the northern hemisphere, but to the left in the southern.* This is an extension of the principle upon which the theory of the trade winds is based, and which has been heretofore supposed to be true only of bodies moving in the direction of the meridian.*

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* Runkle's Mathematical Monthly, Vol. I (1859), p. 307.

It is of interest to quote here from Prof. G. H. Darwin's recent book on tides. Of course, the author's purpose is illustration rather than comprehensiveness or extreme accuracy; but the statements are somewhat misleading in that they impress one with the necessity of north-and-south motion in order that a deflecting force shall arise. Moreover the second sentence is misleading even for north-and-south motion. In fact, the east-and-west acquired component velocity relative to the earth's surface is not simply the difference between the absolute velocities of two points fixed on the surface of the rotating earth. From D'Alembert's principle we readily obtain

$$\frac{d}{at}\Sigma m\left(x\frac{dy}{dt}-y\frac{dx}{dt}\right)=\Sigma m(xY-yX), \tag{25}$$

which equals zero because gravity, being the only impressed force considered, passes through the axis of rotation. For one particle we have

$$m\left(x\frac{dy}{dt}-y\frac{dx}{dt}\right)=\text{constant}=mr^2\frac{d\phi}{dt}=r.mr\frac{d\phi}{dt}=\text{moment of momentum.} \tag{26}$$

That is, the total eastward velocity times r remains the same for all latitudes. In these equations the coordinate axes are fixed in space and r denotes the distance to the axis of rotation.

> When, in the northern hemisphere, water moves from north to south it passes from a place where the surface of the earth is moving slower, to where it is moving quicker. Then, as the water goes to the south, it carries with it only the velocity adapted to the northern latitude, and so gets left behind by the earth. Since the earth spins from west to east, a southerly current acquires a westward trend. Conversely, when water is carried northward of its proper latitude, it leaves the earth behind and is carried eastward. Hence the water can not oscillate northward and southward, without at the same time oscillating eastward and westward.*

That a particle moving upon the earth's surface with an eastward velocity tends toward the equator, while a particle having a westward velocity tends toward the poles can be readily seen from the fact that the ellipticity of the earth's meridian is chiefly, directly or indirectly, due to the motion of rotation. Therefore an addition to the absolute eastward velocity increases the ellipticity while a diminution in this velocity lessens the ellipticity.†

Since the earth rotates 360° in one sidereal day, its angular velocity (k_1) is 0.000 072 921 radian per second, and so the deflecting force becomes

$$0.000\ 145\ 842\ v\cos\theta \tag{27}$$

poundals. This force divided by g gives

$$0.000\ 004\ 533\ 18\ v\cos\theta \tag{28}$$

where v is expressed in feet per second, or

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* The Tides and Kindred Phenomena in the Solar System (American edition), p. 176.

† The following references relate to the subject of the earth's deflecting force: Ferrel, A Popular Treatise on the Winds, Ch. II. Lamb, Hydrodynamics, p. 322. Under Maclaurin, this manual, Part I, § 95.

$$0.000\,014\,872\,6\, v \cos \theta \qquad (29)$$

where v is expressed in meters per second. This is the gradient or transverse slope of a narrow stream arising from the earth's deflecting force.

12. *Amphidromic regions in straits and canals.*

In §§ 4, 5 amphidromic regions due to two systems of free waves in the same body have been briefly considered. Mention is there made of the fact that small, deep bodies of water which obey the corrected equilibrium theory constitute such regions. This section deals with those dependent upon the deflecting force of the earth's rotation.

If a channel or strait of sufficient length be so narrow that its free transverse oscillation period be several times less than twelve hours, the flood and ebb streams will give rise to the transverse slope just indicated.

This transverse oscillation may be combined with longitudinal oscillations, either stationary or progressive, in ways analogous to those given in Chapter I. Of course, this treatment will be only approximate because the character of such motions, when influenced by the earth's rotation, has never been fully ascertained. However, if the transverse motions are small, this treatment must be nearly correct. Allowance must be made for the variation in velocity at different parts of the channel, as the value of the transverse slope depends directly upon the velocity of the stream.

In a strait connecting two bodies of water whose high waters differ in time of occurrence by six hours, and so indicate the existence of a nodal line across the strait, the alternating transverse slope will reduce the nodal line to a no-tide point around which the cotidal lines will be amphidromic; the progression, i. e., sequence of tidal hours, will be counterclockwise in the Northern Hemisphere and clockwise in the Southern. Similarly for a stationary oscillation in a canal more than ¼ λ in length.

Examples of this are North Channel, Strait of Korea, Norton Sound, arm of sea between Holland and England (Figs. 20, 22, 34, 36).

In a narrow canal or tidal river up which the tide wave is propagated at the rate due to depth, the range of tide will be increased upon that side toward which the flood stream crowds and decreased upon the opposite side. The times of the tide will, however, not be altered.

In a canal-like body having both a stationary and a progressive wave, the no-tide point will either disappear or be transferred from the position given by the stationary wave. The effects can be seen by combining all waves, as in Chapter I. Suppose high water of the progressive wave falls upon the nodal line of the stationary wave at the time of maximum flood stream; then for a small amplitude of the progressive wave the no-tide point will be moved from the center of the stream toward one side, and for a large amplitude the no-tide point will cease to exist, but a crowding up of the cotidal lines will occur on the one side and a spreading out on the other.

Examples are the English Channel, Irish Channel, Gulf of California, Gulf of Georgia, and Adriatic Sea (Figs. 19, 20, 31, 32).

13. *Dependent landlocked wave eddies.*

In § 115, Part IV A, a brief account is given of ordinary eddies; i. e., eddies in which the flow is everywhere steady for a time at least. We are now to consider eddies in bodies of water which are largely surrounded by land, and which are so large and shallow that various phases of the tidal streams exist simultaneously. Comparison may be made with cases 2 and 5 of the section just referred to.

The motion may be assumed to begin at a point of the coast of the embayment (or body of water covered by the wave eddy) where the rise and fall is comparatively large. This can be inferred from the rise and fall of the neighboring waters, upon which the derived wave eddy depends. The wave proceeds thence along the shores of the embayment, but gradually decreasing in amplitude, until it again joins the main or outside body of water or passes into some other arm of the sea. Through the greater part of its course the rate of the shore wave is about that due to depth; but there may be much crowding together or spreading apart of the cotidal lines where the wave finally joins the main body. Generally speaking, the nearer this shore wave comes to agreeing in phase with the main body where the latter is finally reached, the more likely are such wave eddies to exist. The point of beginning of the shore wave is often a cape or headland where the coast suddenly recedes from the general direction of the tidal motion in the outside body. (Of. Lemma 19.)

Examples are the southern part of the Gulf of St. Lawrence, Fox Channel, southern part of the Gulf of Pechili, the waters between Borneo and Malacca Strait, and the main body of the North Sea. The first three are twelve-hour eddies, the fourth a twenty-four-hour eddy, and the North Sea may be regarded as an incomplete eddy, since the final progression passes into the Skagerrak. There may, however, be a small wave from the Naze toward Stavanger, thus completing the twenty-four hours. (See Figs. 7, 13, 21, 22, 26, 36.)

Suppose that for some distance the main body of water rises and falls simultaneously, but that the amplitude decreases from the cape at which the progression of the eddy is supposed to originate toward, but not generally as far as the other cape or corner of the embayment. This diminution is generally due to the failure of any considerable transverse wave motion to set out from the tide of the main body across the central or some other part of the opening of the embayment because of the deflecting influence or shielding effects of near-by capes and lands. It is sometimes due to there being a nodal line of the main body abreast the center of the opening. In this case an island situated near the center of the opening will facilitate the formation of the wave eddy.

Consider the low water of the shore wave a short time after leaving the first cape. The surface slope from the region of the main body where the amplitude is small, toward the locality of low water just mentioned, will then have its maximum value. The maximum radial velocity will, because the motion is oscillatory, occur three hours later, and so high water from this cause will occur six hours later; i. e., will coincide in time with the high water of the progressive transverse shore wave. The causes which produce transverse motion at the cape do not exist to any great extent near the region of small rise and fall, and so the apparent transverse progression in the embayment is governed by the progression along the shore. The cotidal lines radiate from some point or locality where the range of tide disappears or becomes very small. If the circuit requires 24 hours instead of 12, it is probable that the range of tide nearly disappears over a region of considerable size; because radial flows in nearly opposite directions for opposite points of the eddy are in this case necessitated at one and the same time.

In all of these cases the cotidal lines may be spoken of as amphidromic.

Each of the wave eddies referred to in this section is dependent upon the tide of an outside or main body of water with which it is connected. But dependent wave eddies are not always landlocked. Suppose the tide wave to be progressing from open water toward the coast through shallow waters. Suppose a broad gulf in the shore line converts the incoming wave into a stationary wave of large range at the head of the gulf and of small range $\frac{1}{4}\lambda$ seaward from this point.* Now suppose that from one of the capes marking the head of the gulf the adjacent shore line so recedes that a progressive wave sets along the coast and even outward.† For a while it will have a greater range than has the incoming tide. But as it must finally join the latter there will be much crowding up of the cotidal lines soon after leaving the cape; consequently there will be little or no progression at the rate due to depth, as was assumed to characterize the shore wave of a landlocked eddy during a portion of its course.

Two such eddies are situated off the eastern coast of Patagonia (see Fig. 29).

In all these cases the effect of the earth's rotation, although of course present, is probably insignificant, notwithstanding the fact that the order of the cotidal lines is generally counterclockwise in the northern hemisphere and clockwise in the southern.

14. *Incomplete eddies, and islands.*

Incomplete eddies more or less landlocked may be formed in a similar way. Referring to Fig. 36 it will be noticed that at Shantung Promontory the range of tide is only 4 feet, while at the cape on opposite Korean coast it is 7.7 feet. The shore wave follows the Korean coast and governs the time of tide in the shallow sea between the Yellow Sea and Pechili Strait. Shantung Promontory is a turning point for the tide around which the cotidal lines are crowded together. Lemma 28 applies to this case, but it also applies to many capes at which the range of tide is even greater than in the offing. The southwestern corner of the Falkland Islands is a turning point for an imperfect wave eddy, whose sustaining shore line extends from Staten Island to Port Santa Cruz. Cape Chidley and Ungava Bay form another example.

In channels of moderate width incomplete eddies may result from the deflecting force of the earth's rotation. Examples are given at the close of § 12.

If near one end of an island in the ocean there is a much larger tide than prevails off the other coasts of the island, the tide wave may appear to progress completely around it and the tidal hours form a complete cycle of values. The cotidal lines are made to radiate, as it were, from the island from two causes—the first, that given under lemma 28, depending upon the curvature and trend of the shore line, and the second that given in § 36, Part IV A, and depending upon the shoaling around the island. Examples are New Zealand and Iceland.

Generally, however, the wave which passes around both ends of an island is so nearly alike in range and in phase that although some of the cotidal lines radiate from the island (both causes just mentioned being operative) only certain tidal hours will be represented. Examples of this are the Falkland Islands, New Caledonia, Formosa, and Franz Josef Land.

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* Cf. § 34, Part IV A.

† Lemma 19.

15. *Amphidromic regions in the ocean.*

If an ocean be conceived to oscillate in more than one system it may happen that around a certain point or region the theoretical hours of the tide; i. e. those given by the tidal systems, form a cycle of values.

In § 4 the cotidal lines for two systems in a square body of water have been discussed. An irregular progression from the points representing the middle of the loops of one system to similar points of the other system was shown to exist—the direction of the progression being such that the time difference between any two adjacent loops is less than six hours. But if a nodal line of one system, whatever its form, crosses a nodal line of the other there must be a progression about a no-tide point, or point where the nodal lines intersect; for, these lines may always be regarded as right lines for some distance from their intersection, and the particles of each system there oscillate as if near the nodal lines of two rectangular areas. Upon referring to Fig. 23, Part IV A, it is evident that one such progression must occur along the coast of Somali Land and another along the coast of California.

Antecedent waves which move toward openings in the coast line (or toward suddenly receding parts of it) at approximately the rate due to depth, often govern the time of tide in certain parts of amphidromic regions, especially near the nodal lines and the free boundaries of the oscillating areas, where the range of the direct tide is small. Such a progression, due to the openings and shallow seas into and around the British Isles, to Denmark Strait, and to the opening between Cape Farewell and Labrador, extends across the northern part of the North Atlantic Ocean (Figs. 6, 12, 18, and 20).

The southwesterly progression toward the Fiji Islands and New Caledonia influences the time of tide in the northwestern half of the amphidromic region whose no-tide point is situated northwest of the Society Islands.

According to lemma 25, between two not too distant nonsimultaneous regions, the time of tide will gradually change from the value belonging to the one to that of the other; i. e., the tide wave will seem to progress, but not as a free wave at the rate due to depth. That this must be true is self-evident; but how the change takes place between two regions belonging to different systems has not been ascertained.

If two bodies of water having tides of their own, which differ in time by six hours, are connected by a strait, the wave of the strait is stationary and there will be no progression from the one to the other, and a nodal line will extend across the strait.* If now on one side of the strait a progression exists it will obliterate a portion of the nodal line, and a very rapid progression between the two bodies will be observed. The horizontal motions of the stationary and progressive waves may be supposed to agree in phase at the nodal line. Similarly, for a progression which may exist on the other side of the strait. If both progressions are in the same direction the cotidal lines will simply bunch up in the strait. If the progressions take opposite directions on opposite shores the strait will constitute an amphidromic region. The cotidal lines will either radiate from a no-tide point, or, if the amplitudes of the progressive waves become zero not far from the shores, they will branch off from the nodal line. In either case there will be at each end of the strait a region of nearly simultaneous tide, while along the shores the time of tide changes rapidly.

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*Cf. §§ 35, 102, Part IV A.

Examples: The broad strait between Iceland and the Färöe Islands has at its Iceland side a southerly progression due to the considerable tide passing through Denmark Strait and following the northern and eastern coasts of Iceland; at its Färöe side it has a northward progression due to the fact that these islands form a part of the broken boundary adjoining a good rise and fall.* In a similar way is explained the amphidromic region between the Färöe and Shetland islands.

As noted in the last section, islands or capes accompanied by gradual shoaling of near-by waters often have the effect of turning or deflecting toward themselves progressive waves. The reasons for this are obvious in case of a solitary wave advancing at rates due to depths. The phenomenon is analogous to refraction.† Other means of accomplishing deflections are given under lemma 28.

Amphidromic regions in the ocean generally have one or two broad spaces or sectors of practically simultaneous tides. Over such sectors none of the three causes just mentioned as giving rise to apparent progressions are more than barely discernible. They are regions in which progressions from other quarters of the ocean lose themselves or in which progressions to distant quarters begin to appear. According to circumstances the range of the tide may be considerable or it may be small.

That the deflecting force of the earth's rotation materially assists in the production of amphidromic regions in the ocean is doubtful; moreover, the one in the Indian Ocean lies under the Equator and the one around Tahiti lies comparatively near to it.

16. *The principal amphidromic regions of various kinds.*

Location	Position of no-tide point or center						Kind
	Latitude			Longitude			
	°	′		°	′		
Indian Ocean	1	33	S.	64	52	E.	Ocean eddy
S. E. of Newfoundland	40	00	N.	40	00	W.	Ocean eddy
Off Holland	52	27½	N.	3	14½	E.	Channel eddy ‡
S. W. of Norway	57	37	N.	5	15	E.	Wave eddy
North Channel	55	18	N.	6	00	W.	Channel eddy ‡
Bet. Shetland and Färöe Is.	61	39	N.	5	25	W.	Broad-strait eddy
Bet. Färöe and Iceland	63	06	N.	10	18	W.	Broad-strait eddy
Fox Channel	69	09	N.	79	00	W.	Wave eddy
Off Patagonia	45	18	S.	63	37	W.	Wave eddy
Off Patagonia	40	55	S.	60	45	W.	Wave eddy
Bet. California and Hawaii	30	25	N.	141	25	W.	Ocean eddy
Norton Sound	63	53	N.	163	41	W.	Channel eddy ‡
Strait of Korea	35	32	N.	130	45	E.	Channel eddy ‡
Gulf of Pechili	38	24	N.	119	47	E.	Wave eddy
West of Borneo	0	21	S.	107	20	E.	Wave eddy
N. W. of Society Is.	14	7½	S.	153	13	W.	Ocean eddy
S. E. of New Zealand	51	30	S.	172	10	W.	Ocean eddy
Mediterranean Sea	Isle of Crete						Equilibrium eddy
Gulf of St. Lawrence	Magdalen Islands						Wave eddy
W. end of Java Sea	Billiton Island						Wave eddy

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* Lemma 14.

† See § 36, Part IV A.

‡ That is an eddy due to the deflecting force of the earth's rotation acting upon a stationary wave which possesses a nodal line and occurs in a channel, strait, or sound whose width is a moderately small fraction of λ, § 12.

CHAPTER IV.

COTIDAL LINES.

17. *Remarks on cotidal charts.*

Definite suggestions concerning cotidal lines were made by Dr. Thomas Young about a century ago.* In the Philosophical Transactions for 1831, Sir John W. Lubbock marked upon two charts, one for Great Britain and one for the world, the Greenwich and local times of the tide at the time of new or full moon. In a few instances he indicated the positions of cotidal lines. Dr. William Whewell drew cotidal lines for Great Britain, the coasts of Europe, and the world at large, although attempting little in the Pacific Ocean. †

A few years later, Sir Geo. B. Airy gave in his Tides and Waves a chart for Great Britain and one for the world based chiefly upon the charts of Whewell.

A map of the world showing the establishments, Greenwich times of tide, and spring ranges is given in a book entitled "The Tides" published by the Society for Promoting Christian Knowledge, London, 1857. A chart of the coasts of Europe, showing the Greenwich times of tide, the spring ranges, also the character of the tide waves, whether progressive or stationary, accompanies the text. No attempt is there made at drawing the cotidal lines.

In the U. S. Coast Survey Reports for 1854 and 1857, Superintendent Bache gives a sketch of the cotidal lines for the Atlantic Coast; a similar sketch is given for the Pacific Coast in the Report for 1855. In the Report for 1856 a sketch is given for the diurnal wave of the Gulf of Mexico, and in the Report for 1862, maps for both diurnal and semidiurnal waves around the Gulf coast of Florida.

Many other maps of cotidal lines for limited areas have been published at various times. The most recent cotidal chart of the world is one by Berghaus, constructed in 1889-90, and which accompanies his Physikalischer Atlas; it is reproduced as Fig. 25, Part IV A. He also gives a chart for western Europe, reproduced as Fig. 26, Part IV A, one for the East Indies and China, and one for the West Indies and the Atlantic coast of the United States. Van der Stok, in his book entitled "Wind and Weather, Currents, and Tidal Streams in the East Indian Archipelago," gives two maps around this archipelago, which are reproduced as Figs. 29, 30, Part IV A.

Generally the cotidal charts have been constructed for the purpose of showing the Greenwich lunar time of high water on the days of full and change of the moon; that

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*Lectures on Natural Philosophy, Vol. 1; Nicholson's Journal, Vol. 35 (1813), pp. 145-217; Encyclopedia Britannica (Eighth Ed.), article "Tides;" Miscellaneous Works, Vol. II.

†Phil. Trans., 1833, 1836, 1848.

is, the vulgar establishment is converted into lunar hours and to it the west longitude, expressed in hours, is added or from it the east longitude is subtracted. If harmonic analyses were sufficiently numerous, the establishment obtained by dividing $M_2°$ by 30 could be used to advantage; the chief drawback to this proceeding would be the fact that the mean time of high water is affected by the higher harmonics M_4, M_6, M_8, . . .

In the charts accompanying this paper, the mean or corrected establishment has been used. While this may, from a scientific point of view, be less desirable than the M_2 establishment, it has the advantage of referring to actual high water instead of to component high water. The difference may be considerable in rivers and other shallow bodies of water.

The Roman numerals denote the Greenwich lunar time of mean high water. *The side of the line upon which a numeral is written indicates the direction in which the wave appears to progress.* Of course in most oceans and deep bodies of water simple progressions of free waves at rates due to depth seldom occur by themselves; and reasons for this fact have already been given. For convenience the word "progression" will be constantly used in connection with any sequential change however irregular or complicated this may be.

At most localities the vulgar establishment is about one-fourth of a lunar hour greater than the corrected. The approximate cotidal hours from the values of M_2 intervals are given in § 97, Part IV A; § 19, Part IV B. The values of the true mean intervals, which alone are supposed to be used in the accompanying charts, have not always been determined. Many are given in the Coast and Geodetic Survey Tide Tables.

The Arabic numerals scattered over the cotidal maps indicate mean ranges of the tide in feet at the points or localities to which they refer. If the values are estimated from spring and neap ranges they are generally given to whole feet only; if, however, a somewhat closer estimate is attempted, common, and not decimal, fractions are used. The latter fractions generally signify that the mean ranges have been determined either by computation from harmonic constants (according to rules given in Part III) or have been deduced directly from observations. If the diurnal wave is so large that only one high water and one low water occurs daily when the moon is near extreme declination, the diurnal components are omitted from the computation of the mean semidaily range of tide, and the resulting ranges are bracketed.

Charts of ocean depths are given as Figs. 19, 20, Part IV A, but in actually constructing cotidal lines many detailed charts are required. A few of the more interesting localities are given as Figs. 31–39, Part IV A.

In shallow bodies there may be progressions at rates due to the depths. Table 50, Part II, may be adapted to such cases. Table 51, Part IV A, is for deeper bodies.

Time and data are wanting for constructing cotidal lines for the diurnal tides, but this work may be undertaken in the future. It is hardly necessary to say that the accompanying charts have cost much labor, and still leave much to be done.

18. *Sources of information.*

Much data relating to tides can be found in §§ 79–97, Part IV A. A table containing the more important harmonic constants from analyses recently available is given in § 19. It forms a continuation of the table found in § 97, Part IV A. A brief list for general reference is given here. Other references intended for particular regions or localities will appear in connection with the descriptions of the cotidal lines. Many sources of minor importance, although used in constructing the charts, will not be referred to.

Tide Tables for the British and Irish Ports, by the Admiralty.

Tide Tables, by the Coast and Geodetic Survey.

Philosophical Transactions of the Royal Society of London.

Proceedings of the Royal Society of London, especially Vol. 39 (1885), Vol. 45 (1889), Vol. 71 (1902).

Reports of the British Association for the Advancement of Science.

Annales Hydrographiques.

Reports of the Survey of India, 1886–89, 1892–95, 1900–1901.

Reports of the Coast and Geodetic Survey.

Comptes-Rendus des Séances de l'Association Géodésique Internationale for 1900, Vol. II, special report.

J. P. Van der Stok: Wind and Weather, Currents, and Tidal Streams in the East Indian Archipelago. Batavia, 1897.

W. Bell Dawson: Reports of the Survey of Tides and Currents in Canadian Waters.

Archives Néerlandaises des Sciences Exactes et Naturelles, 2d Series, Vol. 6.

Algemeene Dienst van den Waterstaat. Verzamelingstabel der Waterhoogten, for the month of April, 1894.

Vandstands-Observationer, Udgivet af den norske Gradmaalings-Kommission. Christiania, 1882.

Resultater af Vandstands-Observationer paa den Norske Kyst Udgivet af den Norske Gradmaalings-Kommission. Christiania, 1904.

Narrative of the Surveying Voyages of His Majesty's Ships Adventure and Beagle, Appendix to Vol. II. London, 1839.

Voyage autour du Monde, de l'Uranie, Vol. II. Paris, 1826.

Voyage autour du Monde sur la Frigate Vénus. Paris, 1844.

Data relating to tides and tidal streams in nearly all parts of the world may be found in the various Pilots, also upon many of the Charts, both of which are published by the British Admiralty. Somewhat similar matter may be found in the Pilots and upon the Charts issued by the U. S. Hydrographic Office; also, for the United States and dependencies, in the Coast Pilots issued by the Coast and Geodetic Survey. Many references to particular sources of information are given in the preface to the Coast and Geodetic Survey Tide Tables.

19. *Intervals, ranges, cotidal hours, etc., derived from harmonic constants.*

The following table forms a continuation of the one given under § 97, Part IV A, where a brief description may be found.

No.	Station.	Geographic position.			M_2.	$M_2°$.		S_2.	$S_2°$.	N_2.	$N_2°$.	K_1.
		Latitude.	Longitude.			Degrees.	Lunar hours.					
			Arc.	Time.								
		° ′	° ′	h. m.	Ft.	°	h.	Ft.	°	Ft.	°	Ft.
	EAST COAST OF AMERICA.	North.	West.									
154	Nassau, Bahamas	25 05	77 21	5 09	1.24	213.4	7.11	0.21	237	0.30	191	0.28
155	Great Harbor, Culebra Island	18 18	65 17	4 21	0.29	241.2	8.04	0.04	266	0.05	223	0.25
156	San Juan	18 29	66 07	4 24	0.49	246.3	8.21	0.07	267	0.11	232	0.27
157	Ponce, P. R	17 59	66 40	4 27	0.03	280.0	9.33	0.02	264	0.01	160	0.24
165	Colon	9 18	79 51	5 19	0.27	8.2	0.27	0.03	195	......	......	0.37
170	Iles du Salut	5 17	52 35	3 30	2.59	118	3.93	0.92	142	......	......	0.33
		South.										
180	Rio de Janeiro	22 55	43 09	2 53	1.03	82.7	2.76	0.59	75	......	......	0.16
184	Montevideo	34 53	56 12	3 45	0.19	34.2	1.14	0.04	318	0.06	354	0.05
	WEST COAST OF AMERICA.	North.										
251	Sergius Narrows	57 25	135 38	9 03	4.93	11.7	0.39	1.66	45	1.06	348	1.58
251.5	Hooniah	58 07	135 47	9 03	5.97	14.2	0.47	2.03	48	1.12	341	1.71
252	Port Althorp	58 07	136 17	9 05	3.61	353.5	11.78	1.13	35	......	......	1.48
252.5	Granite Cove	58 12	136 24	9 06	4.01	5.9	0.20	1.29	38	0.77	337	1.45
255	Kokinhenic I	60 18	145 03	9 40	1.12	11.9	0.40	0.28	51	0.26	348	0.41
256	Pete Dahl Slough	60 23	145 24	9 42	3.52	12.7	0.42	1.05	46	0.64	358	1.57
259	Orca, Prince William Sound	60 34	145 41	9 43	4.52	357.7	11.92	1.61	40	0.88	335	1.53
260	Orca, Cape Whitshed	60 28	145 55	9 44	4.42	8.4	0.28	2.56	44	0.80	344	1.51
261	Camp April	60 32	146 00	9 44	4.54	356.0	11.87	1.53	32	0.91	331	1.47
262	Valdez Arm	61 07	146 27	9 46	4.51	353.7	11.79	1.52	25	0.86	327	1.66
267	Peterson Bay	54 24	162 38	10 51	1.92	354.8	11.83	0.73	18	0.37	342	1.36
268	Tigalda Bay	54 05	165 10	11 01	0.38	60.1	2.00	0.28	5	0.20	47	1.09
269	Unalga Bay	54 00	166 10	11 05	0.61	105.2	3.51	0.13	304	0.29	67	1.06
270	Dutch Harbor	53 54	166 32	11 06	0.86	111.5	3.72	0.07	350	0.31	62	1.06
271	Kashega Bay	53 28	167 05	11 08	0.71	95.5	3.18	0.11	91	......	......	1.13
285	Port Clarence	65 14	166 24	11 06	0.47	213.4	7.11	0.03	346	0.14	133	0.25
	EAST COAST OF ASIA.											
300	Pitlekaj	67 03	173 30	11 34	0.10	4.8	0.16	0.03	69	......	......	......
			East.									
309	Tomari	43 46	145 29	9 42	0.94	107.9	3.60	0.43	149	......	......	0.85
317	Kiritappu, Yezo	43 03	145 10	9 41	0.92	105.4	3.51	0.43	144	......	......	0.68
328.5	Ohatake, Nippon	41 25	141 10	9 25	0.89	108.5	3.62	0.42	144	......	......	0.59
333	Orinohama	38 23	141 26	9 26	1.11	114.3	3.81	0.52	152	......	......	0.77
336	Hirataka	36 51	140 48	9 23	0.97	115.4	3.85	0.48	145	......	......	0.72
337	Chosi Kawaguchi	35 44	140 50	9 23	0.67	132.8	4.43	0.23	173	......	......	0.63
338	Nagasaki	35 42	140 51	9 23	1.11	118.8	3.96	0.51	149	......	......	0.73
339	Katsura	35 10	140 17	9 21	1.19	138.3	4.61	0.52	170	......	......	0.78
339.5	Otohama	34 55	139 56	9 20	1.10	143.2	4.77	0.53	180	......	......	0.69
341	Shinagawa	35 37	139 45	9 19	1.60	159.0	5.30	0.74	191	......	......	0.71
341.5	Kanagawa	35 28	139 39	9 19	1.45	140.0	4.67	0.80	181	......	......	0.83
342.1	Uraga nishi Uraga	35 15	139 44	9 19	1.24	145.9	4.86	0.60	177	......	......	0.78
342.2	Aburatsubo	35 09	139 37	9 18	1.21	143.4	4.78	0.53	173	......	......	0.77
342.3	Hashirimitzu	35 15	139 44	9 19	1.36	150.3	5.01	0.66	181	......	......	0.77
342.4	Sagami Daiichi Kaiho	35 19	139 46	9 19	1.46	148.7	4.96	0.69	180	......	......	0.81
342.6	Yokosuka	35 18	139 39	9 19	1.43	152.3	5.08	0.69	181	......	......	0.77
342.7	Shimoda	34 40	138 57	9 16	1.29	162.4	5.41	0.59	186	......	......	0.79
342.8	Tago	34 48	138 47	9 15	1.33	166.9	5.56	0.69	186	......	......	0.74
357	Hii	33 55	135 06	9 00	1.52	180.8	6.03	0.73	203	......	......	0.70
357.1	Osaki, Inland Sea	34 07	135 09	9 01	1.49	185.7	6.19	0.73	207	......	......	0.77
357.2	Wakanourá Dejima, Inland Sea	34 11	135 11	9 01	1.40	185.2	6.17	0.68	225	......	......	0.75
357.3	Osaka, Inland Sea	34 39	135 26	9 02	1.01	214.8	7.16	0.62	227	......	......	0.88

K_1^o.	O_1.	O_1^o.	P_1.	P_1^o.	$\frac{S_2}{M_2}$.	$\frac{N_2}{M_2}$.	$\frac{O_1}{K_1}$.	$\frac{P_1}{K_1}$.	$K_1 + O_1$.	$S_2^o - M_2^o$.	$M_2^o - N_2^o$.	$K_1^o - O_1^o$.	½ ($K_1^o + O_1^o$).		Cotidal hour.		No.
													De-grees.	Lunar hours.	Semi-diurnal.	Diurnal.	
°	*Ft.*	°	*Ft.*	°					*Ft.*	°	°	°	°	*h.*	*h.*	*h.*	
120	0.21	124	0.09	122	0.17	0.24	0.75	0.32	0.49	24	22	−4	122	8.13	0.26	13.28	154
162	0.19	155	......	......	0.14	0.17	0.76	......	0.44	25	18	7	158.5	10.57	0.39	14.92	155
163	0.24	161	......	......	0.14	0.22	0.89	......	0.51	21	14	2	162	10.80	0.61	15.20	156
186	0.18	175	......	......	0.67	0.33	0.75	......	0.42	− 16	120	11	180.5	12.03	5.72	....	157
158	0.20	160	......	......	0.11	......	0.54	......	0.57	−173	......	−2	159	10.60	5.59	15.92	165
199	0.23	181	......	......	0.36	......	0.70	......	0.56	24	......	18	190	12.67	7.43	16.17	170
161	0.33	101	......	......	0.57	......	2.06	......	0.49	− 8	......	60	131	8.73	5.64	11.61	180
318	0.02	256	......	......	0.21	0.32	0.40	......	0.07	− 76	40	62	287	19.13	4.89	22.88	184
130	1.03	111	......	......	0.34	0.22	0.65	......	2.61	33	24	19	120.5	8.03	9.44	17.08	251
130	0.98	111	......	......	0.34	0.19	0.57	......	2.69	34	33	19	120.5	8.03	9.52	17.08	251.5
119	0.65	99	......	......	0.31	......	0.44	......	2.13	41	......	20	109	7.27	8.86	16.35	252
126	0.94	114	......	......	0.34	0.19	0.65	......	2.39	32	29	12	120	8.00	9.30	17.10	252.5
157	0.34	178	......	......	0.25	0.23	0.83	......	0.75	39	24	−21	167.5	11.17	10.07	20.84	255
137	0.84	121	......	......	0.30	0.18	0.54	......	2.41	33	15	16	129	8.60	10.12	18.30	256
130	0.98	115	......	......	0.36	0.19	0.64	......	2.51	42	23	15	122.5	8.17	9.64	17.89	259
130	1.06	118	......	......	0.35	0.18	0.70	......	2.57	36	24	12	124	8.27	10.01	18.00	260
124	0.98	110	......	......	0.34	0.20	0.67	......	2.45	36	25	14	117	7.80	9.60	17.53	261
123	0.97	111	......	......	0.34	0.19	0.58	......	2.63	31	27	12	117	7.80	9.56	17.57	262
124	0.77	97	......	......	0.38	0.19	0.57	......	2.13	23	13	27	110.5	7.37	10.68	18.22	267
146	0.63	134	......	......	0.74	0.53	0.58	......	1.72	− 55	13	12	140	9.33	1.02	20.35	268
148	0.72	131	......	......	0.21	0.53	0.68	......	1.78	−161	38	17	139.5	9.30	2.59	20.38	269
152	0.72	142	......	......	0.08	0.36	0.68	......	1.78	−122	49	10	147	9.80	2.82	20.90	270
151	0.74	129	.....	......	0.15	......	0.65	......	1.87	− 5	......	22	140	9.33	2.31	20.46	271
115	0.12	287	.....	......	0.06	0.30	0.48	......	0.37	133	80	−172	201	13.40	6.21	0.50	285
......	......	......	......	......	0.30	......	......	.....	......	......	......	......	......	....	11.73	....	300
160	0.70	142	......	......	0.46	......	0.82	......	1.55	64	......	18	151	10.07	5.90	0.37	309
152	0.62	161	......	......	0.47	......	0.91	......	1.30	41	......	− 9	156.5	10.43	5.83	0.75	317
144	0.48	142	......	......	0.47	......	0.81	......	1.07	35	......	2	143	9.53	6.20	0.11	328.5
156	0.66	152	......	......	0.47	......	0.86	......	1.43	38	......	4	154	10.27	6.38	0.84	333
159	0 56	156	......	......	0.49	......	0.78	......	1.28	30	......	3	157.5	10.50	6.47	1.12	336
174	0.44	166	......	......	0.34	......	0.70	......	1.07	40	......	8	170	11.33	7.05	1.95	337
161	0.59	150	......	......	0.46	......	0.81	......	1.32	30	......	11	155.5	10.37	6.58	0.99	338
166	0.56	154	......	......	0.44	......	0.72	......	1.34	31	......	12	160	10.67	7.26	1.32	339
172	0.60	155	......	......	0.48	......	0.87	......	1.29	37	......	17	163.5	10.90	7.44	1.57	339.5
169	0.61	164	......	......	0.46	......	0.86	......	1.32	32	......	5	166.5	11.10	7.98	1.78	341
164	0.63	160	......	......	0.55	......	0.76	......	1.46	41	......	4	162.5	10.80	7.35	1.48	341.5
163	0.61	154	......	......	0.48	......	0.78	.....	1.49	31	......	9	158.5	10.57	7.54	1.25	342.1
170	0.59	154	......	......	0.44	......	0.77	......	1.36	30	......	16	162	10.80	7.48	1.50	342.2
169	0.64	158	......	......	0.49	......	0.83	......	1.41	31	......	11	163.5	10.90	7.69	1.58	342.3
165	0.58	158	......	......	0.47	......	0.72	......	1.39	31	......	7	161.5	10.77	7.64	1.45	342.4
164	0.61	137	......	......	0.48	......	0.79	......	1.38	29	......	27	150.5	10.03	7.76	0.71	342.6
169	0.64	163	......	......	0.46	......	0.81	. ....	1.43	24	......	6	166.0	11.07	8.14	1.80	342.7
182	0.50	170	......	......	0.52	......	0.68	......	1.24	19	......	12	176	11.73	8.31	2.48	342.8
177	0.55	172	......	......	0.48	......	0.79	......	1.25	22	......	5	174.5	11.63	9.03	2.63	357
182	0.63	170	......	......	0.49	......	0.82	......	1.40	21	......	12	176	11.73	9.17	2.71	357.1
189	0.57	165	......	......	0.49	......	0.76	......	1.32	40	......	24	177	11.80	9.15	2.78	357.2
195	0.65	180	......	......	0.61	......	0.74	......	1.53	12	......	15	187.5	12.50	10.13	3.47	357.3

No.	Station.	Geographic position.			M_2.	M_2°.		S_2.	S_2°.	N_2.	N_2°.	K_1.
		Latitude.	Longitude.			Degrees.	Lunar hours.					
			Arc.	Time.								
	EAST COAST OF ASIA—continued.	° ′ *North.*	° ′ *East.*	*h. m.*	*Ft.*	°	*h.*	*Ft.*	°	*Ft.*	°	*Ft.*
357.4	Kobe, Inland Sea	34 41	135 11	9 01	1.02	216.0	7.20	0.55	226	.....	.....	0.84
357.5	Akashi, Inland Sea	34 39	134 59	9 00	3.44	256.7	8.56	1.31?	245	.....	.....	0.83
357.6	Shikama, Inland Sea	34 47	134 41	8 59	0.89	319.5	10.65	0.37	306	.....	.....	1.02
362.05	Setoda, Inland Sea	34 18	133 05	8 52	3.48	306.7	10.22	1.21	343	.....	.....	0.91
362.10	Kure, Inland Sea	34 14	132 32	8 50	3.40	277.1	9.24	1.29	309	.....	.....	0.99
362.15	Ujima, Inland Sea	34 21	132 29	8 50	3.26	283.4	9.45	1.60	300	.....	.....	0.93
362.20	Etauchi, Inland Sea	34 15	132 28	8 50	3.25	278.1	9.27	1.43	311	.....	.....	0.97
362.25	Nasakejima, Inland Sea	33 57	132 28	8 50	3.13	262.8	8.76	1.48	298?	.....	.....	1.05
362.30	Ohatake, Inland sea	33 58	132 10	8 49	2.92	260.9	8.70	1.32	290	.....	.....	0.95
362.35	Aohama, Kiusiu	33 57	131 02	8 44	3.54	254.1	8.47	1.74	287	.....	.....	0.95
362.40	Kakachi, Inland Sea	33 41	131 31	8 46	3.08	258.4	8.61	1.33	286	.....	.....	0.97
362.45	Kaminoseki, Inland Sea	33 50	132 06	8 48	2.66	257.6	8.59	1.18	289	.....	.....	0.86
362.50	Okikamuro Shima, Inland Sea	33 51	132 22	8 49	2.94	262.5	8.75	1.10	291	.....	.....	0.97
362.55	Aoshima, Shikoku, Inland Sea	33 44	132 29	8 50	3.03	255.2	8.51	1.23	284	.....	.....	1.01
362.60	Gokoshima, Shikoku, Inland Sea	33 55	132 41	8 51	3.15	270.3	9.01	1.19	303	.....	.....	0.98
362.62	Mitarai, Shikoku, Inland Sea	34 10	132 52	8 51	3.59	289.3	9.64	1.26	323	.....	.....	0.96
362.65	Kurushima, Shikoku, Inland Sea	34 07	132 59	8 52	3.54	288.7	9.62	1.35	328	.....	.....	1.05
362.70	Kuroshima, Niigori Syo	33 59	133 20	8 53	3.71	290.8	9.69	1.33	356	.....	.....	1.05
362.75	Awashima, Shikoku	34 16	133 38	8 55	3.54	328.3	10.94	1.35	3	.....	.....	1.03
362.80	Naoshima	34 27	134 00	8 56	2.22	319.3	10.64	0.73	355	.....	.....	0.99
362.85	Konoura	34 26	134 14	8 57	1.60	317.5	10.58	0.49	336	.....	.....	1.01
362.90	Jeshima	34 40	134 31	8 58	0.95	339.9	11.33	0.38	309	.....	.....	0.90
362.95	Aiketa, Shikoku	34 14	134 24	8 58	1.14	348.1	11.60	0.29	333	.....	.....	0.90
363	Murotsu, Awaji	34 32	134 53	9 00	0.72	334.7	11.16	0.26	286	.....	.....	0.86
363.05	Anaga, Awaji	34 16	134 40	8 59	1.09	338.1	11.27	0.24	341	.....	.....	0.90
363.10	Fukura, Awaji	34 15	134 43	8 59	1.48	192.3	6.41	0.77	214	.....	.....	0.73
363.15	Swaya, Awaji	34 36	135 01	9 00	0.37?	219.9	7.33	0.36?	237	.....	.....	0.78
363.20	Dōnoura, Shikoku	34 13	134 35	8 58	0.95	218.9	7.30	0.56	232	.....	.....	0.77
363.25	Kitodomari, Shikoku	34 14	134 35	8 58	0.58	270.1	9.00	0.31	260	.....	.....	0.85
363.30	Aziro Kameura	.....	.....	.....	1.17	350.7	11.69	0.29	340	.....	.....	0.88
363.35	Magosaki, Shikoku	34 14	134 39	8 59	0.99	329.9	11.00	0.20	347	.....	.....	0.89
363.40	Tosadomari, Shikoku	34 11	134 38	8 59	1.10	204.6	6.82	0.62	225	.....	.....	0.75
363.50	Fukuoka, Kiusiu	33 36	130 22	8 41	1.88	272.4	9.08	0.80	306	.....	.....	0.48
363.60	Fuyasikemura, Kiusiu	33 47	130 27	8 42	1.58	280.7	9.36	0.75	303	.....	.....	0.69
363.70	Kanekasemura, Kiusiu	33 53	130 30	8 42	1.51	336.1	11.20	0.59	344	.....	.....	0.45
363.80	Moji, Kiusiu	33 57	130 39	8 43	2.44	261.5	8.72	1.08	297	.....	.....	0.53
363.90	Hedomari, Shemonseki Str	33 57	130 52	8 43	1.26	289.8	9.66	0.58	321	.....	.....	0.38
363.95	Omishima, Nippon	34 24	131 13	8 45	0.63	316.5	10.55	0.34	340	.....	.....	0.32
365	Kosigahama, Nippon	34 28	131 24	8 46	0.53	326.1	10.88	0.28	338	.....	.....	0.30
379	Maizuru, Nippon	35 27	135 19	9 01	0.24	67.1	2.24	0.05	94	.....	.....	0.23
379.5	Wajima, Nippon	37 24	136 53	9 08	0.20	75.2	2.51	0.07	106	.....	.....	0.16
381	Nanao, Nippon	37 03	136 57	9 08	0.21	77.9	2.60	0.08	115	.....	.....	0.19
384.5	Futami	37 57	138 14	9 13	0.20	81.5	2.72	0.08	100	.....	.....	0.18
385	Ebisu	38 05	138 25	9 14	0.18	73.9	2.46	0.07	117	.....	.....	0.18
385.5	Kamo	38 48	139 48	9 19	0.17	88.4	2.95	0.08	128	.....	.....	0.18
386.05	Fukaura	40 41	139 59	9 20	0.17	97.8	3.26	0.08	137	.....	.....	0.16
386.10	Kodomari	41 07	140 17	9 21	0.25	89.4	2.98	0.07	126	.....	.....	0.13
386.15	Asadoko	40 57	140 48	9 23	0.59	104.9	3.50	0.31	140	.....	.....	0.20
386.20	Moura	41 01	141 12	9 25	0.58	105.0	3.50	0.29	134	.....	.....	0.18
386.25	Ominato	41 15	141 09	9 25	0.66	103.9	3.46	0.30	134	.....	.....	0.18
386.40	Suttsu	42 47	140 16	9 21	0.16	116.4	3.88	0.06	158	.....	.....	0.15
386.45	Iwanai	42 59	140 33	9 22	0.18	118.4	3.95	0.07	155	.....	.....	0.17

$K_1°$.	O_1.	$O_1°$.	P_1.	$P_1°$.	$\frac{S_2}{M_2}$.	$\frac{N_2}{M_2}$.	$\frac{O_1}{K_1}$.	$\frac{P_1}{K_1}$.	K_1+O_1.	$S_2°-M_2°$.	$M_2°-N_2°$.	$K_1°-O_1°$.	$\frac{1}{2}(K_1°+O_1°)$. De-grees.	$\frac{1}{2}(K_1°+O_1°)$. Lunar hours.	Cotidal hour. Semi-diurnal.	Cotidal hour. Diurnal.	No.
°	*Ft.*	°	*Ft.*	°					*Ft.*	°	°	°	°	*h.*	*h.*	*h.*	
192	0.67	183	......	......	0.54	......	0.80	......	1.51	10	......	9	187.5	12.50	10.18	3.48	357.4
212	0.62	194	......	......	......	......	0.75	......	1.45	− 12	......	18	203	13.53	11.56	4.53	357.5
220	0.85	205	......	......	0.42	......	0.83	......	1.87	− 14	......	15	212.5	14.17	1.67	5.19	357.6
224	0.80	206	......	......	0.35	......	0.88	......	1.71	36	......	18	215	14.33	1.35	5.46	362.5
206	0.70	199	......	......	0.38	......	0.71	......	1.69	32	......	7	202.5	13.50	0.37	4.67	362.10
217	0.80	201	......	......	0.49	......	0.86	......	1.73	17	......	16	209	13.93	0.62	5.10	362.15
198	0.78	192	......	......	0.44	......	0.80	......	1.75	33	......	6	195	13.00	0.44	4.17	362.20
196	0.75	189	......	......	0.47	......	0.71	......	1.80	35	......	7	192.5	12.83	11.93	4.00	362.25
198	0.70	199	......	......	0.45	......	0.74	......	1.65	29	......	− 1	198.5	13.23	11.88	4.41	362.30
197	0.71	196	......	......	0.49	......	0.75	......	1.66	33	......	1	196.5	13.10	11.74	4.37	362.35
202	0.68	189	......	......	0.43	......	0.70	......	1.65	28	......	13	195.5	13.03	11.84	4.26	362.40
197	0.61	191	......	......	0.44	......	0.71	......	1.47	31	......	6	194	12.93	11.79	4.13	362.45
200	0.72	193	......	......	0.37	......	0.74	......	1.69	28	......	7	196.5	13.10	11.93	4.28	362.50
193	0.73	183	......	......	0.41	......	0.72	......	1.74	29	......	10	188	12.53	11.68	3.70	362.55
204	0.79	193	......	......	0.38	......	0.81	......	1.77	33	......	11	198.5	13.23	0.16	4.38	362.60
203	0.80	201	......	......	0.35	......	0.83	......	1.76	34	......	2	202	13.47	0.79	4.62	362.62
212	0.76	201	......	......	0.38	......	0.72	......	1.81	39	......	11	206.5	13.77	0.75	4.90	362.65
232	0.71	207	......	......	0.36	......	0.68	......	1.76	65	......	25	219.5	14.63	0.81	5.75	362.70
225	0.76	224	......	......	0.38	......	0.74	......	1.79	35	......	1	224.5	14.97	2.02	6.05	362.75
222	0.74	177	......	......	0.33	......	0.75	......	1.73	36	......	45	199.5	13.30	1.71	4.37	362.80
221	0.67	197	......	......	0.31	......	0.66	......	1.68	18	......	24	209	13.93	1.63	4.98	362.85
221	0.70	209	......	......	0.40	......	0.78	......	1.60	− 31	......	12	215	14.33	2.36	5.36	362.90
221	0.69	215	......	......	0.25	......	0.77	......	1.59	− 15	......	6	218	14.53	2.63	5.56	362.95
221	0.78	206	......	......	0.36	......	0.91	......	1.64	− 49	......	15	213.5	14.23	2.16	5.23	363
236	0.68	211	......	......	0.22	......	0.76	......	1.58	3	......	25	223.5	14.90	2.29	5.92	363.05
194	0.55	177	......	......	0.52	......	0.75	......	1.28	22	......	17	185.5	12.37	9.43	3.39	363.10
205	0.68	196	......	......	......	......	0.87	......	1.46	17	......	9	200.5	13.37	10.33	4.37	363.15
198	0.59	194	......	......	0.59	......	0.77	......	1.36	13	......	4	196	13.07	10.33	4.10	363.20
224	0.64	195	......	......	0.53	......	0.75	......	1.49	− 10	......	29	209.5	13.97	0.03	5.00	363.25
220	0.67	215	......	......	0.25	......	0.76	......	1.55	− 11	......	5	217.5	14.50	......	......	363.30
263	0.77	198?	......	......	0.20	......	0.87	......	1.66	17	......	......	......	......	2.02	......	363.35
215	0.56	187	......	......	0.56	......	0.75	......	1.31	20	......	28	201	13.40	9.84	4.42	363.40
254	0.46	244	......	......	0.43	......	0.96	......	0.94	34	......	10	249	16.60	0.40	7.92	363.50
257	0.43	254	......	......	0.47	......	0.62	......	1.12	22	......	3	255.5	17.03	0.66	8.33	363.60
......	0.44	280	......	......	0.39	......	0.98	......	0.89	8	......	......	......	......	2.50	......	363.70
211	0.45	226	......	......	0.44	......	0.85	......	0.98	35	......	−15	218.5	14.57	0.00	5.85	353.80
266	0.46	267	......	......	0.46	......	1.21	......	0.84	31	......	− 1	266.5	17.77	0.94	9.05	363.90
320	0.38	301	......	......	0.54	......	1.19	......	0.70	24	......	19	310.5	20.70	1.80	11.95	363.95
321	0.38	303	......	......	0.53	......	1.27	......	0.68	12	......	18	312	20.80	2.11	12.03	365
328	0.14	306	......	......	0.21	......	0.61	......	0.37	27	......	22	317	21.13	5.22	12.11	379
329	0.17	314	......	......	0.35	......	1.06	......	0.33	31	......	15	321.5	21.43	5.38	12.30	379.5
328	0.20	320	......	......	0.38	......	1.05	......	0.39	37	......	8	324	21.60	5.47	12.47	381
320	0.17	267?	......	......	0.40	......	0.94	......	0.35	18	......	......	......	......	5.50	......	384.5
336	0.15	329	......	......	0.39	......	0.83	......	0.33	43	......	7	332.5	22.17	5.23	12.94	385
336	0.19	328	......	......	0.47	......	1.06	......	0.37	40	......	8	332	22.13	5.63	12.81	385.5
338	0.17	329	......	......	0.47	......	1.06	......	0.33	39	......	9	333.5	22.23	5.93	12.90	386.05
352	0.13	326	......	......	0.28	......	1.00	......	0.26	37	......	26	339	22.60	5.63	13.25	386.10
167	0.11	155	......	......	0.53	......	0.55	......	0.31	35	......	12	161	10.73	6.12	1.35	386.15
153	0.11	147	......	......	0.50	......	0.61	......	0.29	29	......	6	150	10.00	6.08	0.58	386.20
157	0.14	142	......	......	0.45	......	0.78	......	0.32	30	......	15	149.5	9.97	6.04	0.55	386.25
342	0.16	346	......	......	0.38	......	1.07	......	0.31	42	......	− 4	344	22.97	6.53	13.62	386.40
331	0.14	322?	......	......	0.39	......	0.82	......	0.31	37	......	9	326.5	21.77	6.58	12.40	386.45

No.	Station.	Geographic position.			M_2.	$M_2°$.		S_2.	$S_2°$.	N_2.	$N_2°$.	K_1.
		Latitude.	Longitude.			Degrees.	Lunar hours.					
			Arc.	Time.								
	EAST COAST OF ASIA—continued.	° ′ North.	° ′ East.	h. m.	Ft.	°	h.	Ft.	°	Ft.	°	Ft.
386.50	Otaru	43 12	140 00	9 20	0.17	111.0	3.70	0.07	144	......	......	0.18
386.55	Raigishi	43 20	140 24	9 22	0.15	111.8	3.73	0.08	139	......	......	0.17
386.60	Hamamashi	43 36	141 23	9 26	0.15	107.6	3.59	0.06	153	......	......	0.16
386.65	Rumoye	43 56	141 39	9 27	0.14	125.4	4.18	0.07	157	......	......	0.17
386.70	Tomamae	44 19	141 39	9 27	0.15	132.9	4.43	0.08	159	......	......	0.15
386.75	Wakanai	45 25	140 40	9 23	0.07	80.6	2.69	0.07	156	......	......	0.19
386.80	Oshidomari	45 14	141 14	9 25	0.09	136.0	4.53	0.06	156	......	......	0.17
388.2	Mimitsu	32 20	131 37	8 46	1.71	178.9	5.96	0.67	200	......	......	0.71
388.4	Kagoshima	31 36	130 34	8 42	2.54	205.7	6.86	1.20	231?	......	......	0.82
388.6	Yamakawa	31 12	130 38	8 43	2.44	205.1	6.83	1.16	233	......	......	0.84
388.8	Misumi	32 37	130 27	8 42	3.94	256.6	8.55	1.70	290	......	......	0.87
389.2	Wakatsu	33 07	130 20	8 41	5.27	261.9	8.73	2.23	301	......	......	0.82
389.4	Fake saki shima	32 57	130 14	8 41	5.25	259.2	8.64	2.37	296	......	......	0.92
389.6	Haedomari	32 47	130 22	8 41	4.36	259.4	8.65	1.81	299	......	......	0.90
389.8	Kuchinotsu	32 36	130 11	8 41	3.18	242.9	8.10	1.42	287	......	......	0.82
390.2	Ikenoura	32 23	130 21	8 41	3.45	253.1	8.44	1.47	283	......	......	0.88
390.4	Ushibuka	32 12	130 01	8 40	2.75	226.1	7.54	1.21	252	......	......	0.93
390.7	Tomioka	32 31	130 02	8 40	2.93	219.0	7.30	1.36	255	......	......	0.84
390.8	Senzokushima, Zogoseto	32 34	130 29	8 42	3.83	249.9	8.33	1.63	292	......	......	0.98
392.2	Kogozaki	33 06	129 40	8 39	2.73	238.1	7.94	1.24	270	......	......	0.79
392.4	Sasebo	33 10	129 43	8 39	2.84	246.8	8.23	1.31	275	......	......	0.82
392.6	Ainoura	33 11	129 39	8 39	2.90	230.9	7.70	1.28	256	......	......	0.81
392.8	Wamakatsu (Goto Island)	32 53	129 0	8 36	2.73	250.1	8.34	1.21?	283	......	......	0.78
394.1	Kamoize	34 40	129 22	8 37	1.54	253.9	8.46	0.76	274	......	......	0.27
394.2	Nishidomari	34 39	129 28	8 38	1.12	249.5	8.32	0.59	282	......	......	0.09
394.3	Shimayama	34 19	129 18	8 37	2.16	255.9	8.53	0.95	280	.....	......	0.37
394.4	Hirugaura	34 19	129 16	8 37	2.17	259.1	8.64	1.04	288	......	......	0.40
394.45	Tsu Shima Sound	34 17	129 21	8 37	3.97	275.6	8.19	1.51	313	......	......	0.92
394.5	Izuhara	34 11	129 17	8 37	1.72	251.0	8.37	0.86	288	......	......	0.24
394.6	Kazamoto	33 51	129 41	8 39	1.96	270.0	9.00	0.91	298	......	......	0.51
394.7	Gonoura	33 44	129 41	8 39	2.17	271.9	9.06	1.05	303	......	......	0.51
394.8	Kurotojima	33 23	129 33	8 38	2.69	250.7	8.36	1.16	272	......	......	0.64
395	Fukushima	33 24	129 48	8 39	2.38	277.7	9.26	1.17	305	......	......	0.63
395.5	Hoshigaura	33 23	129 40	8 38	2.18	258.4	8.61	1.14	287	......	......	0.58
400	Kasari	28 27	131 30	8 46	1.82	199.2	6.64	0.78	231	......	......	0.65
400.2	Kuji	28 14	129 15	8 37	1.71	211.3	7.04	0.84	234	......	......	0.70
400.4	Unten	26 40	128 00	8 32	1.72	196.2	6.54	0.77	228	......	......	0.64
400.6	Sesoko	26 38	127 53	8 32	1.85	197.0	6.57	0.65	231	......	......	0.61
400.8	Naka	26 23	127 40	8 31	1.86	197.5	6.58	0.85	222	......	......	0.68
401	Tamsui	25 11	121 24	8 06	3.36	321.7	10.72	0.87	6	......	......	0.72
401.2	Kiirun	25 09	121 45	8 07	0.73	277.3	9.24	0.13	285	......	......	0.64
401.4	So-ō	24 35	121 52	8 07	1.80	185.0	6.17	0.44	209	......	......	0.64
402	Miyakojima	24 50	125 11	8 21	1.65	215.9	7.20	0.69	240	......	......	0.55
402.2	Funauke	24 20	123 44	8 15	1.49	199.9	6.66	0.64	216	......	......	0.70
402.4	Taketomijima	24 09	124 05	8 16	1.47	197.4	6.58	0.65	217	......	......	0.62
403	Gyo-o-to	23 37	119 31	7 58	2.94	332.4	11.08	0.74	20	......	......	0.79
403.2	Santakuto	23 38	119 31	7 58	3.99	323.9	10.80	1.15	6	......	......	0.89
403.4	Hatto retto	23 21	119 31	7 58	2.43	134.5?	4.48?	0.36	276?	......	......	0.81
403.6	Toko, Formosa	22 28	120 27	8 02	0.59	242.5	8.08	0.24	233	......	......	0.58
414	Sosaingpho	35 28	129 25	8 38	0.54	209.1	6.97	0.28	246	......	......	0.09
414.2	Tsauliang Hai	35 08	129 02	8 36	1.34	232.7	7.76	0.64	261	......	......	0.13
414.4	Douglas Inlet	35 02	128 48	8 35	1.85	240.0	8.00	0.93	268	......	......	0.28

K_1°.	O_1.	O_1°.	P_1.	P_1°.	$\frac{S_2}{M_2}$.	$\frac{N_2}{M_2}$.	$\frac{O_1}{K_1}$.	$\frac{P_1}{K_1}$.	K_1+O_1.	$S_2^\circ-M_2^\circ$.	$M_2^\circ-N_2^\circ$.	$K_1^\circ-O_1^\circ$.	$\frac{1}{2}(K_1^\circ+O_1^\circ)$		Cotidal hour.		No.
													Degrees.	Lunar hours.	Semidiurnal.	Diurnal.	
°	*Ft.*	°	*Ft.*	°					*Ft.*	°	°	°	°	*h.*	*k.*	*h.*	
340	0.16	322	......	......	0.41	......	0.89	......	0.34	33	......	18	331	22.07	6.37	12.74	386.50
344?	0.15	324	......	......	0.53	......	0.88	......	0.32	27	......	20	334	22.27	6.36	12.90	386.55
339	0.18	321	......	......	0.40	......	1.12	......	0.34	46	......	18	330	22.00	6.16	12.57	386.60
326	0.17	334	......	......	0.50	......	1.00	......	0.34	32	......	−8	330	22.00	6.73	12.55	386.65
334	0.17	324	......	......	0.50	......	1.14	......	0.32	26	......	10	329	21.93	6.98	12.48	386.70
360	0.16	322	......	......	1.00	......	0.84	......	0.35	75	......	38	341	22.73	5.31	13.35	386.75
344	0.18	338	......	......	0.67	......	1.06	......	0.35	20	......	6	341	22.73	7.11	13.31	386.80
185	0.57	168	......	......	0.39	......	0.80	......	1.28	21	......	17	176.5	11.77	9.19	3.00	388.2
184	0.61	178	......	......	0.47	......	0.74	......	1.43	25	......	6	181	12.07	10.16	3.37	388.4
195	0.70	178	......	......	0.48	......	0.83	......	1.54	28	......	17	186.5	12.43	10.11	3.71	388.6
202	0.64	189	......	......	0.43	......	0.74	......	1.51	33	......	13	195.5	13.03	11.85	4.33	388.8
215	0.60	193	......	......	0.42	......	0.73	......	1.42	39	......	22	204	13.60	0.05	4.92	389.2
208	0.69	197	......	......	0.45	......	0.75	......	1.61	37	......	11	202.5	13.50	11.96	4.82	389.4
209	0.69	194	......	......	0.42	......	0.77	......	1.59	40	......	15	201.5	13.43	11.97	4.75	389.6
210	0.69	193	......	......	0.45	......	0.84	......	1.51	44	......	17	201.5	13.43	11.42	4.75	389.8
210	0.60	196	......	......	0.43	......	0.68	......	1.48	30	......	14	203	13.53	11.76	4.85	390.2
195	0.65	187	......	......	0.44	......	0.70	......	1.58	26	......	8	191	12.73	10.87	4.06	390.4
199	0.65	183	......	......	0.46	......	0.77	......	1.49	36	......	16	191	12.73	10.63	4.06	390.7
207	0.67	183	......	......	0.43	......	0.68	......	1.65	42	......	24	195	13.00	11.63	4.30	390.8
201	0.60	192	......	......	0.45	......	0.76	......	1.39	32	......	9	196.5	13.10	11.29	4.45	392.2
214	0.63	198	......	......	0.46	......	0.77	......	1.45	28	......	16	206	13.73	11.58	5.08	392.4
200	0.65	193	......	......	0.44	......	0.80	......	1.46	25	......	7	196.5	13.10	11.05	4.45	392.6
204	0.58	196	......	......	0.44	......	0.74	......	1.36	33	......	8	200	13.33	11.74	4.73	392.8
216	0.16	209	......	......	0.49	......	0.59	......	0.43	20	......	7	212.5	14.17	11.84	5.55	394.1
217	0.11	248	......	......	0.53	......	1.22	......	0.20	32	......	−31	232.5	15.50	11.69	6.87	394.2
201	0.31	203	......	......	0.44	......	0.84	......	0.68	24	......	−2	202	13.47	11.91	4.85	394.3
197	0.31	197	......	......	0.48	......	0.77	......	0.71	29	......	1	198.5	13.23	0.02	4.60	394.4
185	0.54	167	......	......	0.49	......	0.59	......	1.46	37	......	18	176	11.73	0.57	3.10	394.45
211	0.18	194	......	......	0.50	......	0.75	......	0.42	37	......	17	202.5	13.50	11.75	4.88	394.5
242	0.44	235	......	......	0.46	......	0.86	......	0.95	28	......	7	238.5	15.90	0.35	7.25	394.6
227	0.42	228	......	......	0.48	......	0.82	......	0.93	31	......	−1	227.5	15.17	0.41	6.52	394.7
220	0.60	212	......	......	0.43	......	0.94	......	1.24	21	......	8	216	14.40	11.73	5.77	394.8
230	0.51	224	......	......	0.49	......	0.81	......	1.14	27	......	6	227	15.13	0.61	6.48	395
235	0.52	216	......	......	0.52	......	0.90	......	1.10	29	......	19	225.5	15.03	11.98	6.40	395.5
191	0.47	181	......	......	0.43	......	0.72	......	1.12	32	......	10	186	12.40	9.87	3.63	400
201	0.54	196	......	......	0.49	......	0.77	......	1.24	23	......	5	198.5	13.23	10.42	4.61	400.2
195	0.51	192	......	......	0.45	......	0.80	......	1.15	32	......	3	193.5	12.90	10.01	4.37	400.4
202	0.52	184	......	......	0.35	......	0.85	......	1.13	34	......	18	193	12.87	10.04	4.34	400.6
195	0.50	193	......	......	0.46	......	0.74	......	1.18	24	......	2	194	12.93	10.06	4.41	400.8
240	0.58	217	......	......	0.26	......	0.81	......	1.30	44	......	23	228.5	15.23	2.62	7.13	401
124?	0.48	205	......	......	0.18	......	0.75	......	1.12	8	......	......	......	......	1.12	......	401.2
217	0.57	207	......	......	0.24	......	0.89	......	1.21	24	......	10	212	14.13	10.05	6.01	401.4
235	0.51	212	......	......	0.42	......	0.93	......	1.06	24	......	23	223.5	14.90	10.85	6.55	402
208	0.54	197	......	......	0.43	......	0.77	......	1.24	16	......	11	202.5	13.50	10.41	5.25	402.2
209	0.56	196	......	......	0.44	......	0.90	......	1.18	20	......	13	202.5	13.50	10.31	5.23	402.4
271	0.76	245	......	......	0.25	......	0.96	......	1.55	48	......	26	258	17.20	3.11	9.23	403
264	0.84	231	......	......	0.29	......	0.94	......	1.73	42	......	33	247.5	16.50	2.83	8.53	403.2
268?	0.72	250	......	......	0.15	......	0.89	......	1.53	......	......	18	259	17.27	......	9.30	403.4
294	0.53	256	......	......	0.41	......	0.91	......	1.11	−9	......	38	275	18.33	0.05	10.30	403.6
35	0.07	346	......	......	0.52	......	0.78	......	0.16	37	......	49	10.5	0.70	10.34	16.07	414
130	0.06	144	......	......	0.48	......	0.46	......	0.19	28	......	−14	137	9.13	11.16	0.53	414.2
150	0.15	136	......	......	0.50	......	0.54	......	0.43	28	......	14	143	9.53	11.42	0.95	414.4

No.	Station.	Geographic position.			M_2°.	M_2°.		S_2.	S_2°.	N_2.	N_2°.	K_1
		Latitude.	Longitude.			Degrees.	Lunar hours.					
			Arc.	Time.								
	EAST COAST OF ASIA—continued.	° ′ North.	° ′ East.	h. m.	Ft.	°	h.	Ft.	°	Ft.	°	Ft.
414.6	Masanpho	35 12	128 34	8 34	2.10	244.8	8.16	1.00	269	.....	.....	0.28
414.8	Sylvia Basin	35 04	128 33	8 34	2.12	239.2	7.97	1.04	252	.....	.....	0.30
415	Koje Do	34 50	128 42	8 35	1.96	244.0	8.13	0.77	273	.....	.....	0.34
415.2	Cargodo Bluff	34 50	128 35	8 34	2.68	251.2	8.37	0.85	311	.....	.....	0.67
415.4	Shadwell Gulf	34 53	128 27	8 34	2.29	244.6	8.15	1.15	290	.....	.....	0.24
415.6	Sylvia Basin, Koje Do	34 55	128 30	8 34	2.04	230.4	7.68	1.06	254	.....	.....	0.26
415.8	Daryang Do	34 57	128 20	8 33	3.24	241.8	8.06	1.24	271	.....	.....	0.58
416	Sinko Do	34 51	128 13	8 33	2.73	251.7	8.39	1.26	277	.....	.....	0.57
416.2	Willie's Gulf	34 44	127 45	8 31	3.34	251.8	8.39	1.55	278			0.68
416.4	North of Herschel Island	34 37	127 33	8 30	3.65	267.7	8.92	1.75	289	.....	.....	0.72
416.6	Herschel Island	34 28	127 28	8 30	3.43	260.1	8.67	1.58	283	.....	.....	0.82
416.8	Mandarin (Goalen Island)	34 21	126 53	8 28	3.00	282.3	9.41	1.35	303	.....	.....	0.86
417	Mandarin Island, Long Reach	34 22	126 47	8 27	3.51	262.8	8.76	2.03	309	.....	.....	0.77
417.2	Chrichton Har	34 08	126 38	8 27	2.79	295.4	9.85	1.31	328	.....	.....	0.71
417.4	Green Islands	34 27	126 25	8 26	3.22	307.8	10.26	1.33	355	.....	.....	0.93
417.6	East of Thistle Island	34 24	126 19	8 25	3.01	341.5	11.38	0.67	166?	.....	.....	2.60
417.8	Thistle Island	34 24	126 08	8 25	3.70	3.7	0.12	1.34	43	.....	.....	0.97
418	Montreal Island	34 20	126 04	8 24	3.04	345.6	11.52	1.12	12	.....	.....	0.95
418.2	Amherst Island	34 32	126 02	8 24	3.57	5.1	0.17	1.26	38	.....	.....	1.01
418.3	Mokpho	34 45	126 22	8 25	3.94	53.0	1.77	1.32	98	.....	.....	1.03
418.4	Pigum Do	34 44?	125 56	8 24	3.83	17.4	0.58	0.71	55	.....	.....	1.00
418.6	North Twin Island	34 51	126 02	8 24	4.50	43.4	1.45	1.49	74	.....	.....	0.88
418.8	Fire Island	35 03	126 05	8 24	4.67	44.5	1.48	1.93	81	.....	.....	0.83
419	Kokuntau Islands	35 49	126 25	8 26	7.40	85.2	2.84	2.36	118	.....	.....	1.22
419.2	Won-san Islands	36 22	126 26	8 26	7.86	91.2	3.04	2.94	128	.....	.....	1.06
420.8	Gets-nai-tau Island	38 03	124 49	8 19	3.48	161.4	5.38	1.15	212	.....	.....	1.28
421	Dau-chen Island	38 37	125 00	8 20	5.04	226.2	7.54	1.42	270	.....	.....	1.60
421.2	Piõ sem	38 40	125 10	8 21	5.48	243.8	8.13	1.81	280	.....	.....	1.31
421.4	Ping-yang Inlet	38 38	125 35	8 22	6.68	261.7	8.72	2.05	308	.....	.....	1.22
427	Wei-hai-wei	37 30	122 11	8 09	2.06	312.6	10.09	0.55	2	.....	.....	0.77
436	Swatow, China	23 23	116 39	7 47	1.35	23	0.77	0.32	86	0.24	358	0.94
438	Whampoa	23 05	113 26	7 34	2.18	32	1.07	0.67	64	0.38	16	1.07
445	Nau-chau, Kwangsi	21 00	110 38	7 23	2.59	303	10.10	1.05	345	.....	.....	1.34
446	Port Beaumont	.....	.....	.....	3.12	322	10.73	1.15	19	.....	.....	1.28
	OCEANICA.											
590	Boloengan, Borneo	2 50	117 22	7 49	0.93	336	11.20	0.49	291	0.12	228	0.55
		South.										
591	Samarinda, Borneo	0 30	117 08	7 49	1.39	209	6.97	0.86	261	.....	.....	0.58
592	Batoe Panggal, Borneo	0 32	117 06	7 48	1.20	208	6.93	.....	.....	.....	.....	.....
593	Moera Djawa, Borneo	0 37	117 18	7 49	1.61	198	6.60	1.05	256	0.14	152	0.55
594	Bay of Balik Papan, Borneo	1 16	116 48	7 47	1.89	153	5.10	1.64	204	0.20	125	0.57
598	Macassar	5 08	119 24	7 58	0.27	70	2.33	0.36	194	0.09	347	0.91
600	Donggala	0 40	119 44	7 59	1.55	159	5.30	1.30	208	0.12	108	0.73
		North.										
602	Tontoli	1 00	120 53	8 04	1.38	161	5.37	1.16	199	0.20	131	0.47
634	Iloilo, Point Gimalik	10 40	122 35	8 10	1.35	332.6	11.09	0.64	18	0.21	306	1.14
634.5	Cebu	10 18	123 54	8 16	1.37	334.3	11.14	0.75	22	0.22	324	0.97
635	Tacloban	11 15	125 00	8 20	0.53	220.6	7.35	0.13	269	0.14	199	0.50
635.5	Santa Elena	11 21	124 59	8 20	0.49	312.3	10.41	0.34	30	.....	.....	0.72
636	Santa Rita Island	11 26	124 57	8 20	1.18	347.8	11.59	0.76	50	0.18	357	0.79
636.5	Catbalogan	11 47	124 52	8 19	1.50	341.1	11.37	0.90	36	0.24	315	0.91
637	Calbayoc	12 04	124 35	8 18	1.11	342.7	11.42	0.74	42	.....	.....	0.77

K_1°.	O_1.	O_1°.	P_1.	P_1°.	$\frac{S_2}{M_2}$.	$\frac{N_2}{M_2}$.	$\frac{O_1}{K_1}$.	$\frac{P_1}{K_1}$.	K_1+O_1.	$S_2^{\circ}-M_2^{\circ}$.	$M_2^{\circ}-N_2^{\circ}$.	$K_1^{\circ}-O_1^{\circ}$.	$\frac{1}{2}(K_1^{\circ}+O_1^{\circ})$.		Cotidal hour.		No.
													Degrees.	Lunar hours.	Semi-diurnal.	Diurnal	
°	*Ft.*	°	*Ft.*	°					*Ft.*	°	°	°	°	*h.*	*h.*	*h.*	
170	0.12	143	......	......	0.48	......	0.43	......	0.40	24	......	27	156.5	10.43	11.59	1.86	414.6
143	0.11	124	......	......	0.49	......	0.37	......	0.41	13	......	19	133.5	8.90	11.40	0.33	414.8
170	0.17	145	......	......	0.39	......	0.50	......	0.51	29	......	25	157.5	10.50	11.55	1.92	415
191	0.35	151	......	......	0.32	......	0.52	......	1.02	60	......	40	171	11.40	11.80	2.83	415.2
166	0.13	147	......	......	0.50	......	0.54	......	0.37	45	......	19	156.5	10.43	11.58	1.86	415.4
179	0.11	107	......	......	0.52	......	0.42	......	0.37	24	......	72	143	9.53	11.11	0.96	415.6
176	0.52	147	......	......	0.38	......	0.90	......	1.10	29	......	29	161.5	10.77	11.51	2.22	415.8
165	0.37	151	......	......	0.46	......	0.65	......	0.94	25	......	15	158.5	10.57	11.84	2.02	416
165	0.42?	151	......	......	0.46	......	0.62	......	1.10	26	......	14	158	10.53	11.87	2.01	416.2
184	0.46	171	......	......	0.48	......	0.64	......	1.18	21	......	13	177.5	11.83	0.42	3.33	416.4
174	0.53	157	......	......	0.46	......	0.65	......	1.35	23	......	17	165.5	11.03	0.17	2.53	416.6
182	0.53	170	......	......	0.45	......	0.62	......	1.39	21	......	12	176	11.73	0.94	3.26	416.8
182	0.70	157	......	......	0.58	......	0.91	......	1.47	46	......	25	169.5	11.30	0.31	2.85	417
189	0.57	179	......	......	0.47	......	0.80	......	1.28	33	......	10	184	12.27	1.40	3.82	417.2
201	0.67	179	......	......	0.41	......	0.72	......	1.60	47	......	22	190	12.67	1.83	4.24	417.4
60	......	......	......	......	0.22	......	......	......	......	......	......	......	......	......	2.96	......	417.6
225	0.74	209	......	......	0.36	......	0.75	......	1.71	39	......	16	217	14.47	3.70	6.05	417.8
211	0.67	203	......	......	0.37	......	0.71	......	1.62	26	......	8	207	13.80	3.12	5.40	418
217	0.77	209	......	......	0.35	......	0.76	......	1.78	33	......	8	213	14.20	3.77	5.80	418.2
246	0.81	227	......	......	0.34	......	0.79	......	1.84	45	......	19	236.5	15.77	5.35	7.35	418.3
235	0.80	213	......	......	0.19	......	0.80	......	1.80	38	......	22	224	14.93	4.18	6.53	418.4
240	0.71	238	......	......	0.33	......	0.81	......	1.59	31	......	2	239	15.93	5.05	7.53	418.6
252	0.55	216	......	......	0.41	......	0.66	......	1.38	37	......	36	234	15.60	5.08	7.20	418.8
256	0.95	241	......	......	0.32	......	0.78	......	2.17	33	......	15	248.5	16.57	6.41	8.14	419
266	0.77	249	......	......	0.37	......	0.73	......	1.83	37	......	17	257.5	17.17	5.61	8.74	419.2
304	0.84	274	......	......	0.33	......	0.66	......	2.12	51	......	30	289	19.27	9.06	10.95	420.8
316	0.93	292	......	......	0.28	......	0.58	......	2.53	44	......	24	304	20.27	11.21	11.94	421
316	0.93	294	......	......	0.33	......	0.71	......	2.24	36	......	22	305	20.33	11.78	11.98	421.2
331	0.95	305	......	......	0.31	......	0.78	......	2.17	46	......	26	318	21.20	0.35	12.83	421.4
300	0.58	271	......	......	0.27	......	0.75	......	1.29	49	......	29	285.5	19.03	1.94	10.88	427
292	0.76	254	0.27	285	0.24	0.18	0.81	0.29	1.70	63	25	38	273	18.20	4.99	10.42	436
354	0.82	310	0.35	15	0.31	0.17	0.77	0.33	1.89	32	16	44	332	22.13	5.50	14.56	438
345	1.21	276	......	......	0.41	......	0.90	......	2.55	42	......	69	310.5	20.70	2.72	13.32	445
313	1.21	291	......	......	0.37	......	0.95	......	1.49	57	......	22	302	201.30	......	......	446
319	0.24	254	0.10	264	0.54	0.13	0.44	0.18	0.79	−45	108	65	286.5	19.10	3.38	11.28	590
300	0.71	271	0.11	237	0.58	......	1.22	0.19	1.29	52	......	29	285.5	19.03	11.15	11.21	591
......	0.60	267	......	......	......	......	......	......	......	......	......	......	......	......	11.13	......	592
318	0.44	285	0.38	302	0.65	0.09	0.80	0.69	0.99	58	46	33	301.5	20.10	10.78	12.28	593
203	0.49	257	0.44	189	0.86	0.11	0.86	0.77	1.06	51	28	46	280	18.67	9.32	10.89	594
300	0.56	278	0.34	296	1.33	0.33	0.62	0.37	1.47	124	83	22	289	19.27	6.36	11.30	598
277	0.35	239	0.22	291	0.84	0.68	0.48	0.30	1.08	49	51	38	258	17.20	9.32	9.22	600
285	0.46	227	0.19	328	0.84	0.14	0.98	0.93	0.93	38	30	58	256	17.07	9.30	9.00	602
326	1.01	294	......	......	0.47	0.16	0.89	......	2.15	45	27	32	310	20.67	2.92	12.50	634
330	0.92	294	0.31	332	0.55	0.16	0.95	0.32	1.89	48	10	36	312	20.80	2.87	12.53	634.5
301	0.59	276	......	......	0.25	0.26	1.18	......	1.09	48	22	25	288.5	19.23	11.02	10.90	635
316	0.66	270	......	......	0.69	......	0.92	......	1.38	78	......	46	293	19.53	2.08	11.20	635.5
332	0.79	296	......	......	0.64	0.15	1.00	......	1.58	62	−9	36	314	20.93	3.26	12.60	636
335	0.88	291	......	......	0.60	0.16	0.97	......	1.79	55	26	44	313	20.87	3.05	12.55	636.5
337	0.73	302	......	......	0.67	......	0.95	......	1.50	59	......	35	319.5	21.30	3.12	13.00	637

No.	Station.	Geographic position.			M_2.	M_2°.		S_2.	S_2°.	N_2.	N_2°.	K_1.
		Latitude.	Longitude.			Degrees.	Lunar hours.					
			Arc.	Time.								
	OCEANICA—continued.	° ′	° ′	h. m.	Ft.	°	h.	Ft.	°	Ft.	°	Ft.
		North.	*East.*									
637.5	Halsey Harbor	11 48	119 57	8 00	0.78	311.1	10.37	0.33	4	0.22	289	0.98
641	Olongapo	14 49	120 17	8 01	0.56	292.9	9.76	0.20	325	0.11	283	0.90
642	Santa Cruz	15 46	119 54	8 00	0.38	271.0	9.03	0.06	324	0.09	274	0.84
643	Bolinao	16 24	119 54	8 00	0.32	278.3	9.28	0.12	313	......	......	0.85
644	Sual	16 04	120 06	8 00	0.29	275.9	9.20	0.09	311	0.10	250	0.89
645	Tabaco	13 22	123 44	8 15	1.75	174.7	5.82	0.77	199	0.29	150	0.53
		South.	*West.*									
665	Gambier Island	23 08	135 00	9 00	0.89	86	2.87	0.30	38	......	......	0.07
			East.									
680.5	Wellington	41 17	174 46	11 39	1.60	137.1	4.57	0.09	325	0.35	104	0.08
681	Port Chalmers	45 50	172 30	11 30	2.39	99.0	3.30	0.27	96	0.47	70	0.08
681.5	Port Darwin	12 23	130 37	8 42	6.56	144	4.80	3.44	193	1.04	121	1.91
682	Cooktown	15 27	145 15	9 41	1.87	282	9.40	0.79	258	0.45	239	0.29
682.5	Cairns Harbor	16 55	145 47	9 43	1.96	282	9.40	1.12	245	0.66	269	0.87
683	Brisbane Bar	27 31	153 00	10 12	2.20	290	9.67	0.58	315	0.46	288	0.59
683.5	Ballina	28 52	153 33	10 14	1.08	262	8.73	0.28	275	0.20	254	0.45
684	Newcastle	32 57	151 44	10 07	1.60	249	8.30	0.39	265	0.35	235	0.51
689.5	Princess Royal Harbor	35 08	118 00	7 52	0.16	339	11.30	0.26	342	0.07	17	0.62
	INDIAN OCEAN.											
810	Navanar	22 44	69 43	4 39	6.04	24.4	0.81	1.89	55	1.26	11	1.53
811	Hanstal	22 56	70 21	4 41	6.85	45.6	1.52	1.93	85	1.19	26	1.50
		North.										
845	Suez	29 58	32 32	2 10	1.85	342.4	11.41	0.45	7	0.60	313	0.16
		South.										
863	Diego Saurez	12 25	49 20	3 17	2.10	111	3.70	0.95	155	......	......	0.39
864	Tamatave	18 10	49 28	3 18	0.72	49	1.63	0.30	67	......	......	0.07
866	Mayotte	12 47	45 20	3 01	3.71	121	4.03	1.74	163	......	......	0.56
868	Réunion Island	21 20	55 28	3 42	0.46	79	2.63	0.23	77	......	......	0.16
	WEST COAST OF AFRICA AND EUROPE.	*North.*										
910	Dakar	14 40	17 25	1 10	1.54	224	7.47	0.56	264	......	......	0.20
925	Toulon	43 05	5 55	0 24	0.20	246	8.20	0.09	250	0.05	226	0.10
943	Rochelle	46 09	1 09	0 05	5.82	92.3	3.08	2.11	126	1.22	72	0.21
			West.									
957	Hull	53 44	0 20	0 01	7.56	175.8	5.86	2.34	228	1.25	164	0.56
			East.									
983	Hook of Holland	51 56	4 05	0 16	2.54	72	2.40	0.65	131	0.43	44	0.25
984	Ymuiden	52 28	4 33	0 18	2.20	113	3.77	0.58	180	0.35	89	0.25
985	Helder	52 57	4 46	0 19	1.74	171	5.70	0.50	238	0.26	151	0.18
1000	Christiania	59 55	10 44	0 43	0.37	128	4.27	0.12	86	0.10	92	......
1001	Oscarsborg	59 41	10 37	0 42	0.47	129	4.30	0.16	80	0.12	89	......
1002	Arendal	58 27	8 46	0 35	0.28	100	3.33	0.09	68	0.08	64	......
1003	Stavanger	58 59	5 44	0 23	0.48	282.5	9.42	0.22	332	0.10	264	......
1004	Bergen	60 24	5 08	0 21	1.44	297.5	9.92	0.52	334	0.28	270	0.11
1005	Trondhjem	......	......	......	......	......	......	......	......	......	......	......
1006	Bodoe	67 17	14 23	0 58	2.84	356.5	11.88	0.98	35	0.57	334	0.34
1007	Fineide	67 17	15 30	1 02	1.74	57.0	1.90	0.50	106	0.34	36	0.26
1008	Kabelvaag	68 13	14 30	0 58	2.98	3.5	0.12	1.08	44	0.61	340	0.34
1009	Narvik	......	......	......	......	......	......	......	......	......	......	......
1010	Bredvik	......	......	......	......	......	......	......	......	......	......	......
1011	Vardoe	70 20	31 06	2 04	3.29	163.5	5.45	0.92	208	0.72	130	0.38
1030	Teplitz Bay	81 47	58 04	3 52	0.47	168.4	5.61	0.17	230	......	......	0.09

K_1°.	O_1.	O_1°.	P_1.	P_1°.	$\frac{S_2}{M_2}$.	$\frac{N_2}{M_2}$.	$\frac{O_1}{K_1}$.	$\frac{P_1}{K_1}$.	K_1+O_1.	$S_2^\circ-M_2^\circ$.	$M_2^\circ-N_2^\circ$.	$K_1^\circ-O_1^\circ$.	$\frac{1}{2}(K_1^\circ+O_1^\circ)$.		Cotidal hour.		No.
													Degrees.	Lunar hours.	Semi-diurnal.	Diurnal.	
°	*Ft.*	°	*Ft.*	°					*Ft.*	°	°	°	°	*h.*	*h.*	*h.*	
318	0.98	276	......	......	0.42	0.28	1.00	......	1.96	53	22	42	297	19.80	2.37	11.80	637.5
316	0.81	276	0.27	309	0.36	0.20	0.90	0.30	1.71	32	10	40	296	19.73	1.74	11.71	641
313	0.72	267	......	......	0.16	0.24	0.86	......	1.56	53	− 3	46	290	19.33	1.03	11.33	642
313	0.68	275	......	......	0.38	......	0.80	......	1.53	35	......	38	294	19.60	1.28	11.60	643
325	0.72	274	......	......	0.31	0.34	0.81	......	1.61	35	26	41	294.5	19.63	1.20	11.63	644
203	0.39	190	......	......	0.44	0.17	0.74	......	0.91	24	25	13	196.5	13.10	9.57	4.85	645
84	0.03	276	......	......	0.34	......	0.43	......	0.10	− 48	......	− 92	230	153.30	5.87	6.33	665
81	0.10	36	0.03	67	0.06	0.22	1.25	0.38	0.18	−172	33	45	58.5	3.90	4.92	16.25	680.5
84	0.09	59	0.03	95	0.11	0.20	1.12	0.38	0.17	− 3	29	25	71.5	4.77	3.80	16.30	681
336	1.14	313	0.44	1	0.52	0.16	0.60	0.23	3.05	49	23	23	224.5	14.97	8.10	6.27	681.5
171	0.30	113	......	......	0.42	0.24	1.03	......	0.59	− 24	43	58	142	9.47	11.72	23.79	682
190	0.41	166	......	......	0.57	0.34	0.47	......	1.28	− 37	13	24	178	11.87	11.68	2.15	682.5
176	0.32	139	......	......	0.26	0.21	0.54	......	0.91	25	2	37	157.5	10.50	11.47	0.30	683
155	0.31	128	0.14	149	0.26	0.19	0.69	0.31	0.76	13	8	27	141.5	9.43	10.50	23.20	683.5
120	0.29	88	0.15	116	0.24	0.22	0.57	0.29	0.80	16	14	32	104	6.93	10.18	20.81	684
330	0.42	312	17	332	1.62	0.44	0.68	0.27	1.04	3	−38	18	321	21.40	3.43	13.53	689.5
63	0.68	66	0.28	72	0.31	0.21	0.44	0.18	2.21	31	13	− 3	64.5	4.30	8.16	23.65	810
81	0.75	75	0.38	84	0.28	0.17	0.50	0.25	2.25	39	20	6	78	5.20	8.84	0.52	811
190	0.04	216	0.05	112	0.24	0.32	0.25	0.31	0.20	25	29	− 26	203	13.53	9.24	11.36	845
55	0.26	63	......	......	0.45	......	0.67	......	0.65	44	......	− 8	59	3.93	0.42	0.65	863
56	0.10	73	......	......	0.42	......	1.43	......	0.17	18	......	− 17	64.5	4.30	10.33	1.00	864
49	0.30	61	......	......	0.47	......	0.54	......	0.86	42	......	− 12	55	367.00	1.01	0.65	866
159	0.10	103	......	......	0.50	......	0.62	......	0.26	− 2	......	56	131	8.73	10.93	5.03	868
328	0.13	226	......	......	0.36	......	0.65	......	0.33	40	......	102	277	18.47	6.30	16.30	910
186	0.06	120	0.04	178	0.45	0.25	0.60	0.40	0.16	4	20	66	153	10.20	7.80	9.80	925
67	0.23	321	0.09	58	0.36	0.21	1.10	0.43	0.44	34	20	106	14	0.93	3.00	0.85	943
282	0.43	119	......	......	0.31	0.17	0.77	......	0.99	52	11	163	200.5	13.37	5.88	13.39	957
345	0.35	182	0.13	327	0.26	0.17	1.40	0.52	0.60	59	28	163	263.5	17.57	2.13	17.30	983
350	0.36	185	0.13	334	0.26	0.16	1.44	0.52	0.61	67	24	165	267.5	17.83	3.47	17.53	984
356	0.25	196	0.08	0	0.29	0.15	1.39	0.44	0.43	67	20	160	276	18.40	5.38	18.08	985
......	......	......	......	......	0.32	0.27	......	......	......	− 42	36	......	......	......	3.55	......	1000
......	......	......	......	......	0.34	0.26	......	......	......	− 49	40	......	......	......	3.60	......	1001
......	......	......	......	......	0.32	0.29	......	......	......	− 32	36	......	......	......	2.75	......	1002
......	......	......	......	......	0.46	0.21	......	......	......	50	18	......	......	......	9.04	......	1003
170	0.10	18	0.04	152	0.36	0.19	0.91	0.36	0.21	36	28	152	94	6.27	9.57	5.92	1004
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1005
208	0.13	32	0.10	194	0.35	0.20	0.38	0.29	0.47	39	22	176	120	8.00	10.91	7.03	1006
250	0.08	102	0.07	236	0.29	0.20	0.31	0.27	0.34	49	21	148	176	11.73	0.87	10.70	1007
212	0.13	54	0.09	202	0.36	0.20	0.38	0.26	0.47	40	24	158	133	8.87	11.15	7.90	1008
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1009
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1010
286	0.10	92	0.11	282	0.28	0.22	0.26	0.29	0.48	44	34	−166	9	0.60	3.38	22.53	1011
11	0.05	354	......	......	0.36	......	0.56	......	0.14	62	......	17	2.5	0.17	1.74	20.30	1030

20. *Note on the measurement of tides at sea.*

The measuring of the rise and fall of the tide at sea has seldom been undertaken because of the difficulties connected with such operations.

By anchoring a boat from either end and frequently measuring the depth of the water (about 20 fathoms) over an even bottom, Captain Hewett, R. N., ascertained that there was practically no rise and fall at a point between Holland and England. This has been taken to be a no-tide point in Fig. 22, and it agrees well with the location inferred from the tide along the coasts.*

More recently, attempts have been made to ascertain the rise and fall in shallow bodies of water by means of pressure gauges. The gauges have generally been placed upon the bottom. It has been suggested that a suitable anchorage and several guys might be arranged which would allow the gauge to be floated just below the action of the storm waves, thus reducing the total pressure of the superincumbent water column. If the gauge is not too far below the surface, the pressure may be exerted upon a tube of mercury closed at one end.

In the Surveyor (Sydney, Australia), Vol. 16 (1903), pp. 25–28, Mr. G. H. Halligan describes a gauge designed to be submerged in small depths, and in which the pressure is measured by a column of mercury. Capt. Adolf Mensing, of the Imperial German Navy, has designed an elaborate self-registering tide gauge which works in depths not exceeding 100 fathoms. The instrument does not measure the total pressure, but the difference between the total pressure and the pressure for an assumed depth, which does not quite equal the actual depth of water.

In 1903 Captain Cust of the *Triton* secured tidal curves by means of a pneumatic tide gauge in the North Sea, on Brown Ridge, Swarte Bank, and the northwest corner of Dogger Bank.†

It seems to be worth while to point out the difficulty of getting a good instrumental range when the pressure is exerted upon a column of air contained in a pipe closed at the upper end. Let l denote the length of the pipe and y the distance from the upper end of the pipe downward to the surface of the water which enters it, i. e., y denotes the length of the air column. Let n denote the number of atmospheres which measure the pressure at the mouth of the pipe. Consequently, when the pressure is n atmospheres, the length of the air column will be l/n $(=y)$ and the depth of the mouth of the pipe below the surface will be

$$(n-1)\ 33 \text{ feet } (=z). \tag{30}$$

$$\therefore\ dy=-\frac{l}{n^2}dn,$$

$$dz=33\ dn;$$

$$dy=-\frac{1}{33}\frac{l}{n^2}\ dz=-\frac{33\,l}{(z+33)^2}\ dz. \tag{31}$$

This shows how very small is the change in the length of the air column when the depth is altered by a given amount dz.

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* Report B. A. A. S., 1841, II, pp. 32–35.

† Report on Admiralty Surveys for the year 1903, p. 5.

The most reliable means for measuring the tide away from the coast appears to be a sounding apparatus consisting essentially of a piano wire attached to a heavy weight composed of material of little value, such as a box or bag of stones or gravel. The weight when once cast is to remain immovable on the bottom and is not to be recovered. The wire when drawn taut will indicate whether or not the vessel is directly over the weight. The aim of the observers on board is to so maneuver the boat that the wire shall become approximately vertical as many times as possible throughout the period of observation, and at each such time to note the depth of the water. There certainly can be no serious difficulty in measuring tides in a few hundred fathoms where the surface of the water is reasonably calm. For, the tension can be made sufficiently great for eliminating the errors caused by the sag of the wire resulting from its own weight combined with the impulse of the tidal current.

By aid of this apparatus and suitable floats it is probable that permanent currents can be measured at sea in any depth of water.*

21. *Note concerning the fundamental systems.*

The principal systems upon which the semidiurnal ocean tides depend are shown in Fig. 23, and described in §§ 72–78 of Part IV A. These constitute a rational scheme with reference to which observed facts can be arranged and, in a measure, interpreted; in fact, they make it possible to estimate the time of tide in various parts of the ocean itself.

By aid of the cotidal lines and ranges as now shown in Figs. 6–41, it would doubtless be possible to modify the systems in some details. This, however, would require considerable time and study; and the results obtained by aid of the modified systems could hardly differ much from those depending upon the original. The following are a few suggestions:

The half-wave area extending from Mozambique Channel to Baluchistan and India has in § 73, Part IV A, been described as if belonging to the South Atlantic system. It will be noted in § 26 that it is mainly a dependent area having tides sustained by the South Atlantic and South Indian systems and modified by the North Indian system.

The southern nodal line of the North Atlantic systems should probably have been drawn more nearly parallel to the coast of South America, thus bringing its eastern end nearer to the Cape Verde Islands.

By referring to Figs. 35, 36, 37, and 39, it appears that the nodal line from Japan might be extended southward to the equator, and that the northern shores of Celebes, Gilolo, and New Guinea might be regarded as forming a portion of the southern boundary of the North Pacific system.

It seems probable that the South Pacific system should be considered as comprising little, if anything, besides the L-shaped figure shown on the chart of systems. With this view of the case the nodal line south of the Hawaiian Islands and belonging to the northern branch should be moved southwesterly, or toward the Fiji Islands. The southwesterly progression toward these islands probably helps to explain the tides in the vicinity of this line. It is probable that the nodal line near New Zealand should be moved southeasterly.

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*See Science, Vol. 19 (1904), pp. 704-706.

22. *Remarks on tidal problems.*

While I believe that all candid readers of Parts IV A and IV B will recognize therein a partial and approximate explanation of the tides, I also believe that more comprehensive modes of treatment will be desired and undertaken by the analyst. It is here proposed to show what are some of the difficulties to be encountered.

For many years after the time of Laplace, nearly all writers on tidal theory followed closely in his footsteps and laid great stress upon the tides in an hypothetical sheet of water which either covers a rotating globe or constitutes a zonal sea, the depth being assumed to depend upon the latitude but not upon the longitude. More recently it has been recognized that an important step toward the complete solution of tidal problems is the determination of the free periods of the bodies of water upon a rotating globe. The hopelessness of this undertaking can be easily seen upon recalling the fact that the mode and free period of a plane rectangular body of water rotating about a vertical line have never been determined. The free oscillation of a circular sheet rotating about a central line can, however, be found by aid of Bessel's functions.* Laplace succeeded in finding solutions of his tidal equation for a rotating globe covered with water. But the possible modes of free oscillation for an ocean covering a globe uniformly has only recently been investigated by Mr. S. S. Hough in the Philosophical Transactions. If the effect of rotation be ignored, spherical sheets of water bounded by meridians or parallels of latitude or both can be treated by aid of general spherical harmonics. These results are, to say the least, not very encouraging.

The real tidal problem presented to us by nature is concerned not so much with the possible free oscillations of an ocean as a whole as with those oscillations which may exist across certain parts of the ocean and whose free periods are nearly equal to the period of the tidal forces.

Consider for the moment an oscillation between two opposing walls placed in a broad tank of water at such a distance apart as to best respond to the impressed periodic forces. If one or both of the lateral boundaries be wanting, the deflecting force caused by rotation at a moderate rate about any vertical axis can have little to do with the oscillation because its effect can not accumulate. Even in the case of a rectangular body of water bounded on all sides by rigid walls, the deflecting force due to rotation would not, excepting for certain critical widths, seriously alter the mode and period of oscillation. The approximate effect upon a narrow rectangular body can be seen from § 11, making $\theta = 0$ for the case of a plane sheet of water.

In nearly all cases of tidal oscillations rigid lateral boundaries are incomplete. The problems seeming to require first attention are those relating to the free oscillations of such bodies disregarding in the first instance the deflecting force of the earth's rotation. It is probable that similar problems relating to plane sheets of water if capable of satisfactory solution could be readily extended to sheets upon a sphere. A somewhat analogous subject is that of the vibration of a stretched membrane where a portion of the rigid boundary is wanting; but the analogy is obviously incomplete, because we are in this latter case concerned only with the membrane itself. The problem of an open organ pipe is in some respects more nearly analogous to the one in question, for account must be taken of the motion of the air outside of the pipe as well

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*Lamb: Hydrodynamics, §§ 201–203.

as of the air within. It seems probable that experiments, if carefully made by aid of suitable apparatus, can throw much light upon the movements of the water particles, especially along the free boundaries of imperfectly inclosed areas.

Many tidal problems of minor importance require attention. One intimately connected with the problem just referred to is the law of transition of the times of the tide between two nonsimultaneous areas in the open ocean (lemma 25). Another is the transition or sequence of the times experienced in passing through a strait connecting two independently tided bodies; or bodies whose tides are not independent of each other. Another problem relates to the possibility of equilibrium tides in a gulf or partially inclosed sea.*

Questions relating to the resistances in liquid motion and to the nature of flow at various depths will be considered in Part V.

The resistance referred to in Chapter VI, Part IV A, is assumed to be small and to vary as the first power of the velocity of the moving particles. This assumption generally permits the character and period of the motion to remain the same as it would have been had no resistance (and so no sustaining force) been involved. The amount being kept in abeyance leaves the absolute value of the amplitude of tide undetermined. Even if the amount of resistance were known, the fact that the free period of the body differs somewhat from the period of the forces will directly affect the amplitude of the tide.

Many important conclusions respecting tides in canals, where friction (proportioned to the velocity) is taken into account, have been reached by Airy.† For simplicity such matters have not been brought into Parts IV A and IV B, although a complete explanation of the tides in shallow bodies of water must depend largely upon them. For instance, Airy shows that in a canal stopped by a barrier the tide can not consist of a stationary wave alone, but that the resistance encountered necessitates a wave progressing inward and up the canal. Observations show that, however suddenly terminated a shallow bay or river may be, the stationary wave is always accompanied by a progressive one, although it is hard to find examples in which other causes are not also operative. It is not probable, however, that progressions found in deep bodies often owe their existence to the frictional resistance experienced by the bodies themselves.

The effect upon the tides of the attraction of the water in its disturbed state can be safely assumed to be small. (See Fig. 6.)

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* See Bulletin of the Philosophical Society of Washington, Vol. 14, pp. 93-99.

† Tides and Waves, Arts. 315-346.

CHAPTER V.

THE SEMIDIURNAL TIDES IN THE INDIAN OCEAN.

23. The Indian Ocean north of the thirtieth degree of south latitude is, with one exception, but little influenced by the tides of other waters. The exception is due to the fact that there is a good rise and fall around southern Africa and in Mozambique Channel, where the tide depends upon two systems of oscillations which are determined by boundaries largely outside of the North Indian region. These systems, styled South Atlantic and South Indian, are described in Chapter VII, Part IV A. It may be noted here that observations indicate about I.5 as the Greenwich lunar time of high water in Mozambique Channel, and that this is about the theoretical time of the tide, for it is a mean between XII or o and III; see Fig. 1, which is taken from the chart of semidiurnal systems in the Part just referred to. Extending from Mozambique Channel to Baluchistan and India is a half-wave area whose time of tide, as will be noted later, is largely governed by the tide in the channel.

24. *The North Indian system.*

This system consists of the canal-like whole-wave area extending from the northwestern coast of Australia to the coast of Somaliland and Arabia, and of a dependent fractional area, viz., the Bay of Bengal. Since the eastern part of the whole-wave area has much greater depth than the western, there are some advantages in regarding the whole strip as two half-wave areas.

First of all it is required to ascertain the theoretical times of high water at the loops (i. e., ends and middle) of this strip by applying thereto arrows which denote the intensity and direction of the tidal forces at as many points as we find it necessary to take. In this instance the two points where the axis or central line crosses the two nodal lines will probably be sufficient. The positions of these points are about latitude 12½° south, longitude 103° east, and 3½° north, 67¾° east, respectively. The trend of the axis of the eastern half of the canal is about south 75° east and of the western half, north 58° 40′ west. The free period of this body of water being reasonably close to a half lunar day for a binodal mode of oscillation, therefore the elongation of the particles, and the high or low water, must happen when the virtual work of the impressed periodic forces becomes zero.* For, as will appear from the inspection of Fig. 2, the length and position of the canal are such that the forces tend to incite a considerable oscillation; that is, their effects are not continually neutralized. At various assumed Greenwich lunar hours reduced to the local time by adding the east longitude, project the force arrows upon the axis of the canal.† Considering first the canal as uniform throughout its length, and supposing the forces to act upon equal masses undergoing equal but opposite displacements at the two nodes, the virtual work at any

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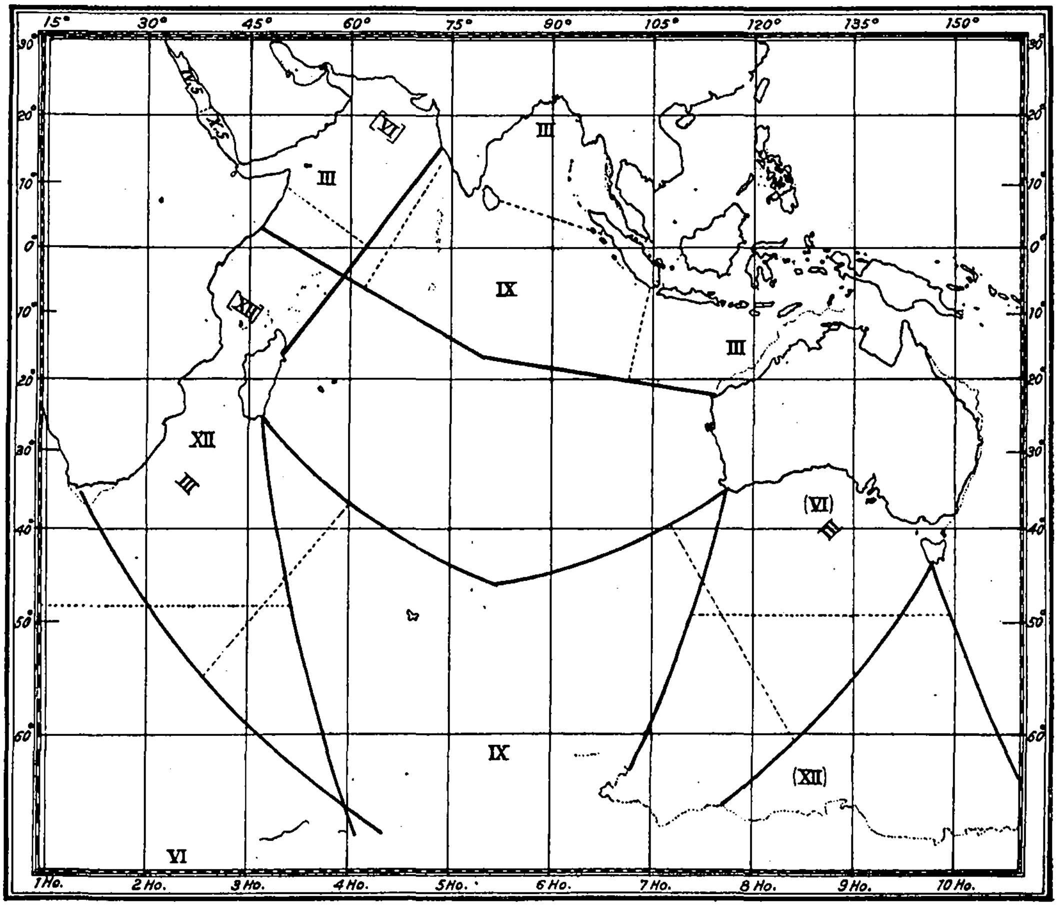
* § 63, Part IV A.

† §§ 2, 65, Part IV A.

given time may be represented simply by the sum of the forces applied to the two nodes provided we regard those as positive which urge the water, say, toward the ends, and as negative those urging it from the ends toward the center. In Fig. 2 the forces being applied only at the two nodes, are given equal weight; those acting on the western area are written to the left of the ordinate, and those acting on the eastern are placed to the right. Forces directed westerly are represented by broken lines and easterly by full lines. The curve in Fig. 2 may be regarded as representing the virtual work in the

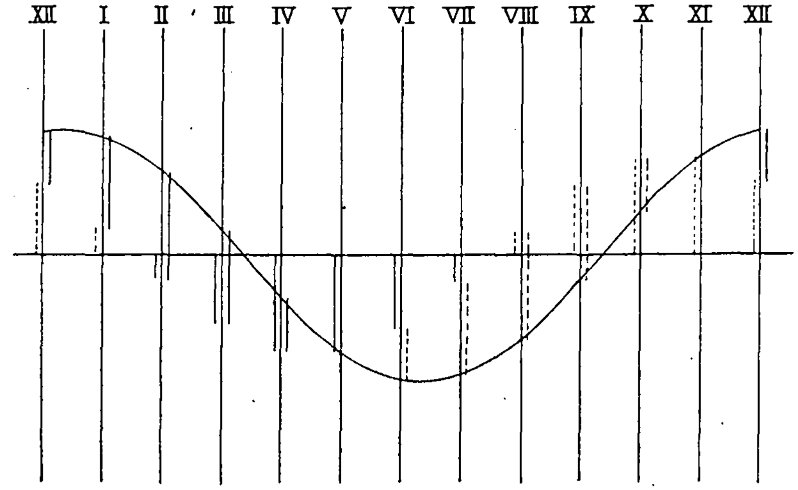
No. 1.



Semidiurnal systems for the Indian Ocean.

present instance for all hours because we can assume that at various times the magnitude of the arbitrary time element is so taken that at a given point the absolute length of the corresponding virtual displacement remains the same for all times; in other words, that the numerical values of the virtual displacements are independent of the time and depend only on the positions of the points considered. They are comparatively large at nodal lines and zero at the loops. Fig. 2 shows that high water at the ends should occur at III.36, Greenwich lunar time, and so at the middle at IX.36. Fig. 3 shows the surface of the water and the configuration of the forces at III.36 both for the nodal points and for points halfway between nodes and loops. It will be noted that the forces in the eastern half are then equal to those in the western and act in the same direction. But if the points are given a slight horizontal virtual displacement, as by putting them in positions which they occupy just previous to the time of elongation, it will be noted that for a uniform canal the displacements are equal and opposite in the two half-wave lengths. Hence the sum of the products of the impressed periodic forces by the virtual displacements must be zero at the hour III.36.*

No. 2.



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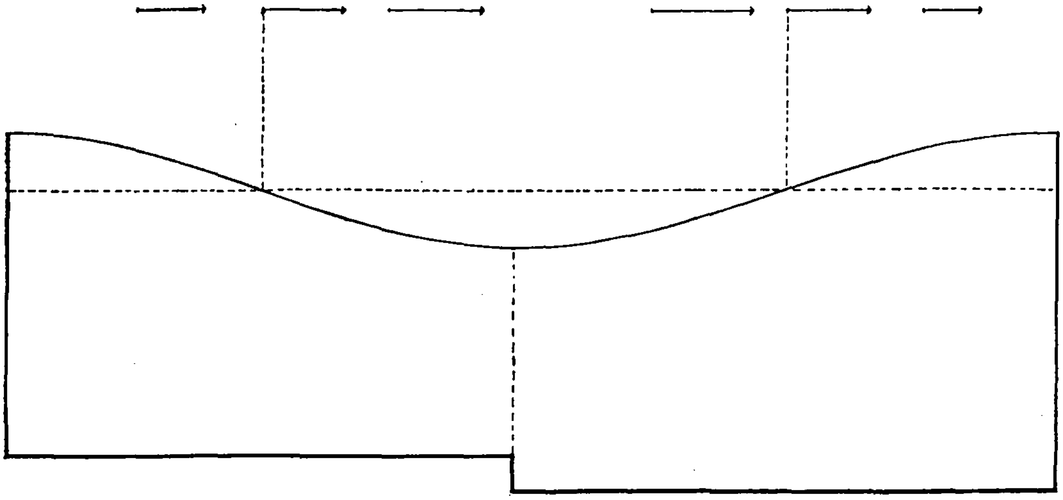

If two half-wave rectangular areas of different depths and widths meet end-to-end at a loop and are otherwise completely surrounded by rigid walls, the above rule for

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*It may be noted here that the factor cos $\alpha_{\nu,\mu}$ should be annexed to each of the parts of eq. (314) Part IV A, it having been accidentally omitted in the copying or printing.

finding the time of tide by means of the virtual work can be carried out in almost as simple a manner as in the case where both are uniform; for, considering each area as being divided into the same number of elementary slices, the product mass × force × displacement, in the two areas, is proportional to depth × width × force. In other words, instead of giving equal weights to the two sets of values, as was done in Fig. 2, one set is to be given greater weight than the other. Again, and this probably has more bearing upon the actual strip under consideration, it is reasonable to suppose that, because of the numerous straits eastward from Java, and the obliquity of the northwestern coast of Australia to the general direction of the strip and the shoaling along this coast, a greater percentage of the forces acting upon the eastern half-wave area will be lost than of those acting upon the western. In other words, the set of values in Fig. 2 belonging to the western part should have a slightly greater weight than the set belonging to the eastern. For this reason it appears that III is probably about as good a value for the times of high water of the stationary wave at the two ends as can be readily estimated from theoretical considerations.

Immediately connected with the whole-wave area is the Bay of Bengal. We can consider the water extending from the head of the bay to some distance southeast of Ceylon as a dependent area somewhat canal-like in form with a nodal line extending from Ceylon to the western coast of Sumatra at a distance from the virtual head of the bay of ¼ λ, or one-quarter wave length. This area synchronizes with the remainder of the system of which it forms a part, and the two together constitute the north Indian system.*

25. *The waters north and northwest of Australia.*

The eastern half of the whole-wave area has, besides the stationary wave, whose high waters occur at III and IX, a progressive wave, due largely to straits or openings between the islands. Of special importance is the strait south of Timor Island. From this opening to the Gulf of Carpentaria, especially where the water is shallow, the tide is chiefly progressive, as shown by the cotidal lines. The progression due to this and other openings is felt halfway or more to the African coast. On account of the great depth of the Banda Sea and of the shortness and considerable depths of the passages around Timor Island and vicinity, the tide is nearly simultaneous over this sea. It is somewhat later and a trifle smaller than the tide around Timor. The maximum eastward velocity through Ombay Passage north of Timor must occur between the time of mean sea level rising (for western Timor) and high water. The progressive wave due to this short strait, approaching from the west, must have its maximum velocity, or high-water phase, northwest of Timor at about the time of maximum velocity in the strait; consequently it must be in advance of what it would be were it to reach the Ombay Passage at the time of high water of the stationary wave. In other words, the tide just west or south of this boundary, pierced by short straits, is a little earlier than it would have been had the straits been broad and the area beyond shallow. It seems reasonable, therefore, to suppose that the progressive wave at the eastern extremity of the one-wave area (say about along the meridian of Kupang) should be about half an hour in advance of the stationary wave. Assuming that the

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* § 76, Part IV A.

amplitude of the progressive wave along the axis of the eastern part of the whole-wave area is equal to the amplitude of the stationary wave at the loops and that the former is half a lunar hour in advance of the latter at the loops, we have, by § 3, the distribution of the cotidal lines shown on the map along the central line of the area.

At first sight it seems strange that the amplitude of this progressive wave could be more than a small part of the amplitude of the stationary wave at the loops. But it should be noted that the energy coming through the tidal forces into the oscillating system is mainly consumed in overcoming the resistances experienced throughout its various parts. If, now, a part of this energy be lost to the system because of breaks in the boundary near a loop or because of extensive shoaling, the resulting progressive wave traversing a region small in comparison with the whole system may, for some considerable distance westward from the opening in the boundary, have an amplitude comparable with that of the remaining stationary wave, and the system will oscillate nearly as it would in the case where no energy were thus lost; but, of course, the amplitude will be somewhat diminished.

It is reasonable to suppose that the southern extremities of the cotidal lines west of Australia and numbered IX to II turn eastward, somewhat as shown upon the map, because of the progression directed toward Timor Island.

26. *The half-wave area.*

This area extends from Mozambique Channel to Baluchistan and India, being largely a dependent one whose tide is governed by the rise and fall in and just south of the channel. It has already been remarked that observation and theory give about I.5 as the time of high water in the channel.

The bracketed values XII or 0 and VI, shown in Fig. 1, are intended to refer only to the South Atlantic system; that is, they indicate the theoretical time of tide as it would be without the North and South Indian systems, and not the times of the actual tide.

Assume now the existence of the South Indian system without the North Indian; the tides in this area will, as was assumed before, synchronize with those in the channel, and so instead of 0 and VI we shall have about I.5 and VII.5.

If, on the other hand, a wall were built across the channel, the theoretical times of tide produced in this half-wave area would then be II.1 and VIII.1.

But the L-shaped region extending from Mozambique Channel toward India, thence to northwestern Australia, can not have twelve hours as its free period because the virtual length of either of the two trapezoids into which the region can be divided is too small, being in each case less than that of the original rectangle. It is, therefore, fair to assume that the Mozambique-India half-wave area does not synchronize with the Australia-Arabia whole-wave area; for, although each has a free period approximating twelve hours, the period of the combination regarded as an L-shaped figure is much shorter.*

We can, therefore, by lemma 27, suppose that the oscillations of the north Indian system and that of the Mozambique-India area are nearly independent of each other, although it is probable that the latter is accelerated a few minutes by the former because

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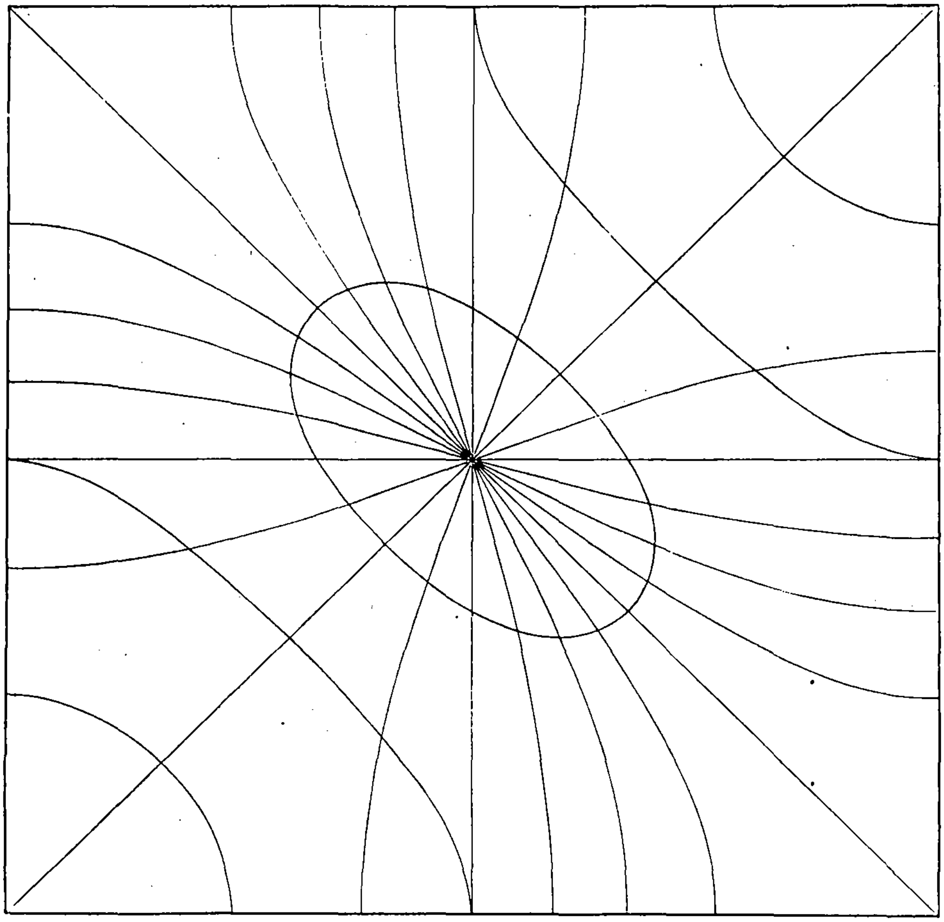
* § 43, Part IV A or lemma 5.

the loop in the Arabian Sea marked III, Fig. 1, lies unequally with respect to the nodal line off Somaliland.

Before proceeding further, let us consider the case of two systems of oscillation in a square area. For simplicity, let the two amplitudes be taken as equal. Suppose the phase of the north-and-south oscillation to be 60° in advance of that of the east-and-west oscillation. Fig. 4 shows the arrangement of the resulting cotidal lines for each half hour, also the lines along which the range of the tide is constant. It is to be noted that the cotidal lines are crowded together near the nodal lines of the component oscillations. The crowding will differ from that shown in Fig. 4, if we use another amplitude ratio and phase difference. But this figure will give a general idea of how the cotidal lines should be drawn for a square area. In all cases where the phase difference is not zero or 180° there must be a no-tide point around which the numbers of the cotidal lines progress, but not uniformly or at the rate due to depth. Where the phase difference is zero or 180° there will be a nodal line and no progression.*

No. 4.



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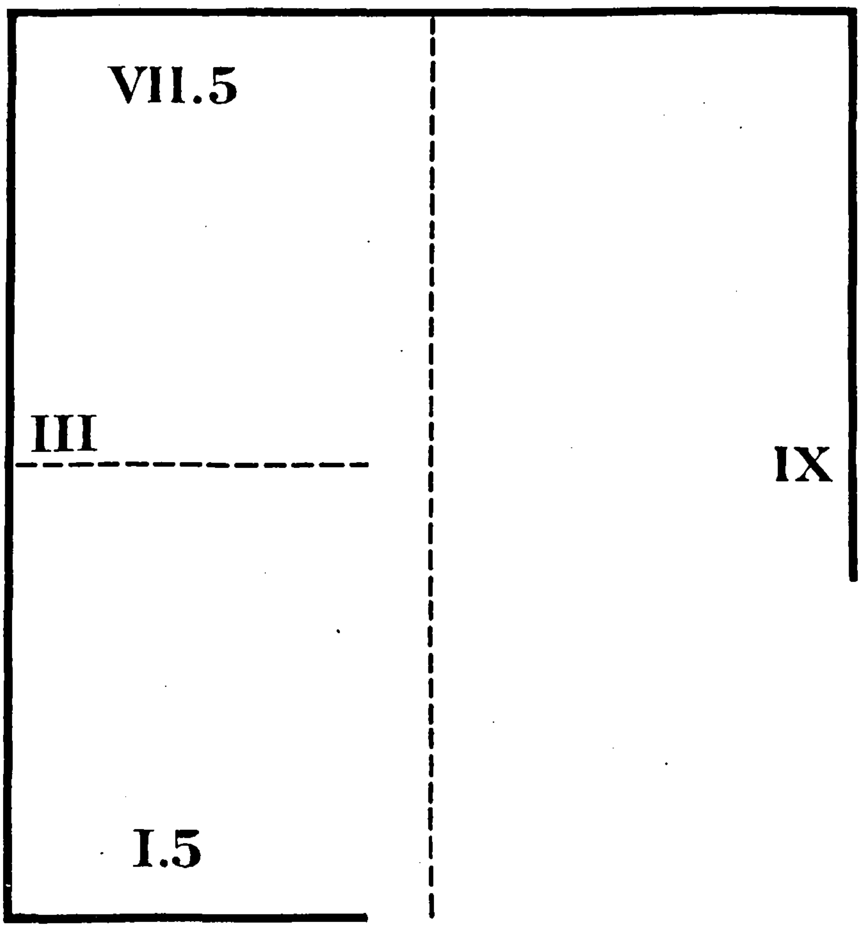
* §§ 26, 32, Part IV A and § 4, Part IV B.

Returning now to the Arabian Sea and adjacent waters we note that the conditions are far from having the simplicity of a square. Nevertheless, considering the superposition of two independent systems, it can hardly be doubted that there exists a point near the intersection of the nodal lines (Fig. 1) where the range of tide is very small. It is almost certain that the cotidal lines should approximately radiate from this point being crowded together in the vicinity of Cape Guardafui and spread apart in the Arabian Sea and toward the Mozambique Channel. Moreover, the progression around this point should be clockwise and apparently irregular.

No. 5.



Instead of the complete square, Fig. 4, imagine a region having nearly the form of a square, but deprived of a portion of its boundary, as shown in Fig. 5. The half-wave area occupies the greater part of the western half of region. The western half of the whole-wave area covers a little more than the northern half of the region. The eastern boundary, although imaginary or latent,* is as good as rigid so far as producing the tide is concerned. Although, as will be noted in § 31, the cotidal hour for the region

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* § 29, Part IV A.

lying between the central loop of the North Indian system and that of the South Indian system is not far from VIII, and so the hour for the whole of the eastern end of the hypothetical square differs but little from IX, it is impossible to have an east-and-west oscillation across the southern portion of the square because no whole-wave area is possible immediately south of the North Indian system, and so the latent boundary of the eastern side of the square can not extend beyond the southern limits of this system.

At the India end of the Mozambique-India region the east-and-west or whole-wave oscillation is probably as important as the north-and-south or half-wave, while at the south end the east-and-west oscillation is not directly felt. Hence, at India the tide occurs between the hours III and VII.5. In the Mozambique Channel, on the contrary, it occurs at I.5, or probably a little earlier (say at I), because of the slight influence of the north Indian system already referred to. Around the southern Maldive Islands, and especially around the Chagos Archipelago, the half-wave oscillation does not exist. From the Arabian Sea to the loop south of Ceylon the tide is small, and there an irregular progression occurs, as is usually the case between two nonsimultaneous regions not too far apart.* There is also an irregular progression from the loop south of Ceylon to northern Madagascar. The direction of these progressions is clockwise, as was that inferred at the close of the preceding paragraph. In the Gulfs of Aden and Oman the tide consists chiefly of stationary oscillations, although there is some progression on account of the inner waters beyond. Each of these two gulfs constitutes a dependent canal-like area whose length is a small fraction of the wave length λ.†

The Persian Gulf being a large, shallow body of water connected with the Gulf of Oman by a large strait, has a tide which progresses at about the rate due to depth. There is some retardation and therefore some crowding up of the cotidal lines in the strait.

27. *The Red Sea.*‡

The tide in this sea is composed of a stationary wave caused by the tidal forces acting on its waters and a progressive wave produced by the outside tidal disturbances acting through the Strait of Bab el Mandeb. The force arrows applied to the nodal line of this sea, regarded as a simple canal-like area whose period is about a half day, give IV.5 and X.5 as the cotidal hours of the north and south ends, respectively.

Because the range of the outside tide diminishes rapidly in passing through the strait, it is difficult to ascertain where a wave progressing at the rate due to depth will be established. But observations made at the north end of the sea indicate that high water of the resultant or combined wave occurs there at about III.75 hours, whereas, according to what has just been said, the high water of the stationary part should occur at IV.5. If now we assume the amplitude of the progressive wave over the Red Sea to be constantly equal to the amplitude of the stationary wave at the loops, and assume the phase of the progressive wave to be 45° in advance of the phase at the loops of the stationary wave, the result of combining the two is as shown by the cotidal lines, the extreme southern end of the sea being excepted (§ 3). On account of the extreme narrowness of the strait, these assumptions concerning the progressive tide seem to be reasonable. In making the computations the depth of the sea was assumed

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* Lemma 25.

† Lemma 12.

‡ §§ 80–82, Part IV A.

to have a certain constant value over the region north of the nodal line and a slightly smaller but constant value over the region south of it. The manner in which the cotidal lines should be distributed in and near the strait is somewhat uncertain because the theory underlying such cases has not yet been worked out.*

As indicated by the map the tide in the narrow but deep Gulf of Akabah is chiefly a stationary wave, whose high water is about simultaneous with that at its mouth.

The tide in the much shallower Gulf of Tor is also chiefly a stationary wave with a node at Tor Bank.† However, as the ending of the gulf is not extremely abrupt there must be some small progression upward. Assuming the cotidal hour of both stationary and progressive waves to be III.75 at the mouth and the constant amplitude of the progressive wave to be one-third of the maximum amplitude of the stationary wave, we obtain the cotidal lines shown on the map.

28. *No large wave progresses from the South Indian Ocean into the North Indian, producing the tide of the latter.*

An harmonic analysis of the tides at Freemantle, Swan River entrance, western Australia, shows that the average range of semidiurnal tide is there only 0.4 foot. A similar analysis at Port Louis, Mauritius Island, gives for the mean range of tide 1.1 feet.

Upon examining any chart of the Indian Ocean which shows the depths approximately, it will be seen, upon making a few measurements, that the region of small range extending from Freemantle to Mauritius Island can not indicate a true nodal line. Again, observations do not indicate that nearly the whole of the Indian Ocean belongs to one system, as such an extended nodal line would imply.

We are therefore led to believe that there is a region of small semidiurnal tides extending from Freemantle to Mauritius Island, and that the absence of a good tide is due to the fact that the distance between western Australia and Madagascar does not approximate to λ or to one-half λ, as an east-and-west stationary wave would require. Some tide, however, exists, and for reasons which will be given in § 31.

By referring to the table given in § 97, Part IV A, it will be seen that for Freemantle (690), Kupang (614), Banjuwangi (561), and Port Louis (870), the ratio $S_2:M_2$ is larger than the corresponding ratio of the tidal forces, i. e., than 0.465. The same is true of Port Darwin (681.5), given in § 19, Part IV B. This indicates that the length of the whole-wave area of the North Indian system, especially of this area when joined with or influenced by the waters between Australia and Madagascar, corresponds better to a solar-wave length than to a lunar. This accords with inferences made from known distances and depths by aid of Table 51.

Again referring to the same tables it will be seen that the ratio $O_1:K_1$ is considerably less than the corresponding ratio of the forces ($=0.711$), not only for the stations just mentioned but for the Indian Ocean generally. This shows what might have been inferred from Fig. 24, Part IV A, that the Indian diurnal system responds better to the period of K_1 than to the period of O_1.

There is some inward progression from Rodriguez northwesterly toward the Farquhar Islands and Cape Amber, but it is to some extent mixed up with the

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*113, Part IV A.

†81, Part IV A.

stationary wave around northern Madagascar. In fact the tide between Rodriguez Island and Cape Amber is due chiefly to the rise and fall at the north end of Mozambique Channel; that is, a species of dependent transverse oscillation, part stationary and part progressive, is maintained by this rise and fall. A somewhat similar effect may exist off Northwest Cape, Australia. The cotidal lines must change from VIII to I in going from the early region east to Reunion Island to the northern end of Mozambique Channel, and from VIII to III in going from this early region to the loop northwest of Australia.*

29. *Miscellaneous remarks.*

Upon referring to Fig. 1 it will be noticed that because of proximity to nodal lines the range of tide around Ceylon and southern Hindustan must be small. For the same reason the tide along the outer or southwestern coast of Sumatra should be small. The tide at the western end of the southern coast of Java should be smaller than is the tide farther east. All these requirements accord well with the observed facts, as can be seen upon referring to the large map, Fig. 7.

The distribution of the cotidal lines through each of the nodal lines respectively located east of Ceylon, off the Malabar coast, and off Somaliland has not been made upon the map in accordance with any assumed mathematical law. The lines are chiefly conjectural, although in accord with the observations.

Upon measuring the dimensions of the oscillating areas, it may appear that the actual lengths are a trifle too short for the existence of large tides, although no definite criterion has been laid down in such matters. There are difficulties in the application of Lagrange's rule to even a canal-like body of variable depth. It seems, however, upon comparing the times required for the eruption of Krakatoa to have been felt at ports in India, Arabia, and Africa, that the areas as laid down on Fig. 1 must have a free period sufficiently long to permit good stationary oscillations.†

The map shows several cases in which a derived wave is produced at a sudden shoaling. For example, the Gulf of Martaban, the vicinity of the mouths of the Ganges, the Gulf of Cambay, and off the Gulf of Kutch. The progression north of Australia is due largely to such sudden shoalings as the Sahul Bank. A dependent stationary wave is apparent in the Gulf of Kutch, and some traces of dependent stationary waves, shown in the acceleration of the times of the tide, can be seen at the 80-mile beach (on the northwestern coast of Australia) and near and in the mouth of the Hugli River.

Sokotra Island and neighboring shoal have some influence upon the distribution of the cotidal lines in that locality. A similar remark may be made concerning the Laccadive and Maldive Islands.

In passing through Sunda Strait, the range rapidly diminishes, while the cotidal lines bunch up.‡ A somewhat similar statement is true of the narrow straits farther east.**

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*Lemma 25.

†Cf. The Eruption of Krakatoa, and Subsequent Phenomena, tabulation opposite page 148 and Plate XXXV.

‡Lemma 10.

** §§ 104–106, Part I V A.

The tide wave entering Palk Strait proceeds southwesterly up Palk Bay, at about the rate due to depth, nearly to Adams Bridge.

The tide proceeds southeasterly through Malacca Strait, but not at the rate due to depth alone, excepting in the broader portion.

30. *Evidence obtained from tidal streams.*

The directions of the observed tidal streams as given in the Admiralty Pilots afford some clue to the character of the tidal oscillation, especially in localities where the motion is rectilinear. Around the Maldive Islands the flood stream sets easterly and around the Chagos Archipelago it sets southeasterly. In the northern end of Mozambique Channel the flood sets southerly and in the southern end northerly. Moreover, we find that flood slack occurs soon after high water in the channel, as a stationary oscillation requires. These facts could have been inferred from Figs. 1 and 7.

On the southern coast of Cape Colony, from Table Bay eastward to Port Alfred, no sensible tidal stream exists, although there is a moderately large rise and fall. This is in accordance with the lines of motion terminating at the shore which runs nearly perpendicular to them. See Fig. 1.

The southern shore of Baluchistan lies at the loop of the half-wave area as also of the whole-wave area. Consequently the tidal streams should there be weak, and observation shows this to be the case.

Across the shoals and around the islands east and northeast of Madagascar there are strong tidal streams. According to the map of cotidal lines, this is a region where the tide varies both in time and in range; such conditions always imply large accelerating forces for the water masses and generally large velocities, especially over shoals.

In the short straits which separate from one another the islands east of Java, the currents should be swift. This statement is confirmed by observation. But whether or not the time of maximum flood velocity is an hour or so before the time of high water at the southern ends of the straits has not yet been ascertained.

Strong tidal currents occur among the Nicobar Islands and generally among the Andaman Islands. At Table Island the streams turn at about the times of high and low water.

The streams in the Gulf of Suez accord well with the notion of a stationary wave, the times of slack water very nearly coinciding with the times of the tide at the head of the gulf.*

31. *The South Indian system.*

The South Indian system has been briefly considered in § 77, Part IV A. It extends from the south coast of Australia southwesterly ½ λ to where it is supported by the Antarctic Continent; thence northwesterly ½ λ to Madagascar and South Africa. By constructing a diagram similar to Fig. 2, it will be found that the theoretical cotidal hour for either end is about III, and for the middle IX. According to Figs. 6 and 40, the cotidal hour for the south coast of Australia is about III.

By referring to Fig. 6, it will be noticed that there exists a region north of Kerguelen Island, from which the numbers of the cotidal lines increase in whatever direction one goes. The approximate time of tide of this region can be seen from theoretical

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* § 80, Part IV A.

considerations, viz.: It should be not far from IX, because this is the time for the loop of the systems lying to the north and to the south of it.* On account of the magnitude of the space between the two systems, it is reasonable to expect to find small ranges between Australia and Madagascar. Farther south the range is greater; the mean range at St. Paul Island being 3.0 feet, and at Betsy Cove, Kerguelen Island, 3.2 feet. According to Fig. 6, the hour for this region is VIII. Figs. 6 and 7 show a number of progressions in various directions whose antecedent waves extend to this region † and have the effect of causing its tides to occur a little earlier.

Just westward of this early region, particularly of its northern part, a great crowding up is necessitated because the tide south of Africa and Madagascar occurs at I, Greenwich time, and its range is there considerable.

Spencer Gulf.—According to Fig. 40, the tide is partly progressive and partly stationary. The same is true of the Gulf of St. Vincent. This can be seen by using the depths given in Fig. 34, Part IV A, and Table 50 or 51.

The tides off Kangaroo Island are delayed by openings on either side of the island.‡

Bass Strait.—The Pacific tide joins the Indian tide near the western end of the strait. The range of tide is somewhat greater at the eastern end than at the western.

In Port Phillip the tide is delayed and its range diminished by the narrow entrance. (See Figs. 34, 35, and § 105, Part IV A.)

South of Tasmania there is a large region whose cotidal hour is about X. The tide is largely due to the Pacific acting through the channel between New Zealand and Tasmania. But upon referring to the South Pacific system (Fig. 23, Part IV A) it will be seen that the loop marked XII lies near the Antarctic Continent southeast of New Zealand, while the loop marked IX of the South Indian system rests upon the Antarctic Continent southwest of Australia. Hence the time of tide along the Antarctic Continent changes from IX in this last locality through X south of Tasmania to XII southeast of New Zealand.

From this X region to the loop marked III just south of Australia the time of tide changes rapidly, as is indicated by the crowding up of the cotidal lines just west of Tasmania.

32. *References to Indian Ocean tidal observations and discussions.*

India.—Reports of Survey of India, referred to in § 18.

India; Kerguelen Island; and Southwest Australia.—Proceedings of the Royal Society of London. Vols. 39, 45, and 71.

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Port Louis, Mauritius Island.—Voyage autour du Monde, de l'Uranie, Vol. II. Paris, 1826.

St. Paul Island.—Recueil de Mémoires, Rapports, et Documents Relatifs à l'Observation du Passage de Vénus sur le Soleil. Paris, 1878.

Madagascar and Indo-China.—Comptes-Rendus de l'Association Géodésique Internationale, 1900.

Annales Hydrographiques, 1901.

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* Lemma 25, last line.

† Lemma 29.

‡ Lemma 31, Case 3.

CHAPTER VI.

THE SEMIDIURNAL TIDES IN THE ATLANTIC OCEAN.

33. *Character of Atlantic tides.*

The tides of the Atlantic Ocean are remarkable for the smallness of the diurnal wave, a circumstance due to the absence of oscillating systems whose free period approaches 24 hours.* As the small tides of the Mediterranean Sea caused the civilized nations of antiquity to pay little attention to the semidaily rising and falling of its surface, so in later times the small diurnal inequality in the Atlantic caused the western nations to regard as remarkable the tides observed in other seas where this inequality becomes prominent. But when Newton calculated its theoretical amount by his equilibrium hypothesis he saw that the forces indicated an inequality in the tides several times greater than any which had been observed on the coasts of Europe. This led him to an erroneous explanation of the phenomenon. The error was pointed out by Laplace. But he in turn makes the erroneous suggestion that the smallness of the diurnal rise and fall in the Atlantic may be analogous to its total absence in case of a globe uniformly covered with water. †

The semidiurnal tides of this ocean are due chiefly to two oscillating systems, which are described in §§ 72–73, Part IV A.

By referring to Fig. 6, it will be seen that there is one conspicuous amphidromic region southeasterly from Newfoundland, the center being placed at 40° N. and 40° W.

It will also be seen that there is, generally speaking, a northerly progression in the time of tide from the Antarctic Continent south of Cape Colony, through the main body of the Atlantic. The progression from South Africa northward led to the once common belief that the tides of the Atlantic are largely, or even chiefly, derived from the waters farther east. It is true that unaccountable irregularities in the rate of this progression and great variations in the range of tide caused many students of the subject to doubt the derived-wave hypothesis.

The reasons for a general northward progression along the western coasts of Africa and Europe are not difficult to find, nor are its irregularities surprising. Given several regions of high water, such as would be produced by two oscillating systems, it is clear that in going from one region to another the times of tide for all intervening points will be forced to assume all intervening values. The change may be made suddenly, causing a crowding together of the cotidal lines, or it may be made in such a way as to distribute them more equably. ‡ Progressive waves in the ocean are generally caused by openings in the shore lines at or near the loops of the oscillations where the rise and

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* § 92, and Fig. 24, Part IV A. † See §§ 88, 101, Part I. ‡ Lemma 25. Cf. § 35, Part IV A.

fall is considerable.* A similar cause is the sudden receding of the shore line from a part of it which supports a good rise and fall.† The openings around the northern part of the North Atlantic generally favor northward progression; so do the sudden recessions of the coast and changes of depth near Cape Frio, South Africa, and between Sierra Leone and Cape Verde.

But even in this ocean there are progressions taking other than northerly directions. The tidal hour for the waters around southern Greenland lies between VIII and IX, and for deep water off the eastern coast of the United States it is about XI½. Some kind of southerly progression from the former region to the latter must, in consequence, take place.‡ The tide progresses southwesterly from a region west of the Cape Verde Islands to the northeastern coast of Brazil. This is largely due to the overlapping of the two systems (§ 4).

However, on account of the general tendency of the progressions of the times of tides, we shall begin with the southeastern corner of the ocean and gradually work northerly and westerly. The tides of Patagonia and Argentina will be described in connection with the South Pacific system, from which they are derived.

34. *South Atlantic Ocean.*

The first half wave of the South Atlantic system (Fig. 23, Part IV A), extends from the Antarctic continent to latitude about 27° S. The southern coast of Cape Colony is therefore less than ½ λ distant from the Antarctic continent, and so the intervening region responds to the solar forces more readily than to the lunar.

The east-and-west extent of the Cape Colony coast line is not, however, sufficient for the establishment of an independent solar system of large range of tide.||

Doubtless the South Indian system, taken in connection with the adjoining waters to the north of it, also favors the solar forces. Hence it is not surprising to find that the ratio S_2/M_2 is 0.55 for Durban, Port Natal, and 0.47 for Port Elizabeth, Algoa Bay. Cape Town being less influenced by the South Indian system, the ratio S_2/M_2 becomes somewhat smaller, viz., 0.42.

The considerable progressive wave over this half-wave area is necessitated by the progressive wave generated near Cape Frio, as mentioned in the preceding section, and which is chiefly responsible for the tides in the Gulf of Guinea.

Between the loop marked XII, west of South Africa, and the eastern coast of Brazil is a branch of the next or second area of the South Atlantic system.

The great distance between the lines V½ and VI, east of Brazil, Fig. 9, indicates the stationary character of the oscillation. The decrease of range in going from Pernambuco to Rio de Janeiro indicates approach to the free southern boundary of this branch area.

The Admiralty Tide Tables give 2 feet as the value of the spring range at Ascension Island. This indicates that the nodal line of the area probably passes not far from it.¶

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* Lemma 14.

† Lemma 19.

|| Lemma 3.

‡ Lemma 25. Cf. § 35, Part IV A.

¶ § 79, Part IV A.

35. *From Liberia to the Windward Islands.*

The tides of Liberia and Sierra Leone are not much affected by the North Atlantic system, but belong chiefly to the South Atlantic system. Hence, unless delayed by shoals, the tidal hour should be VI. A nodal line of the North Atlantic system probably passes just south of the Cape Verde Islands. Hence it happens that from a region south of these islands or even from Liberia to the Barbados the time of tide changes by scarcely more than half an hour. There are extensive shoals west of Sierra Leone and around the Bijonga Islands.

The northeastern coast of Brazil forms a portion of the end boundary of the North Atlantic system, and so the theoretical time of tide for the greater part of this coast is about VIII.* The southern lateral boundary of the South Atlantic system is situated some distance out from the coast of Guiana and Brazil, somewhat as indicated by a heavy line in Fig. 23, Part IV A. Hence the theoretical time of tide off this coast lies between VI and VIII (§ 4). The extensive shoals off the Amazon and Para rivers cause a considerable progression, and delay the time of tide for this part of the coast.

In going up the shallow delta of the Amazon, the tidal hour is much increased; but tidal data and even soundings are so meager that cotidal lines can not be drawn far up the river. A bore occurs when the range of tide and stage of the river are favorable.†

The tides around Trinidad Island belong almost entirely to the North Atlantic system. The range is much greater on the south side of the island than on the north side, the oscillation in the former locality being better supported than in the latter. Hence the strong currents experienced by Columbus in the Dragon's Mouth.‡

From Trinidad to Guadeloupe the semidiurnal range of the tide diminishes rapidly. The tides in the southeastern part of the Caribbean Sea are derived from the loop marked VIII of the North Atlantic system influenced, however, by the loop marked VI of the South Atlantic system.||

36. *From Guadeloupe to the United States.*

The range of the semidaily wave on the south coast of St. Thomas Island is a little less than 0.3 foot, and the mean range of tide San Juan, P. R., is 1.1 feet. These indicate that the nodal line lies not far east of St. Thomas. Figs. 11, 14, 16, show how nearly simultaneous are the tides along the greater part of the Atlantic coast of the United States, the Bahamas, the northern coast of eastern Cuba, the northern coast of Haiti, and of Porto Rico. Moreover, the range steadily increases in going from St. Thomas to Savannah River entrance where it is 6.8 feet. All these facts point to a stationary oscillation, and Fig. 23, Part IV A, indicates that it forms part of the South Atlantic system.

Here we have one of those rare cases where a nodal line of a system is not obscured by progressive waves or by the overlapping of another system.

Upon consulting the charts of soundings, Figs. 19, 20, Part IV A, and making use of Table 51, it will be seen that the length of the South Atlantic system is a little more than $3/2\ \lambda$. Hence unless neighboring waters alter the mode of oscillation for the solar wave it follows that the ratio S_2/M_2 must be less than the ratio of the corresponding

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* Lemma 9.

† § 15, Part I.

‡ § 75, Part I.

|| Lemma 14.

forces. The quarter wave length here considered is almost free from such influences. Hence the remarkably small value of this ratio for tides along the Atlantic coast of the United States. See table in § 97, Part IV A, Nos. 32–105.

37. *The Caribbean Sea.*

The tide along the coast of Panama agrees well with the corrected equilibrium theory both as to time and range (§§ 2, 3, Part IV A).

The tide in the northern portion of the sea is due chiefly to the tide north of Cuba and Haiti acting through the Windward Passage. Farther west the effect of the tide in the Gulf of Mexico becomes apparent. See Figs. 11 and 17.

As already noted, the tide in the southeastern corner of the sea depends directly upon the tide in the ocean just outside.

The northeastern corner of the sea can have only very small ranges because a nodal line exists in the outside waters, and because the numerous openings between islands which bound the sea on the north and east prevent the formation of an equilibrium tide. The hour of tide changes rapidly, increasing toward the north.

Very little is known of the tides along the southern coast of Haiti or along the opposite coast of South America.

38. *The Gulf of St. Lawrence.*

The tides of the Gulf and River of St. Lawence are interesting in several respects, but chiefly on account of a large, stationary oscillation, a landlocked wave eddy or amphidromic region, and a wide variation of range at different points of the river. The first of these features has been noted in § 91, Part IV A, and the other two are shown upon Fig. 13, Part IV B. A map of soundings covering this region is given as Fig. 31, Part IV A.

North of the Magdalen Islands the range of tide is small while in the channel off Cape Rosier or Gaspé the range is 4 or 5 feet. The shore line here suddenly turns off from the direction of the main channel, forming the western boundary of a broad, shallow embayment. Hence, by lemma 19, a southward progression takes place following the general direction of this shore line. Section 13 deals with cases of this kind; what is there referred to as the "outside body" is here represented by the channel between the Magdalen Islands and Anticosti Island. The range of this progressive shore wave diminishes as it proceeds. The part entering Northumberland Strait from the west meets the wave from the east at Cape Tormentine.

Upon referring to the cotidal chart of this region as well as to the chart of depths, it will be seen that progression in the river at the rate due to depth does occur below the mouth of Saguenay River. The greatest range occurs off the lower end of the Isle of Orleans, where it is nearly 17 feet; the tide disappears at Lake St. Peter.

As might be expected, the duration of fall in the upper part of the river considerably exceeds the duration of rise; at Quebec the difference is two solar hours.

The tide of Chaleur Bay is chiefly stationary.

A branch of the main channel extends northeasterly between Newfoundland and Anticosti Island. The tide in the center of this branch is nearly simultaneous with that at the point where it joins the main channel; but some delay occurs in reaching either shore. Moreover, the gradual narrowing and shoaling of this area between Newfoundland and Quebec causes the range on either side to be considerable, viz., 3 or 4 feet. The tidal hour off the eastern end of Anticosti Island being II½ and off the western end a little more than V½, the cotidal lines must crowd together in the strait north of this island.

The Strait of Belle Isle has little influence upon the tides of the Gulf.

The tidal hour is probably between XII and XII½ for the eastern coast of the Magdalen Islands, and probably assumes all values from ½ to XII along the remainder of the coast, but no data are available for verifying this conclusion.*

39. *From Nova Scotia to Rhode Island.*

Along the greater part of the Atlantic coast, extending from Nova Scotia to Florida, the time of tide is but little delayed on account of the strip of shallow water which borders it. (For depths, see Figs. 19 and 31, Part IV A.) This is an application of lemma 9, since the offshore flood and ebb streams are probably nearly normal to the coast line. We can imagine canals leading from deep water to or into the coast line, each having a stationary oscillation. Generally such canals are less than ¼λ in length. The Gulf of Maine has a shoaling at Georges Bank which causes a progression to there be formed; that is, the Gulf of Maine can not be considered as forming part of the large body of water to the southeast or even as being a dependent area synchronizing with it. The virtual length of the Gulf of Maine and the Bay of Fundy being nearly ¼λ, there must result large tides for the inner waters, sustained by the progression, and occurring three hours later than the tides outside. This has been explained in § 34, Part IV A and alluded to under lemma 12. A similar explanation applies to Long Island Sound, but instead of a shoaling at the mouth we there have a contraction.

In case of tidal rivers, the tide wave is generally progressive, so that there is no tendency to synchronization with the tide outside. Off the mouths of large rivers, antecedent waves become noticeable.

Large as is the tide in the Bay of Fundy, it doubtless would have been a little larger, in the bay proper, had there been no Basin of Mines. For reasons similar to those just referred to, the oscillation of the bay is interfered with by any dependency which can not synchronize with it. As it is, this branch implies an antecedent wave, and so there must be some progression up the bay from this cause.

The converging shore line and lessening depths increase the range in either stationary or progressive waves. For this reason the largest tides of all occur near the head of the Basin of Mines and up the Petit Condiac River, the range in the former reaching about 43 feet and in the latter 40 feet.†

At Boston the range of tide is 9.6 feet and at St. John it is 20.8.

The smallest known mean range of tide connected with the Gulf of Maine oscillation occurs at Tom Nevers Head, on the south coast of Nantucket Island, and amounts to only 1.2 feet. (See Figs. 14 and 15.)

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* For tides in the Gulf of St. Lawrence, see Dawson's Reports on Survey of Tides and Currents in Canadian Waters for 1898, 1899, and 1903.

† For tides in the Bay of Fundy, see Dawson's Report on Survey of Tides and Currents in Canadian Waters for 1899. For tides in St. John River, see Bulletin XV of the Natural History Society of New Brunswick, pp. 65–82.

The tide north of Nantucket Island comes from the east and its hour is about IV½. The XII-hour line passes a short way south of Nantucket Island and meets the land at the western end of Marthas Vineyard. Hence the change of four hours in going through Muskeget Channel and the rapid currents. The change is also rapid between Marthas Vineyard and the mainland. The tide wave in Buzzards Bay is almost stationary, the time of occurrence being less than half an hour later at the head than at the mouth.

The tide reaches the southern side of Sable Island about one hour before it reaches the northern side. This shows the delaying effect analogous to that referred to in lemma 28. (See also Fig. 13, Part IV A.)

In going from the Greenland loop of the North Atlantic system to the United States loop of the South Atlantic system, the tidal hour must change from VIII to XII. The manner in which this change takes place depends largely upon the depths encountered and upon the presence of antecedent waves which are necessitated by the progressive waves, the latter being due to openings in the shore line or to off-lying shoals, lemmas 10, 14; e. g., Cabot Strait, the submerged strait south of Nova Scotia, Georges Bank, Browns Bank, and Florida Strait.

40. *From Rhode Island to Florida.*

The tidal hour for this stretch of coast is about XII. The earliest point is Cape Lookout, where the hour is XI½.

The tides in Long Island Sound are analogous to the tides in the Gulf of Maine and Bay of Fundy, and so at the western part of the Sound are three hours later than the tides outside and upon which they depend. There is, however, some progression. The range varies from 1.9 feet at Montauk Point to 7¼ feet at the western end of the Sound.

On the outer or southern coast of Long Island the tide occurs remarkably early, for reasons given in connection with lemma 32 (case 3). This is so notwithstanding the existence of Fire Island Inlet and other smaller straits leading to Great South Bay. For, the flow through the inlet being simply a hydraulic effect, the tide just south of the inlet will be accelerated rather than retarded. (Cf. § 25 and statements under lemma 29.)

The tides in New York Harbor and the lower part of the Hudson River have nearly the same range as the tide at Sandy Hook, where it is 4.6 feet. At Governors Island the tidal hour is XII.72, while at Willets Point it is III.66. This in a general way explains the strong tidal currents in East River, as was pointed out in § 37, Part I, and § 106, Part IV A.

The tides of Peconic, Great South, Jamaica, and Barnegat bays are chiefly due to hydraulic effects, the rising and falling of the waters outside causing a rapid flow through the connecting straits or inlets. For Great South and Barnegat bays the range is much reduced and the time of tide delayed, as shown in Fig. 15. (See §§ 104, 105, 111, Part IV A.) (In the formula there given for κ, the words "amplitude of tide outside" should be stricken out.)

Up the Delaware Bay and River the wave progresses at nearly the rate due to depth. The values of Fig. 14 show that the range increases considerably above its value at the capes. The difference between the duration of rise and fall at Philadelphia is 2 h. 35 m.

While the funnel-shaped Delaware Bay favors an increasing range of tide, Chesapeake Bay, with its contracted entrance and subsequent expanse and connections with dependent tributaries, tends to reduce the range. The tide progresses up the bay, but in a somewhat irregular manner, as shown in Fig. 14. Near the mouth the high water occurs on the western shore of the bay before it occurs in the western shore of Cape Charles; this is a case coming under lemma 28. Up the numerous tidal rivers the wave progresses regularly. However, by lemma 32 the progression is slower than mean depth would call for.

The tides in Albemarle Sound, Pamlico Sound, and in New River are very small, owing to the narrow openings connecting them with the sea.

For South Carolina, Georgia, and northern Florida the range of tide is larger than for the outer coast farther north. Here the last loop of the South Atlantic system finds a good support; moreover, the distance to the free northeasterly boundary of the system is considerable.

The tide in the St. Johns River is greatly reduced in range at Jacksonville, where there is a constriction in the river.

As the Strait of Florida is approached the range decreases.

41. *The Gulf of Mexico.*

Upon referring to § 3 and Fig. 23, Part IV A, it will be seen that the tidal hour for the eastern part of the Gulf should be III, according to the corrected equilibrium theory, and the hour for the western part should be IX. Upon referring to the chart of cotidal lines for the Gulf, Fig. 17, this will be seen to be the case; but it will also be noticed that, excepting the eastern part, the hours generally progress in going westward, and so the cotidal lines are not amphidromic, as the equilibrium theory requires. Hence arises evidence of a progressive wave from the Strait of Florida. A little west of the center of the Gulf the hour increases rapidly in going westerly, indicating that the amplitude of the progressive wave must there be small; for, if its amplitude were zero, the tidal hour would change suddenly from III to IX in crossing the center of gravity of the equilibrating surface.

Consider the derived wave front extending from Yucatan to the Dry Tortugas. Suppose its center to progress through deep water toward the Mississippi Delta. The eastern wing of this wave crest will approach parallelism to the coast of Florida on account of the rapidly decreasing depth found between the deep water and this coast. (See Fig. 14, Part IV A.) The wave will reach the coast of Louisiana remarkably early or at about the time indicated by the depths of the Gulf. The range in deep water will become smaller as the distance from the source of disturbance increases, because of the ever-increasing length of the crest of the wave, which disperses the motion more and more widely. Hence the range continually diminishes as we go northward parallel to the coast of Florida. The eastern wing of the crest, by moving eastward over continually shoaling water, will cause the range to be much increased by the time the Florida coast is reached. Of course, a somewhat similar east-going progressive wave results from the equilibrium tide, and the range of this derived wave will also increase toward the coast.

The tides between Cape San Blas and the Mississippi Delta can be approximately determined by considering both the progressive wave and equilibrium tide near the edge of deep water, and adding the time of transmission to the shore.

As the eastern wing hinges upon Florida Keys so the western wing hinges upon northeastern Yucatan.* The range diminishes in going from the northern coast of Yucatan northwesterly. Consequently the tides in the southwestern part of the Gulf should be eventually equilibrium tides, and observations indicate that such is the case.

Small as the progressive wave is, its range is greater than that of the equilibrium tide in the deep water south of the coast of Louisiana, thus causing a westerly progression, instead of an easterly one, in this part of the Gulf. From Fig. 23, Part IV A, it is seen that the equilibrium tide off Port Eads, Mississippi Delta, is only 0.1 foot; this, however, increases to 0.4 foot off the mouth of the Rio Grande. The time of tide for the edge of deep water off the coasts of Louisiana and Texas can be estimated by giving greater weight to the derived wave off Port Eads and by gradually increasing the weight given to the equilibrium tide as one goes toward the Rio Grande. If to the times thus determined be added the time of transmission to the shore, the tides of Texas and southern shore of Louisiana will be nearly explained.

As already noted, the equilibrium tide controls the tide in the southwestern corner of the Gulf.

Between Galveston and Tampico no data are available concerning the semidiurnal tides.

The table given under § 97, Part IV A, shows that throughout the Gulf the ratio S_2/M_2 is considerably increased over its value for the Atlantic coast, indicating that the equilibrium tide of the Gulf is generally comparable in magnitude with the tide derived from the ocean. This is also indicated by the fact that the age of the phase inequality, as shown by the value of $S_2^\circ - M_2^\circ$, is much less for the Gulf than for the outside ocean.

The broad simultaneous region in the eastern half of the Gulf is in a general way explained by the fact that the derived and equilibrium tides do for this region approximately agree in phase, while the crowding up of the cotidal lines in the western half results from the two waves being in approximately opposite phases. The time required to transmit a disturbance from the western approach end of Florida Strait to the deep water line off the Rio Grande is about 2½ lunar hours.

Some account of the tides of the Gulf has been given in §§ 89, 90, 92, 96, Part IV A.

42. *Northwestern Africa and Southwestern Europe.*

In passing northeasterly through the Cape Verde Islands, the tidal hour increases rapidly; this indicates proximity to a nodal line of the North Atlantic system, as well as proximity to the free boundary of the South Atlantic system. A tongue-shaped region of early tide extends, as already noted, from south of these islands to the Barbados. South of Cape Verde Islands the hour is VI, while at the loop off Morocco it is II. The general reasons for a northward instead of a southward progression have been given in §§ 8, 33. The wide distances between the cotidal lines north of the Canary Islands and the increased range indicate a loop of the system.

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* § 36, Part IV A, and lemma 28.

Upon inspecting Fig. 18 it will be seen that the range of tide decreases from 9 feet near Cape St. Vincent, to 4½ at the eastern Azores and to 2½ feet at Flores, the most western. This shows that the tide is approaching zero range in going westward, and, taken in connection with the fact that all these places have nearly the same tidal hour, throws much light upon the position of the no-tide point. By comparing the times and ranges of Nova Scotia, Sable Island, and the eastern coast of Newfoundland, some evidence of the existence and location of the no-tide point can be obtained.

The early tides at the Strait of Gibraltar and at the head of the Bay of Biscay have been noticed in § 8 and § 9 case 5.

43. *The Mediterranean Sea.*

The tides of this sea have been discussed at some length in §§ 84–88, Part IV A. The conclusions there reached appear to be mainly correct, with the exception of one concerning the Adriatic found near the close of § 87.

The tidal hours for the eastern part of the sea nearly obey the equilibrium theory, as a comparison of Fig. 19, Part IV B, with Fig. 23, Part IV A, will show. The cotidal lines are probably amphidromic, radiating from the Isle of Crete. High water on the coast of Syria occurs at the time of low water off Tripoli. The tide from this part of the sea joins that of the western part through the straits on either side of Sicily. The cotidal lines are crowded closely together in the straits because the time of high water off the southeastern ends of the straits is II and off the northwestern a little more than VII.

The tide in the Adriatic is partly stationary and partly progressive. The Adriatic constitutes a dependent oscillating area whose length is nearly ½ λ. The crowding together of the cotidal lines indicates proximity to the nodal line. The effect of the earth's rotation is shown by the tendency to radiate from a point on the Italian shore. This body of water is quite analogous to the English Channel, as has been noted in § 12.

The tides of the Ægean Sea being in part derived from those of the Mediterranean near the Isle of Crete are probably small.

The tide in the western part of the Mediterranean is of nearly opposite phase to that of the Atlantic just outside. This accords with the theory of a strait leading from a tided ocean to a near-by but deep tideless sea of moderate dimensions. (§ 103, Part IV A.)

References to Mediterranean Sea tidal observations and discussions.

Malta.—Philosophical Transactions of the Royal Society of London, 1878.

Toulon, Malta, Marseilles.—Proceedings of the Royal Society of London, Vol. 39 (1885).

Genoa, etc.—Annali Idrografici, Vol. 1. Genoa, 1900.

Ragusa, etc.—Mitteilungen des. k. u. k. Militärgeographischen Institutes, Vol. 23. Vienna, 1904.

Adriatic Sea.—Admiralty Tide Tables.

44. *The British Islands and the North Sea.*

Tacitus thus refers to the tides of the Isle of Britain:

> It is not the business of this work to investigate the nature of the ocean and the tides; a subject which many writers have already undertaken. I shall only add one circumstance: that the dominion

> of the sea is nowhere more extensive; that it carries many currents in this direction and in that; and its ebbings and flowings are not confined to the shore, but it penetrates into the heart of the country, and works its way among the hills and mountains, as though it were in its own domain.*
>
> The fourth summer [A. D. 81] was spent in securing the country which had been overrun; and if the valour of the army and the glory of the Roman name had permitted it, our conquests would have found a limit within Britain itself. For the tides of the opposite seas, flowing very far up the estuaries of Clota and Bodotria [Clyde and Forth], almost intersect the country; leaving only a narrow neck of land, which was then defended by a chain of forts. Thus all the territory on this side was held in subjection, and the remaining enemies were removed, as it were, into another island.†

The tides around Great Britain and in the North Sea are remarkable in many respects. They are best described by constantly referring to the cotidal maps of these regions (Figs. 20–22).

The cotidal line IV extends from the northwest corner of France to the southwest capes of Ireland, and thence to Rockall Island. The ranges for these three places are 14, 7, and 4½ feet, respectively. This line shows how the tide approaches the land. The diminution of range gives some indications of the nodal line of the northern half of the North Atlantic system, although it is covered up by the northeasterly progressing wave.

Depending upon the incoming wave are the tides of the English and Irish channels. In these bodies of water the tide is partly stationary and partly progressive, much influenced by the deflecting force of the earth's rotation. (See §§ 3 and 12.)

The oscillation in North Channel is stationary, because high water at the south end of the channel occurs at very nearly the time of low water north of Ireland § 35, Part IV A. Instead of a nodal line extending across the channel, the deflecting force of the earth's rotation causes the cotidal lines to be amphidromic about a no-tide point, off the Mull of Cantire, § 12.

Along the northern coast of Scotland to the Orkney and Shetland islands is an easterly progression. Between these two groups of islands and through Pentland Firth, the tidal hour changes rapidly and the flood and ebb streams are strong. The motion thus transmitted, together with that of a wave rounding the Shetland Islands, is the chief cause of the tides along the eastern shore of Scotland and England. However, a part of the wave passing north of the Shetland Islands proceeds northeasterly along the coast of Norway. Evidently the coast line at the south end of Norway is not touched by these waves, unless the progression up the coast of Norway entails a sensible antecedent wave, which may reach southward toward the Naze.

Down the eastern coast of Scotland and England the wave proceeds at about the rate due to depth.

All accounts agree that there is very little tide between the Naze and Stavanger. Now imagine lines drawn from this region to the Shetland Islands, Orkney Islands, and northern Scotland, and we have reasons to believe that the large wave going down the coast of Scotland and England as far as Norfolk will control the tide over a sector of the North Sea, and that the cotidal lines will radiate from a point a little way off the southwest coast of Norway. (See cotidal maps of the North Sea, Figs. 21, 22, and § 13.)

The main progression from the northwest turns to the east off eastern Norfolk and proceeds along the north coast of Holland and Germany to Holstein and Schleswig. From this locality northward the range of tide rapidly diminishes.

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*Life of Agricola, Ch. 10 (Oxford Trans.).

†Ibid., Ch. 23.

The tidal streams in the arm of the sea between Belgium, Holland, and England indicate that it is essentially a stationary wave about $\frac{1}{3} \lambda$ long with a maximum northeasterly stream occurring at II, as one would expect from the fact that the tidal hour in the strait is XI and the range in the North Sea is comparatively small and of nearly opposite phase. (§§ 102, 103, Part IV A.)*

The earth's rotation should therefore cause the tidal hour at the Holland end of the hypothetical nodal line to occur at II and at the England end at VIII. This agrees fairly well with the observed facts. The stationary oscillation in this arm of the sea is sustained chiefly by the rise and fall at Dover Strait, and so the effect of the main body of the North Sea is little felt excepting where the arm joins it. The theoretical time of high water being II on the Holland coast, and the wave on this coast progressing northeasterly as the amphidromic requires, it will be seen that much crowding up of the cotidal lines must occur just south of Texel. Moreover, the influence of the amphidromic wave causes the tides off Texel to occur earlier than the time indicated by the North Sea tides alone. An opposite effect is produced on the English side. Hence the crowding up of the cotidal lines in the vicinity of Yarmouth and the broad space in the North Sea between the cotidal lines VI½ and VII.

The cotidal lines shown in Figs. 21, 22 have a striking resemblance to the scheme proposed by Whewell (Phil. Trans., 1833, 1836), and which Airy discredits in Arts. 525–528 of his Tide and Waves.

As stated elsewhere, the point at which Captain Hewett observed tides and found no rise and fall has been taken as the no-tide point for the amphidromic region between England and Holland.

In passing up the Zuider Zee the tide is much retarded at the narrows near the middle of that body. South of the narrows the range of tide is diminished to about 1 foot.

The form assumed by the cotidal lines at the mouth of the estuaries of the Forth, Humber, and Thames has been explained in § 31, case 4.

In going up the estuaries and funnel-shaped bays of England and Scotland the range of tide generally increases.

Much might have been said concerning the peculiarities of the tides of Europe, especially the want of simplicity of the wave manifested in double high waters, long stands, short stands, etc.; also the want of equality between the times of rise and fall. But no explanation will now be attempted, for such phenomenon can better be treated in Part V.†

One curious feature of the tides of Europe, and probably of those along the Atlantic coast of Africa as well, is the great variation in the ratio of O_1/K_1, and the large value, positive or negative, of $K_1^\circ - O_1^\circ$. (See Nos. 900 to 995 of the table given under § 97, Part IV A and Nos. 910 to 1011, § 19, Part IV B.)

Upon consulting the same table it will be noticed that $S_2^\circ - M_2^\circ$, and so the age of the phase inequality, is negative for Arendal, Oscarsborg, Christiania, and Copenhagen.

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* See charts entitled "Tidal Streams in the North Sea," by the Admiralty.

† See, for example, Étude Pratique sur les Marées Fluviales et Notamment sur le Mascaret, by Comoy.

References to tidal observations and discussions for the British islands and the North Sea.

General references.—Tide Tables for the British and Irish Ports, by the Admiralty.

Philosophical Transactions, 1831, 1833, 1836, 1845.

Proceedings of the Royal Society of London, Vols. 39, 45.

Norway.—Norske Gradmaalings-Kommission, 1882, 1904.

Holland.—Algemeene Dienst van den Waterstaat. Verzamelingstabel der Waterhoogten, for the month of April, 1894.

Comptes-Rendus de l'Association Géodésique Internationale, 1900.

45. *From the Färöe Islands to Newfoundland.**

By consulting the chart of soundings, Fig. 19, Part IV A, it will be seen that a broad strait exists on either side of Iceland. Now, if a wave of uniform range were progressing northerly up the northern Atlantic Ocean it would be reasonable to expect to find a wave transmitted northward through both of these straits. But upon referring to Fig. 23, Part IV A, it will be seen that the strait between Greenland and Iceland is at the loop of the stationary oscillation while the strait between Iceland and the Färöe Islands is much nearer to the nodal line. Hence, the wave transmitted through Denmark Strait being of much greater amplitude than that which would be transmitted through the other strait, it is easily seen that it might proceed along the northern coast and govern the tides to the northeast of Iceland. As a matter of fact the tides in this last-mentioned region are almost opposite in phase to those just south of the strait. Consequently, § 35, Part IV A, the oscillation in this strait must be chiefly stationary. However, there is some southward progression down the eastern coast of Iceland and some northward progression up the western coast of the Färöe Islands, the direction in the first case being governed by the preceding motion along the northern coast of Iceland and in the latter by the fact that the range north of the Färöe Islands is smaller than the range south of them, so that these islands form a part of a boundary, along the southern side of which is a good rise and fall. Again referring to the chart of soundings and to the chart of systems, it becomes evident that the range of tide for the western coast of the Färöe Islands must considerably exceed that of the eastern. Observations indicate about 7½ feet for the former and 4½ for the latter. The motion thus set up causes the hours to progress southerly down the eastern coast of these islands; that is, the wave is turned or refracted, as it were, around the northern end of the islands because of the shoals and deeper off-lying waters.

The oscillation in the strait between the Färöe and Shetland islands is, in deep water, nearly stationary, since the waters to the southwest of it are nearly opposite in phase to the waters to the north. However, along the northern coast of Scotland and the western coasts of the Orkney and Shetland islands the tide consists chiefly of a wave progressing northeasterly at about the rate due to depth.

The short length of the walls or sides of these two broad straits makes the effect of the earth's rotation, if sensible at all, of secondary importance.

Between Rockall and Labrador there is a considerable progression, due chiefly to the opening between southern Greenland and Labrador.

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*See Figs. 12, 18, 20, 23.

The range of tide at Nennortalik, near Cape Farewell, is 6.3 feet and at St. Johns, 2.6; for the coast of Labrador it is 4 or 5 feet. These values indicate something about the position of the no-tide point.

The tide in Hudson Strait is unexpectedly large. The range at Port Burwell near the eastern end being 15.1 feet; at Ashe Inlet, Big Island, 23.5 feet, and at Port Laperrière, Digges Island, at the western end of the strait, 6.6 feet. The lateness of the tide on the southeastern shore of Ungava Bay has been explained in § 7.

In the northern branch of Hudson Strait, constituting the southern portion of Fox Channel, the range is large, being 9.5 feet at Winter Island.

The cotidal lines of Hudson Bay, as shown in Fig. 12, are little more than conjecture. The lack of reliable observations for the southeastern portion of the bay, and the uncertainties connected with the geography of Southampton and neighboring islands, cause inferences to be of little value. The range of tide is probably about 3 feet on the eastern side of the bay and more than twice that amount on the western.

It may be well to here point out some evidence which goes to prove that the northwestern corner of the North Atlantic Ocean, together with its tidal dependencies, belongs to the North Atlantic system.

Upon referring to Fig. 23, Part IV A, it will be seen that the loop off Gibraltar is not overlapped by any other system, and that the same is true of the loop between Labrador and Iceland. Hence the magnitude of the phase inequality, as well as its age, should be comparable at the two ends of this area. That such is the case can be seen by comparing the values S_2/M_2, $S_2^\circ - M_2^\circ$ for Nos. 6–28 of the table given under § 97, Part IV A, with similar values for Nos. 932–990 of the same table.

As has been already noted, the ratio S_2/M_2 is much smaller for the coast extending from Nova Scotia to Florida Strait, showing that the tides of this coast belong to a different system.

CHAPTER VII.

THE SEMIDIURNAL TIDES IN THE ARCTIC OCEAN.

46. *Indications of land near the pole.*

Before attempting to draw cotidal lines for the Arctic regions, some assumptions have to be made as to the distribution of land and water; but in making such assumptions observations upon the tides and surface drifts form the principal guides, as the matter which follows will show. By considering this question in detail, an estimate can be made of the relative merits of the cotidal lines as drawn for different parts of the Arctic Ocean. Except for slight alterations, the remainder of this section is as it recently appeared in the National Geographic Magazine.*

It is a well-established fact that there are two important surface currents (or drifts) in the Arctic Ocean. One of these flows easterly along the northern coast of Alaska, through the Arctic Archipelago, finally reaching the Atlantic Ocean through Davis and Hudson straits. The other starts in the neighborhood of Herald Island, northwesterly from Bering Strait, and thence flows northwesterly, passing to the north of New Siberia; thence to the north of Franz Josef Land and the Spitzbergen Islands, and through Denmark Strait to and around Cape Farewell. Therefore these currents are near together when north of Bering Strait and again when in the vicinity of southern Greenland.

Some evidence of the American current may be cited. The ships *Advance* and *Rescue*, of the first Grinnell expedition, were for a while carried northerly in Wellington Channel by the drifting ice; but when near the northern end of the channel the current reversed, and thereafter they were carried southerly and easterly through Barrow Strait, Lancaster Sound, Baffin Bay, and Davis Strait, to latitude 65° 30′ N., where they got themselves free from the ice. The amount of southeasterly drifting measures about 1 000 nautical miles, and required a little more than six months, extending from November, 1850, to June, 1851. This gives an average rate of 5 miles per day.

In May, 1854, the British ships *Intrepid* and *Resolute* were abandoned off the western end of Barrow Strait. The *Resolute* was picked up off Cape Mercy, in the south end of Davis Strait, in September, 1855. During these 16 months 1 100 miles were covered, making an average rate of 2⅓ miles per day.

Strong easterly currents are encountered in Fury and Hecla Strait and in Bellot Strait.

Northeasterly currents off the northwestern coast of Alaska have been noted by Captain Collinson,† and easterly currents along the northern coast by Captain McClure.‡

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* Vol. XV (1904), pp. 255–261.

† Collinson: Journal of H. M. S. *Enterprise*, edited by his brother, pp. 137–142.

‡ McClure: The Discovery of the Northwest Passage, edited by Osborn, p. 71.

Collinson noted an eastern set in Dease Strait far to the east,* and McClure found a large quantity of American pine, almost certainly from the Mackenzie River, drifted into Prince of Wales Strait.†

McClure Strait is constantly filled with ice, probably coming in chiefly from the west.

The existence of the current far to the north of Russia is pretty well established by the drifting of the steamship *Jeannette* from Herald Island to a point northeast of New Siberia, where she was crushed in the ice, and by the subsequent drifting of some papers and clothing from the sunken vessel across the polar sea to Julianehaab, near Cape Farewell. The *Jeannette* was frozen in the ice September 6, 1879, and was crushed June 12, 1881, having made good a distance of 600 miles. During the last five of these 21 months much more than half of all the distance made good was covered, and during the last 26 days almost one-sixth. The relics were picked up in 1884, or three years after the sinking of the boat, having gone a distance of at least 2 900 miles. (See Fig. 24.)

Before undertaking his famous voyage in the *Fram*, Nansen adduced, as further evidence of this current, the finding on the coast of Greenland of an implement which almost certainly came from the Alaskan Eskimos in the vicinity of Bering Strait; also the prevalence of driftwood on the Greenland coasts and the north coast of the Spitzbergen Islands, the species indicating that a large portion of this wood came from northern Siberia.

The voyage of the *Fram* verified his previous calculations in a remarkable manner. That vessel became fast in the ice at a point northwesterly from New Siberia, September 22, 1893. It thence drifted to a point north of the Spitzbergen Islands, having passed about midway between Franz Josef Land and the North Pole. It was released from the ice June 14, 1896, thus having drifted for 33 months, the distance made good being 900 miles. At the beginning of the drifting the rate of the current was a little more than half a mile per day, and increased to 1 mile near the end.

Having established the existence of these two prevailing surface currents, and noting that both eventually flow to southern Greenland, the question arises as to why the *Jeannette* did not drift almost due north instead of bearing off to the west. The *Fram* went almost directly toward the eastern coast of Greenland. It is true that after the loss of the *Jeannette* Commander De Long and his party found themselves on ice drifting rapidly northward. As already noted, the last 26 days' drifting of the boat covered about one-sixth of the entire distance. These facts suggest a broad strait north of Bennett Island, beyond which is the corner of a large tract of land dividing the deep Arctic channel traversed by the *Fram* from the shallow sea through which the *Jeannette* drifted. The final accelerated rate and northward direction of De Long's drift seem to indicate proximity to this strait.

This sea extends from Bennett Island to Banks Land. It is about 30 or 40 fathoms deep along the track of the *Jeannette*, and perhaps from 100 to 200 fathoms west of Banks Land, where it is known as Beaufort Sea.

That land probably extends to the north of Beaufort Sea can be inferred from the fact that the ice found here is very old, the sea seeming to have no broad outlet through which the ice can escape, as it does north of Siberia. The openings to the east are long

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* Collinson: L. c., p. 291.

† Richardson: The Polar Regions, p. 232.

and rather narrow channels. This does not argue against a tolerably broad expanse of water extending westward, for the currents setting eastward prevent the ice from escaping to the west. It seems probable that land, continuous or nearly so, must extend far westward from off Banks Land, for this supposed land and the eastward currents might well explain why it is that the ice never recedes far northward from the northern coast of Alaska nor westward from Banks Land.

Osborn thus speaks of the ice encountered by McClure in Beaufort Sea: "Ice of stupendous thickness and in extensive floes, some 7 or 8 miles in extent, was seen on either hand; the surface of it not flat, such as we see in Baffins Strait and the adjacent seas, but rugged with the accumulated snow, frost, and thaws of centuries."*

Such are the arguments for the existence of a tract of land extending from near the northwest corner of Banks Land, or from Prince Patrick Island, to a point north of New Siberia, based upon the drifting of the ice on the one hand and upon its age and comparatively slight movement on the other hand.

Let us next consider what are the indications from the tides. In the first place, the tide at Point Barrow is semidiurnal in character, with a mean range of 0.4 foot, the flood coming from the west. This can not come through Bering Strait, because the tide immediately south of the strait has scarcely one foot range, with a large diurnal inequality, and at a short distance north of the strait, at Pitlekaj, where the *Vega* wintered in 1878–79, the range of the semidiurnal tide was carefully measured and found to be only 0.2 foot. Whence comes the Point Barrow tide? It can not come from the north or east, because all observers agree that the flood comes from the west, and that it is high water on the western side of the point considerably earlier than on the eastern.† De Long's party made careful observations upon the tide at Bennett Island, and these show a range of 2 feet. Such a range, diminished by the broadening of the shallow sea to the east of this island, might well be reduced to that found at Point Barrow, provided one considers that the range generally diminishes off headlands and capes. On the other hand, if no land exists north of Point Barrow, how can the tide there be much less than that found at Bennett Island, and how can the flood come from the west? For practically all of the Arctic Ocean tide is derived from the Atlantic, chiefly through the Greenland Sea, and without land near the Pole one of these stations would be reached about as well as the other.

The reasons for not drawing the boundary straight from the Bennett Island corner to the Banks Land corner, but deflecting it to the south, are, first, the apparent necessity for such a bend in order that the direction of the flood may better accord with observation, and that the times of the tides of northern Alaska may be consistent with those at Bennett Island, and, second, the small north-and-south movement of the ice north of Alaska indicating that the sea is here probably narrower than it is farther west, or north of Siberia.

In the extreme north this land can not extend much beyond the Pole toward Franz Josef Land, because this would undoubtedly have there caused a bend in the track of

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*McClure: L. c., p. 83.

†Thomas Simpson: Discoveries on the North Coast of America, 1836–1839, pp. 161, 162, 167. Accounts and Papers, Navy, vol. 42 (1854), p. 162. Lieut. P. H. Ray: Report of the International Polar Expedition to Point Barrow, Alaska, p. 678.

the *Fram's* drift. Furthermore, the undiminished range of tide at Bennett Island perhaps indicates that the Nansen channel does not greatly broaden at the Pole.

Between this supposed land and the islands recently discovered by Sverdrup may be other islands, forming a continuation of the Arctic Archipelago and separated from one another by channels of moderate depths, or perhaps this land approaches the Garfield Coast and Grant Land. At any rate, the range of tide diminishes from 2 feet at Cape Sheridan to 1½ feet at Northumberland Sound, Penny Strait, and Lockwood and Brainard judged the tide to be small at Greely Fiord. These indicate that the access of the tide from the north is not altogether unrestricted; in fact, part of the tide at Northumberland Sound comes from the east through Belcher Channel.

We come now to another question. A few tides have been observed along the northern coast of Alaska by the explorer Thomas Simpson.* They show that the tide on the outer coast occurs nearly simultaneously from Point Barrow to Camden Bay and Simpson Cove. But as the international boundary line is approached a great change takes place; the tide at Demarcation Point, not 100 miles farther east, is about seven hours later in its time of occurrence. Observations are not sufficient for showing how this change takes place, but it certainly occurs. A few tides in Mackenzie Bay and eastward were observed by Captain Richardson† and Commander Pullen.‡ The set of the flood along the outer coast is given as easterly for all points where it has been observed from Point Barrow to and beyond Cape Bathurst; but such observations are very meager, probably on account of the smallness of the tide. This would seem to preclude the possibility of the principal part of the tide coming from the north or east; hence the probable approach of the polar land to Banks Land, or to Prince Patrick Island, or to Grant Land.

Suppose an island about 100 miles in diameter to be separated from the coast by a shallow strait about 75 miles wide in its narrowest part. By assuming that deeper water exists to the west of the strait and island, and that the tide comes from the west, it seems possible to account for the sudden change in the time of tide; for the main wave, going north of the island, would control the time of the tide to the northeast of it, and deep water west of the island and shallow strait would cause the tide at Camden Bay and westward to occur remarkably early, just as if this coast were at the head of a deep, suddenly terminated canal extending northwesterly.

Immediately eastward from this supposed strait both Simpson§ and McClure‖ found that the waves became more like those upon a sea of some magnitude, and the latter, sailing a little north of east, found the depths to rapidly increase from 9 to 32 fathoms, and soon to 195 with no bottom.

Now the question is, Why this more sea-like appearance unless some huge obstruction lies immediately to the west? It may, of course, be partly due to the open water caused by the influx of the Mackenzie.

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*Simpson: Discoveries on the North Coast of America, 1836–1839, pp. 115, 117, 121–123, 132, 138, 161–162, 167, 178, 183.

†Richardson: Arctic Searching Expedition, pp. 144, 154, 157–160, 169, 175.

‡Pullen in Reports on Arctic Expeditions, 1852, pp. 35, 38, 40, 51.

§Simpson: L. c., p. 176.

‖McClure: L. c., p. 82.

It will be of interest to note that several Arctic authorities have at various times suspected or inferred the existence of land near the Pole. Richardson says:

> The Eskimos of Point Barrow have a tradition, reported by Mr. Simpson, surgeon of the *Plover* [in 1832], of some of their tribe having been carried to the north on ice broken up in a southerly gale, and arriving, after many nights, at a hilly country inhabited by people like themselves, speaking the Eskimo language, by whom they were well received. After a long stay, one spring in which the ice remained without movement they returned without mishap to their own country and reported their adventures. Other Eskimos have since then been carried away on the ice, and are supposed to have reached the northern land, from whence they have not as yet returned. An obscure indication of land to the north was actually perceived from the masthead of the *Plover* when off Point Barrow.*

On August 15, 1850, Captain McClure, anchored off Yarborough Inlet, about half way from Point Barrow to Demarcation Point, writes:

> The packed ice to-day, as far as the eye can reach, appears solid and heavy, without a drop of water discernible. The refraction has been considerable, giving to the edge of the pack the appearance of a continuous line of chalk cliffs, from 40 to 50 feet in height. From the light shady tint, which, in different parts of the pack, is distinctly visible, I should be inclined to think that there may be many of the same kind of islands as those we have met with, extending to the northward, and impeding the progress of the ice, thereby keeping this sea eternally frozen.†

Captain Collinson, who wintered at Simpson Cove, 1853–54, actually undertook a sledge journey, in the spring, northward, one object of which was to see if land would not be reached. The roughness of the ice caused him soon to abandon the project. He writes:

> I therefore returned, and with sorrow gave up an attempt which * * * I had looked forward to with much interest; thinking that, with anything like a favorable road, I should reach 73° north latitude, and settle the question with regard to the open sea, which certainly does not appear to exist here in the same manner as it does to the north of the Asiatic continent. ‡

In 1873 Admiral Sherard Osborn read a paper before the Royal Geographical Society, in which he predicted the existence of an archipelago or land extending from near Prince Patrick Island up very near to the Pole and thence to Wrangell Island, thus forming the northern boundary of a nearly inclosed sea.§

A probably less happy prediction was made by Petermann, who contemplated land extending northeasterly from Greenland, thence across the Pole to Wrangell Island.

Sir Clements Markham is quoted as having said, in November, 1896:

> Personally, as I do not believe in any land near the Pole, or on this side of it beyond Franz Josef Land, I trust an attempt will be made to explore another portion of the Arctic regions. I believe there is land, probably in the form of large islands, between Prince Patrick Land and the New Siberia Islands.‖

Prentiss discredits there being much land north of Bering Strait, but his reasons for so doing can hardly be regarded as convincing.

The following quotation is from a paper by Marcus Baker, in volume 5 of the National Geographic Magazine, entitled "An Undiscovered Island off the Northern

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*The Polar Regions, p. 240.

†McClure: L. c., p. 81.

‡Collinson: L. c., p. 312.

§Clements R. Markham: The Threshold of the Unknown, pp. 216–224.

‖Prentiss: The Great Polar Current, p. 105; see also p. 19.

Coast of Alaska." He suggests that the supposed land be called Keenan Island. The following statements are there furnished by Capt. Edward P. Herendeen, who for many years was engaged in whaling:

> It is often told that natives wintering between Harrison and Camden bays have seen land to the north in the bright, clear days of spring.
>
> In the winter of 1886–87, Uzharlu, an enterprising Eskimo of Ootkeavie, was very anxious for me to get some captain to take him the following summer, with his family, canoe, and outfit, to the northeast as far as the ship went, and then he would try to find this mysterious land of which he had heard so much; but no one cared to bother with this venturesome Eskimo explorer. So confident was this man of the truth of these reports that he was eager to sail away into the unknown, like another Columbus, in search of an Eskimo paradise.
>
> The only report of land having been seen by civilized man in this vicinity was made by Capt. John Keenan, of Troy, N. Y., in the seventies. He was at that time in command of the whaling bark *Stamboul*, of New Bedford. Captain Keenan said that after taking several whales the weather became thick, and he stood to the north under easy sail, and was busily engaged in trying out and stowing down the oil taken. When the fog cleared off, land was distinctly seen to the north by him and all the men of his crew; but, as he was not on a voyage of discovery and there were no whales in sight, he was obliged to give the order to keep away to the south in search of them. The success of his voyage depended on keeping among whales.
>
> The fact was often discussed among the whalemen on the return of the fleet to San Francisco in the fall. The position of Captain Keenan's ship at the time land was seen has passed from my mind, except that it was between Harrison and Camden bays.

It will be noticed that these statements would place the island a little to west of the position shown in Fig. 24.*

47. *Character of Arctic tides.*

An inspection of the tidal forces (Fig. 1, Part IV A) shows that the semidiurnal equilibrium tide, even if possible, would be very small, because the forces vanish at the pole. Again, the dimensions are probably such that no free period of the tide is approached. For these reasons the semidiurnal tide observed in the Arctics must be almost entirely derived from other waters. The cotidal lines indicate that nearly all of the disturbance producing the Arctic tides acts through the waters of Greenland Sea. The small mean range of tide (0.2 foot at Pitlekaj) and the smallness of the diurnal wave at Point Barrow show that the influence of the Pacific extends but a very short distance northward from Bering Strait. The shallowness of Barents Sea prevents its influence as a channel of transmission from being of much consequence to the east of Franz Josef Land and Nova Zembla. In fact, it is probable that the tides around northern Nova Zembla are derived from the wave north of Franz Josef Land. (See Figs. 23, 25.)

The northern half of the North Atlantic system (e. g., western Europe and southern Greenland and Iceland) possesses a good phase inequality which has an "age" generally of about 30 hours along the outer coasts. In the Arctic the phase inequality is of a similar character, with an age varying from 30 to 60 hours.† The tropic range of the diurnal wave is about 2 feet for the Arctic Archipelago, diminishing toward the west, and about 0.3 foot for Franz Josef Land and Bennett Island, and scarcely 0.2 foot for Point Barrow.

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* Since this appendix was prepared the writer has noted in a paper read before a section of the Eighth International Geographic Congress that the small diurnal tides at Pitlekaj and Point Barrow furnish additional evidence of a large tract of land near the North pole.

† Part IV A, § 97, Nos. 6–25; also Part IV B, § 19, Nos. 1011, 1030.

48. *Greenland Sea branch.*

From the north end of the North Atlantic system where the range is large (the mean range at Reikiavik being 10 feet) the disturbance acts through Denmark Strait. A smaller disturbance comes chiefly from the loop off Portugal, passing up the outer coast of Ireland, Scotland, and Norway. The result is that the tide is about simultaneous over the deep Greenland Sea, having a range at Jan Mayen of 3 feet. The tide proceeds from this sea toward the Lena Delta, probably at a rate due to depth. The mean range is 2.0 feet at Cape Sheridan and at the southern part of Bennett Island. Northeastern Franz Josef Land is a turning point of the tide and beyond which the sea suddenly widens; the range of tide at Teplitz Bay is only 1.0 foot. The tide is of about this magnitude on the southern coast (at Cape Flora) probably because the wave passing between Norway and the Spitzbergen Islands is reduced in amplitude in the northern part of the somewhat expanded Barents Sea. From Bennett Island toward Alaska the wave proceeds at about the rate due to depth, the range diminishing because of the breadth and shallowness of the intervening waters. Judging from the few tidal observations made along the northern coast of Alaska, and eastward, and which have already been referred to, the tide appears to progress in an easterly direction somewhat as shown in Fig. 26. If the assumption of a hypothetical island separated from Manning Point by a shallow strait is correct, it is probable that nearly all of the tide between Cape Bathurst and Dolphin and Union Strait, is due to the wave passing north of the island. At Coronation Gulf the semidiurnal tide practically disappears. At Cambridge Bay, Dease Strait, the tide is felt and doubtless comes from the east.* The flood in Prince of Wales Strait has the appearance of setting northeasterly.†

Having traced the tide from Greenland Sea to where it disappears at Coronation Gulf, it will now be well to note that one branch of probably considerable width passes north of Greenland, causing a tide of 2.0 feet at Cape Sheridan, the same wave going southwesterly produces the rather small tides at Greely Fiord, the western coast of Ellesmere Land, and among the islands to the west. The range of tide at Northumberland Sound is 1.5 feet, a part of which doubtless comes from Jones Sound through Belcher Channel.‡ Another branch from the main channel passes around the northeastern corner of Franz Josef Land, producing tides in the Yenisei Gulf, Gulf of Ob and the Kara Sea, the tide being in general small, probably about 1 foot on the outer coasts, but less up the gulfs and rivers.

The tides of the White Sea are worthy of note. At the southern end of the entrance the time of tide changes rapidly—from IX to XII—in a very short distance. The north side of the sea is much deeper than are the gulfs of Archangel and Onega on the south side; the tide in the former locality is nearly simultaneous, but there is progression in the gulfs. The range of tide is probably about 3 or 4 feet.

A great crowding together of the cotidal lines appears to occur in the strait between Kolgoniev Island and Kanin Peninsula.

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* Thomas Simpson: Discoveries on the North Coast of America, pp. 267, 288, 289, 357, 363. Capt. Richard Collinson: Journal of H. M. S. Enterprise, p. 291, also map opposite p. 153.

† Capt. R. McClure: The Discovery of the Northwest Passage, edited by Osborn, p. 197.

‡ Capt. Sir Edward Belcher: The Last of the Arctic Voyages, Vol. 1, p. 105.

Collinson: L. c., map opposite p. 255.

Accounts and Papers, Arctic Expeditions, Vol. 25 (1855), pp. 118-120.

It is probable that the small tide in the Gulf of Ob progresses at the rate due to depth.

No tidal data for the coast of Siberia, extending from the Yenisei Gulf to Pitlekaj, is available, and so the cotidal lines for this coast are only conjectural.

49. *Baffin Bay branch.*

We come now to the Baffin Bay branch of the Arctic tides. This covers much less area than does the Greenland Sea branch, but the amount of the rise and fall is in general much greater. The waters south of Davis Strait, in Davis Strait, and in Baffin Bay are characterized by a stationary wave, but everywhere there is a considerable rise and fall. The cotidal lines are crowded together in the northern portion of the strait and spread apart in the northern portion of Baffin Bay.

A stationary strait wave exists in Robeson and Kennedy channels, Kane Basin being the body of greater range and Lincoln Sea the body of smaller range. The mean range for Kane Basin is nearly 8 feet, for Fort Conger 4.3 feet, and for Cape Sheridan 2.0 feet. The fact that the tide at Cape Sheridan occurs about 1½ hours earlier than at Kane Basin proves that the tide of Lincoln Sea comes from the north. The known tides of this locality gave strong evidence in favor of Greenland being an island some years before that fact was practically established by Lieutenant Peary.*

The Greenwich time of tide for Kane Basin is a little more than III, the cotidal hours increasing toward this body both from the south and from the north.

The range of tide at Cumberland Sound is unexpectedly large, the mean value being 15.9 feet for Kingua Ford and 14.7 feet for Ananito Harbor.

The tide progressing up Lancaster Sound soon divides, one part going westerly through Barrow Strait, the other going southerly through Prince Regent Inlet. The former produces the tide in Wellington Channel, Melville Sound, Franklin Strait, McClintock Channel, James Ross Strait, Victoria Strait, Dease Strait, and probably Coronation Gulf; the latter, the tide in the Gulf of Boothia.

The tides of Fox Channel are produced by the Hudson Strait tides. They appear to be amphidromic, so that the flood goes northward on the east side and southward on the west. The cause is probably the sudden eastward trend of the coast of Fox Land at Capes Dorchester and Willoughby, which turns a wave of large amplitude toward the northeast. The geography is but imperfectly known on the east side of this channel, and no tides or depths have there been measured.

In the straits of Fury and Hecla,† Bellot,‡ and Simpson§ the tidal streams are strong, because the tides at either end generally differ in range and in phase.

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* E. Bessels: Scientific Results of the U. S. Arctic Expedition, C. F. Hall commanding, Vol. 1, pp. 85, 86.

Capt. Sir G. S. Nares: Voyage to the Polar Sea, 1875–6, Vol. II, p. 356, Appendix by Rev. S. Haughton.

Lieut. A. W. Greely: Report U. S. Expedition to Lady Franklin Bay and Grinnell Land, p. 699, Appendix by A. S. Christie.

†Journal of Parry's Second Voyage for the Discovery of the N. W. Passage, pp. 319, 336–7.

‡McClintock: Franklin and his Discoveries, pp. 181–3.

§Simpson, l. c., p. 365.

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CHAPTER VIII.

THE SEMIDIURNAL TIDES IN THE PACIFIC OCEAN.

51. *Character of Pacific tides.*

Upon referring to the chart of diurnal systems (Fig. 24, Part IV A) it will be seen that large diurnal tides can not originate in the South Pacific, and observations show that the diurnal inequality is comparatively small in these waters.

The two systems for the semidiurnal tide have been described in §§ 74, 75, Part IV A.

By referring to Fig. 6 it will be seen that there are three principal amphidromic regions, the positions of the no-tide points being taken as 30° 24′ N., 141° 25′ W.; 14° 7½′ S., 153° 13′ W.; and 51° 30′ S., 172° 10′ W. The first lies between California and Hawaii, at the intersection of two nodal lines; the second, northwest of the Society Islands, near two nodal lines and a free boundary; the third, southeast of New Zealand, near a free boundary.

Some progression is inherent in the overlapping of the systems, as has been pointed out in § 15. This applies to the first amphidromic region mentioned, especially to the coast of Lower and Upper California, and also to the second.

But openings in the coast line have a widely spread influence. Important openings are between Cape Horn and the South Shetland Islands; between the Peninsula of Alaska and Kamchatka; through the Kuril Islands; between Japan and Formosa; between Formosa and Luzon; through the Sulu Archipelago; between New Zealand and Australia.

The shoaling found to the north and northwest of New Zealand, together with the Fiji and neighboring islands and North Island, New Zealand, form an imperfect boundary which gives rise to westerly and southwesterly progressions.

The central portion of the American coast line is farthest removed from openings of this description. Hence it is not surprising to find no progression toward the waters off Panama and Colombia, and very little up the Bay of Panama. We find what would be expected, viz., small progressions outward from the vicinity of the Galapagos Islands.

The following are localities of rapid change of time of tide, due to the fact that regions having good ranges but different times of tide lie near each other: Coast of Peru, connecting the Panama loop to the loop at Chile; western coast of southern Chile, connecting the loop at Chile with the Cape Horn loop; straits through the Aleutian Islands, connecting the northern Pacific and Bering Sea. (See lemma 25.)

Owing to the great extent of the Pacific Ocean, the large number of islands, and the considerable variations in depth, it is not difficult to believe that forces of slightly different periods may be responded to by modes of oscillation quite different in some cases. The land boundaries here are not sufficient for necessitating one particular mode of oscillation for both the lunar and solar forces; there are many chances for the portions of the sea best responding to the lunar forces to annex or discard neighboring masses of water which islands and shoals may partially define. (See § 47, Part IV A.) Hence we can not generally infer by the equality of S_2/M_2 or $S_2^\circ - M_2^\circ$ at two distant loops that the loops form or do not form parts of the same system. Of course between neighboring places either of these quantities will generally vary but little. The ratio S_2/M_2 for the Pacific is, as a rule, less than the corresponding ratio of the forces. The cases where it is greater, like Tahiti* and Mazatlan, are so near the nodal lines that they little affect the generality of this rule; they simply indicate that the modes of the solar oscillation do not exactly agree with those of the lunar, and so at the nodal line of the lunar tide there might exist a sensible solar tide. Even Japan is too near to a nodal line for having the fact that S_2/M_2 there approaches its theoretical value seriously affect the generality of the rule.

On the other hand, the ratio S_2/M_2 is unusually small at Wellington, Port Russell, and Port Chalmers, New Zealand, and even at Apia, Samoan Islands.

52. *From the Galapagos Islands to Cape Horn.*

The change of tidal hour from the Panama loop to the Chile loop, and thence to the Cape Horn loop, has been noted in the preceding section. But the law of the change is influenced by the antecedent wave made necessary by the progression through the strait south of Cape Horn. (See Figs. 6, 27, 28, 30, 41.)

In the deep water surrounding the Galapagos Islands the tidal hour is a trifle less than VIII, but amongst these islands it is a trifle more than VIII. The tidal hour changes rapidly along the coast of Peru.

In latitude about 28°, on the Chilean coast, the time of tide appears to be about an hour earlier than in latitude 23° or 24°. This anomaly is probably due to the directions taken by the tidal streams of the oscillation and the progressive wave, causing a dependent stationary wave at the first-mentioned locality; lemma 32, case 4. In latitude about 41° there is a crowding up of the cotidal lines at the coast. This is a species of turning point of the tide and is to be regarded as analogous to a cape guarding the entrance to a broad bay; lemma 28. The direction of the tidal streams—say 100 or more miles offshore—are, at this latitude, probably nearly parallel to the shore instead of being normal to it, as an early tide requires. The crowding up of the cotidal lines near the western end of Magellan Strait is explained in a similar way.

In Corcovado Gulf is a dependent stationary wave having a 12 or 13 foot range at the head. This produces strong currents (4 to 5 knots) in Chacao Narrows. (Cf. § 106, Part IV A.)

The range of tide is 3.0 feet at Valparaiso and 4.3 feet at Cape Horn.

The axis of the southeastern half-wave length of the South Pacific system may be supposed to terminate in longitude 69° W. The theoretical tidal hour is VI at this Cape Horn loop. Now, superimpose upon this stationary wave an easterly progressing wave of equal amplitude and whose tidal hour is VIII † at longitude 69° W. (§ 3); the result will be the irregular progression shown in Fig. 6 along the axis of the area. Here λ is taken as 84° of a great circle.

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*See Ferrel's Tidal Researches; also this manual, Part I, Fig. 17.

† Lemma 21.

53. *From Cape Horn to Uruguay.*

Upon referring to the chart of semidiurnal systems (Fig. 23, Part IV A), it will be seen that a loop of the South Pacific system has southern Chile and Graham Land for its eastern boundary. The intervening strait, constituting an opening in this boundary, causes a large wave to progress into the Atlantic. Fig. 29 shows that the disturbance thus transmitted produces the tide on the eastern coast of South America up to and including the tide in the Rio de la Plata. North of this river the tide becomes very small, especially at Rio Grande do Sul, and a crowding together of the cotidal lines is there necessitated in order to coalesce with the Brazilian tide due to the South Atlantic system.

The tide occurs earlier on the southeastern coast of the Falkland Islands than elsewhere in this group. One branch of the tide swings around to the north, going rapidly in the deep water northeast of the islands. The other branch appears to progress slowly along the south coast. In reality this rapid change in the tidal hour is due to the fact that the times are here governed by the large tides between Staten Island and Port Santa Cruz. (See § 14.) The two branches are united into one off the western extremity of the group. The tide enters Falkland Sound from both ends and meets near the center. For most of the inland water between West Falkland Island and Pebble Island the tide progresses easterly, the larger opening being to the west.

Three stationary waves, existing because the resultant flood is in certain localities largely directed shoreward, occur along the eastern coast of Patagonia. The head of the first extends from Magellan Strait to Port Santa Cruz. The length (to the 100-fathom line) may be considered as being close to $\frac{3}{4}$ λ, and therefore favorable to the production of large tides. The second includes the Gulf of St. George, with off-lying shallow water; its length lies between $\frac{1}{4}$ λ and $\frac{1}{2}$ λ. The third includes the Gulf of San Matias and immediate approach; its length lies between 0 and $\frac{1}{4}$ λ, but nearer to $\frac{1}{4}$ λ.

The tide in the first is caused by the tide between the Falkland Islands and Tierra del Fuego. The shore line receding at Port Santa Cruz a progressive wave moves northward (lemma 19). This combines with a wave coming from the east, causing the tide which sustains the stationary oscillation in the Gulf of St. George. At Cabo del Sur, marking the northern limit of this gulf, the receding shore line gives a northward progressive wave. On account of the early arrival of the wave coming from the east, the resultant tide must change its tidal hour rapidly between this cape and Delagada Point, Valdes Peninsula. Similarly, the tide east of this peninsula sustains a large oscillation in the Gulf of San Matias and Port San José. Hence the greater range of tide on the north side of the peninsula and its connecting isthmus. At Point Raza the shore line suddenly recedes, giving rise to a northerly progression, which follows the shore line around El Rincon until it meets the wave coming from the southeast.

Thus we see the necessity for two wave eddies such as have been referred to in the latter part of § 13. It is probable that § 5 may be of some assistance in explaining them.

The positions assigned to the no-tide points are 45° 18′ S., 63° 37′ W., and 40° 55′ S., 60° 45′ W.

The tide in the Rio de la Plata is a progressive wave, advancing at about the rate due to depth. Although this estuary is funnel-shaped and of decreasing depth, the irregular shoals so impede the progress of the wave that the range of tide remains about constant. It is 2 feet at Montevideo and 1.8 feet at Buenos Ayres. Here the tide occurs eleven hours later than in the deep water off the mouth of the river.

The range of tide in the eastern portion of Magellan Strait is about 30 feet; after passing the first narrows it is about 16 feet, and in Broad Beach, beyond the second narrows, 4 feet. The tidal streams in these narrows are strong and due to hydraulic effects, §§ 9, 105, Part IV A. The tidal hour increases southward and westward. The hour increases from Froward Reach to Cockburn Channel along either end of Clarence Island and coalesces with that of the tide which progresses eastward through the strait between Cape Horn and Graham Land, thus completing a cycle of values. The branch of the tide which follows the strait proper from Froward Reach westward meets the tide from the west near the eastern end of Desolation Island. One branch of the tide from Froward Reach produces the tide in Otway Water.

54. *From the Galapagos Islands to British Columbia.*

The Panama loop of the North Pacific system, marked IX in Fig. 23, Part IV A, is made possible by the fact that the trapezoidal branch of this system has a loop not far away also marked IX. Hence by the latter part of lemma 25 the tidal hour for the intervening waters should be IX. The Panama loop may, therefore, be described as having a large portion of its southern boundary latent (§ 29, Part IV A). Only at the extreme eastern end is there a rigid southern boundary. Observations indicate VIII instead of IX for the tidal hour of this loop. (See Fig. 30.) This discrepancy is probably due to the progressions (antecedent waves) setting out from this loop both southerly and northerly.

Some inward progression occurs in the gulfs along this coast. How the tide is delayed at the mouth of a bay and how the far side of the mouth of a bay is sometimes reached as early as the near side have been explained under lemma 31, cases 3, 4.

The nodal line terminating just above Acapulco is remarkably well defined both by the small range and remarkably sudden change in the tidal hour.

The tide in the Gulf of California is chiefly stationary, although there is enough inward progression to prevent there being a no-tide point from which the cotidal lines would radiate.

On account of the low latitude and the obstructions due to islands, the effect of the earth's rotation in crowding together the lines on the Lower California side and spreading them apart on the opposite side is probably less marked than in the case of the English or Irish Channel.

The range of tide at Mazatlan is 2.6 feet and at the head of the Gulf about 20 feet. Strong tidal currents due to hydraulic effects (§ 106, Part IV A) occur between Tiburon Island and the mainland.

The progression along both Lower and Upper California is due to the overlapping of the two Pacific systems (§ 15).

The curved nodal line of the North Pacific system terminating at Point Arguello is obscured by a loop of the South Pacific system. From this cape northward to Alaska, the range of tide increases. It is 3.6 feet at Point Arguello and 7.7 feet at Sitka. Ranges varying from 10 to 15 feet are usual for the inner waters of Alaska. (See Figs. 32, 33.)

The Gulf of Georgia, including the Juan de Fuca Strait, has a large stationary wave whose nodal line is near Discovery Island Light. There is, however, some progression, so that the influence of the earth's rotation is to cause the cotidal lines to crowd together at the Vancouver end and to spread apart on the Washington side, where, as is usual in such cases, the range of tide is considerable.

The tide entering Queen Charlotte Sound reaches the vicinity of Discovery Passage several hours before the time of tide in the upper end of the Gulf of Georgia. The range of tide in the first locality is somewhat larger than the range in the second. The hydraulic effect is a current in Seymour Narrows of from 4 to 8 knots (§ 106 and Fig. 32, Part IV A).

Upon referring to the table given under § 97, Part IV A, Nos. 215–219, it will be seen that the ratio S_2/M_2 for Mazatlan and near-by stations in Lower California is larger than the ratio of the corresponding forces. For all other parts of the Pacific coast of America from Cape Horn to Bering Strait the tidal ratio is less than the ratio of the forces.

55. *Alaska and Bering Sea.*

The north angle of the large triangle forming the greater part of the North Pacific system is bounded for a considerable distance by the coast of Alaska. In § 74, Part IV A, it was pointed out that the range of tide should here be large and that its theoretical hour should be not far from IX. Upon referring to the charts of cotidal lines, Figs. 31, 33, we see this to be the case. The chart covering lower Alaska, Fig. 33, shows that the tides in the numerous canals seldom occur more than half an hour later than do the tides outside. The range, however, is considerably increased. These facts show that the tide in these canals consists largely of a stationary wave a moderately small fraction of a wave length long. (See also § 91 and Fig. 32, Part IV A.) The small difference in both time and range of tide throughout these canals and straits prevents the tidal streams from becoming as violent as the large range of tide and the peculiar formation of the coast might indicate. But hydraulic effects are not altogether wanting; in Clarence Strait, northeast of Prince of Wales Island (Fig. 33, Part IV A) the tidal current is 5 knots. Strong currents are likewise found in Sergius Narrows, Peril Strait. Throughout most of the canals and straits tolerably strong currents are necessitated for carrying in and out the large tidal volumes.

The large tides in Cook Inlet probably indicate that the virtual length of this body is about $\frac{1}{4}\ \lambda$.

The diminution of range of the Pacific tides experienced in going west from the Gulf of Alaska indicates the existence of a nodal line farther on. But the Bering and Okhotsk seas are bodies of water which permit extensive progressions, and so it is not strange to find an antecedent wave as far east as the Gulf of Alaska, and to find the nodal line off Rat Islands much obscured in consequence.

The tides of Bering Sea are derived from those of the Pacific. (See chart of soundings, Fig. 19, Part IV A, and chart of cotidal lines, Fig. 34, Part IV B.)

The Gulf of Anadir, although shallow, is characterized by a stationary wave, and so by nearly simultaneous tides.

Between St. Lawrence Island and Alaska the tidal hour changes rapidly and the range diminishes in going northeasterly through this strait.

At the mouth of the Yukon River the range of tide is 1.4 feet; 60 nautical miles up the river, the range is 0.4 foot.

Norton Sound is an amphidromic region, the no-tide point being about ¼ λ from the head of the sound. Without the deflecting force of the earth's rotation, this body of water would constitute a dependent fractional area with a nodal line running nearly north and south. But this deflecting force, on account of the narrowness of the sound, causes the water to pile up on the south side and to recede from the north side when the eastward motion across the nodal line prevails. The reverse is true for the west-going stream. On account of the relatively large diurnal wave in Norton Sound there is generally but one high water per day when the moon is far from the equator.

Around St. Lawrence Island the time of the tide probably assumes all values, as shown on the cotidal chart, but no observations for establishing this supposition are available. The range of tide is probably about 1 foot at the east end and somewhat greater at the west end.

The range of tide in the deep water south of the Pribilof Islands is about 2 feet; but the extensive shoaling and favorable configuration of the shore line cause the range to become 20 feet near the heads of the estuaries terminating Bristol Bay. There is undoubtedly considerable tide in Kuskokwim Bay.

From the Peninsula of Alaska westward to Umnak Island are numerous passages leading from the Pacific to Bering Sea. Through these the time of tide changes rapidly. The tidal streams are swift, particularly in the narrow passes, and are, in the main, hydraulic effects (§ 106, Part IV A). The range of tide is much greater on the southern side of these islands than on the northern side or in the passes.

56. *Islands of the North Pacific.*

The cotidal charts covering this region are Nos. 31, 35, 36.

The progression for waters lying easterly and northerly from the no-tide point situated between California and Hawaii has just been explained as being due to the overlapping of systems in the one case and the broken northwestern boundary of the Pacific in the other. The question now arises as to what may produce a southerly progression for the waters lying to the west of this point. By referring to the chart of systems it will be seen that north of this point is a region marked IX and south-southwest of it one marked XII. But XII or 0 combined with III, which number covers a very wide region, gives an intermediate value, say I½. We should therefore expect to find a change from IX to I½ for the western side of the amphidromic region, especially if there exists a favorable progressive wave in the vicinity of the nodal line west of the no-tide point. Such a wave is the antecedent wave moving toward the Fiji and New Hebrides Islands and involved in the progression caused by the shoaling and openings north and northwest of New Zealand, where the rise and fall of the South Pacific system is considerable (Fig. 20, Part IV A). It extends northeasterly to and even beyond the Hawaiian Islands, giving to the tides of all intervening waters a tendency to progress southwesterly.

South of the no-tide point is a region over which the time of tide changes but little, that time being between I½ and II, which is, of course, intermediate between XII and III. In this region progressive waves, if felt at all, are small in comparrison with the resultant stationary wave.

West of the Hawaiian Islands a general westerly progression is apparent because of the small range of the stationary wave over the extensive region marked III on the chart of systems. This is caused in part by the antecedent wave just referred to, but chiefly by similar waves entrained by the tides of the Sea of Okhotsk and the Yellow and China seas. In the western angle of the North Pacific triangle (between the Philippines and Guam) this progression is no longer apparent, partly because of the directions and limitations of the antecedent waves and partly because the range of the stationary tide becomes great as the angle of the triangle is approached (§ 27, Part IV A).

57. *From Kamchatka to Japan.*

The tides at Petropaulovsk, although not different in character from the tides of British Columbia and Alaska, have some historic interest because they were observed as long ago as 1828 and found to possess a large diurnal inequality, especially in the low waters.

Very little is known of the tides in the Sea of Okhotsk and comparatively few soundings have been made.

The tide is probably large in gulfs of Jijiginsk and Penjinsk; the range for the western and northern shores of the sea is probably 7 or 8 feet.

Upon referring to Fig. 23, Part IV A, it will be seen that a nodal line passes through the Caroline Islands just east of the Ladrone Islands and terminates off the eastern coast of Japan. On account of the progression up the Yellow Sea, and into the China Sea, it is probable that the northern end of this nodal line will be somewhat obscured by the antecedent wave. However, Fig. 36 shows a sufficient crowding up of cotidal lines to prove the existence of a nodal line. The fact that the tide reaches the eastern coast of the Philippine Islands within less than an hour after the time it reaches Guam, and that the range in the former locality is several times greater than in the latter, shows clearly the existence of a nodal line and loop.

Along the eastern coast of Japan to about the latitude of Tokyo the range of tide is about 2 feet. Going thence westerly along the coast the range continually increases, being 6.2 feet at Nagasaki.

The tide, entering from the south, progresses up the Inland Sea as far as the most northern point of Sikok Island, where it is met by the tide from the northern entrance.

The tidal hour changes rapidly from IX½ to I½ and from X to I½ in the southern and northern straits, which connect this sea with the northern entrance, or Kii Channel.

The tide reaches a point on the eastern coast of Kiusiu Island remarkably early for reasons given under lemma 32.

The tide which progresses westerly through Bungo Channel coalesces with that of Korea Strait a short distance west of Simonoseki.

The tides in the Sea of Japan are caused mainly by the disturbance acting through the Strait of Korea, where the cotidal lines are amphidromic. It is high water nearly simultaneously over the southern half of the sea, and this happens at about the time of low water for the southern end of the strait. The case is one of a tidal body producing tides in a nearly tideless sea. Hence § 35, Part IV A, the greatest inward velocity occurs three hours after high water at the south end of the strait. The extreme south end of the sea being narrow, the deflecting force of the earth's rotation causes it to then be piled up along the Japanese coast, while it recedes from the Korean coast. The reverse occurs on the outgoing stream.

The table given under § 97, Part IV A, and continued under § 19, Part IV B, shows great activity on the part of the Japanese in observing and analyzing tides. The ratio S_2/M_2 has here generally about its theoretical value; but as the nodal line is not far away, the value of the ratio here can not be expected to compare closely with its value in other parts of the system.

58. *Philippine Islands and China.*

The cotidal chart of the Philippine Islands, Fig. 37, shows that the tidal hour for the Pacific coast of these islands is about IX½.

The tide of the Celebes Sea is almost simultaneous with the tide east of the islands. The tide is delayed and its character somewhat altered in passing through the Sulu Archipelago into the Sulu Sea.

In passing through the channel north of Luzon the tide is much retarded. Over the deeper portion of the China Sea the tide is nearly simultaneous and the range small. Somewhat similar instances to this are Denmark Channel and the basin extending thence to Spitzbergen, also the strait south of Cape Horn and the deep waters towards South Georgia and the Sandwich Group. As the tide enters the China Sea it is delayed at the coast of Luzon, lemma 28, and the cotidal line becomes nearly parallel to the western coast of Luzon and Palawan.

Which part of the tide comes directly from the Pacific and the Celebes Sea and which part from the China Sea can be seen upon the map. It will be noticed that the tide ranges of Sulu Sea comes mainly from the south. By observing where bracketed occur, localities which at times have but one high water daily can be inferred.

In the southern part of San Jacinto Strait the time of tide changes suddenly from X½ to II, and in San Bernardino Strait from IX½ to II.

The tide passes up the Yellow Sea at nearly the rate due to depth. Between Shantung Promontory and Korea there is some crowding together of the cotidal lines. By lemma 28 the northern shore of Shantung Promontory should have very late tides, and observations at Wei-hai-wei show that such is the case. (See also § 14.) The wave advances northwesterly through the waters connecting the gulfs of Pechili and Liaotung, to the northwestern shore near the terminus of the Great Wall. One branch passes northeasterly up the Liaotung Gulf; the other follows the western and southern shores of the Gulf of Pechili, finally coalescing with the incoming waves, thus forming a wave eddy (§ 13).

The chart of cotidal lines (Fig. 36) shows the range to be generally large for the eastern coast of China, and especially for the western coast of Korea. The range at Wei-hai-wei is, however, only 4.5 feet.

Some observations made upon the bore of the Tsien-tang Kiang are shown in Fig. 19, Part I.*

Lemma 28 applies to the northern and southern ends of the island of Formosa, and the cotidal lines finally become parallel to the sides of Formosa Strait.

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* This bore is described by Prof. G. H. Darwin on pp. 59–71 of his book entitled "The Tides and Kindred Phenomenon in the Solar System."

In passing up the Gulf of Tonkin the small semidiurnal tide from the China Sea becomes very small toward the head of the gulf, while the diurnal tide suffers no such diminution. The tide here is of historic interest, having been observed by Francis Davenport and discussed by Dr. Edmund Halley and Sir Isaac Newton.*

From the deep portion of the China Sea an extensive progression extends to Singapore and to the Gulf of Siam. This gulf causes an increase in range as Bangkok is approached.† The progression to Singapore coalesces with that of the Strait of Malacca and continues southeasterly for a short distance along the coast of Sumatra. At Banca Island it turns east, and reaching Borneo turns northerly, finally coalescing with the incoming tide. This is a species of wave eddy, mentioned in § 13, whose period requires 24 instead of 12 hours. It resembles the one occupying the greater part of the North Sea. It is probable that for considerable distance around the no-tide point the range of tide is very small.

The tides of Gillolo Passage, Molucca Passage, and Macassar Strait are shown in Figs. 7, 36. They coalesce with the Pacific tides at the northern ends of the passes. In case of the first two some crowding up of the lines is required, while the northern portion of Macassar Strait is characterized by simultaneous tides. (See §§ 35, 102, Part IV A.)

By means of a large-scale chart of soundings the apparently irregular arrangement of the cotidal lines in the Banda and Java seas are easily accounted for, at least in a general way. The tide progresses westerly in the Java Sea because the range of the ocean tide upon which it depends is large near the loop and small near the node of the North Indian system.

59. *Islands of the South Pacific.*

The sequence of tidal hours around the no-tide point near the Society Islands can be obtained from the following considerations: According to the loops of the oscillating systems (Fig. 23, Part IV A), east of the point the hour should be IX; north of the point it should be I and II; west of the point it should be VI; south of the point there should be little or no tide. The antecedent wave involved in the progression resulting from the shoals and openings north and northwest of New Zealand indicates that northwest of the no-tide point there is a progressive wave moving southwesterly. Southwest of the point is a sector over which there is little progression, as the tidal hours for the Samoan and the Hervey or Cook Islands go to show. South of this point the range of tide is small, but an eastward progression is necessitated because the tidal hour for the Cook Islands is VI while for Rapa or Oparo Island it is IX½ and for Tahiti between X and X½. East of the point there is a northward progression, as observation made in the Low Archipelago and on the Marquesas Islands prove. Observations made on the Marquesas, Caroline, and Penrhyn islands prove a westerly progression to exist north of the no-tide point. Northeast of the point, the change in tidal hour is very slow, as might have been inferred from the chart of systems. All these considerations agree in

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* See §§ 85, 88, Part I.

† Since Fig. 36 was drawn, new constants for several places in Cochin China have become available through the French colonial tide tables for the year 1904. They indicate that the tidal hours for Nha-trang and vicinity should be increased by an hour or more; also, that between Cambodia Point and Hatien the tide is much delayed in accordance with § 7.

giving an amphidromic region similar to the one shown in Fig. 38. The position of the no-tide point is quite accurately fixed by the known tides at Tahiti, and Tonga-reva or Penrhyn islands; at these two places the range is small, and when it is high water at the one it is almost low water at the other.

It may be well to note that no observations appear to have been made for the central portion of the loop marked IX.

The tides at Pitcairn, Henderson, and Ducie islands would probably be little influenced by those not belonging directly to the system.

Between Easter Island and Sala-y-Gomez a rapid change takes place in the tidal hour. This crowding up of the cotidal lines is due to the proximity of a nodal line modified by the wave antecedent to the Cape Horn eastward progression.

The Kermadec, New Hebrides, Fiji, and Ellice islands all lie at or near the western loop of the South Pacific system. Their theoretical tidal hour is VI. However, the southwesterly progression started by the imperfect character of the outer boundary of this loop has the effect of making the number of the hours increase southwesterly.

The tide on the southwestern coast of New Caledonia occurs 2 hours later than on the northeastern. (Cf. lemma 28.)

In going westward from the Gilbert and Ellice islands to the northern coast of New Guinea the range of tide continually decreases, indicating approach to the nodal line which passes just east of the Ladrone Islands.

The progression from the Marshall and Gilbert islands through the Solomon Islands, thence across the Coral Sea to the Australian coast, seems to be the result of two neighboring regions having tides at different hours. In the first region the tidal hour is about V and in the latter IX. Thus the tide in the Coral Sea comes from both the north and the east, the tide from the east being the controlling factor.

The extreme shallowness of Torres Strait prevents the Pacific tide from exerting much influence on the tides in the Gulf of Carpentaria.

60. *New Zealand and eastern coast of Australia.*

The westward and southwestward progression resulting from the imperfect support of the western loop of the South Pacific system constitutes the tides along the eastern coast of Australia and in the adjacent waters. One portion going southwesterly through the broad passage between New Zealand and Australia has the effect of producing, with the aid of the South Indian system and the XII loop of the South Pacific system, a region south of this passage over which the tides are nearly simultaneous. The progression extends completely around New Zealand, the portion found east of North Island being an antecedent wave. The tidal hours thus form a complete cycle of values (§ 14).

The tidal hour at the south end of Cook Strait is IV½. The hour increases in going northward to X on the southern shore of North Island and to IX½ near Cape Farewell, where it meets the tide progressing down the western coast of the islands. The range at the south end of the strait is considerably less than at the north end. The motion in the strait is largely a stationary oscillation. The maximum velocity occurs about 3 hours after the maximum surface slope through the strait. (Cf. §§ 11, 35, 102, Part IV A.) In many parts of this strait there are strong tidal currents.

A no-tide point southeast of New Zealand appears to be required for the following reasons, although its exact location is, of course, doubtful: Observations show a sequence of hours, I to VI, to the west and northwest of the assumed point. To the north there must be a crowding together of cotidal lines because of the proximity to a nodal line. For the Chatham Islands the tidal hour is IV½ and for Rapa or Oparo, near the loop marked IX on the chart of semidiurnal systems, it is IX½, indicating that the tidal hour increases in going northeasterly from Chatham Islands. East of the point the theoretical considerations indicate that the tidal hour must be XII (Fig. 23, Part IV A). Hence the southeasterly increase from IX½ to XII. This change is probably helped along by the antecedent wave of the Cape Horn progression. To the south must be a wide sector of nearly simultaneous tide, because observations made at Auckland and Campbell islands, west of the point, give a tidal hour but little different from the theoretical tidal hour southeast of the point.

61. *References to observations and discussions of Pacific Ocean tides.*

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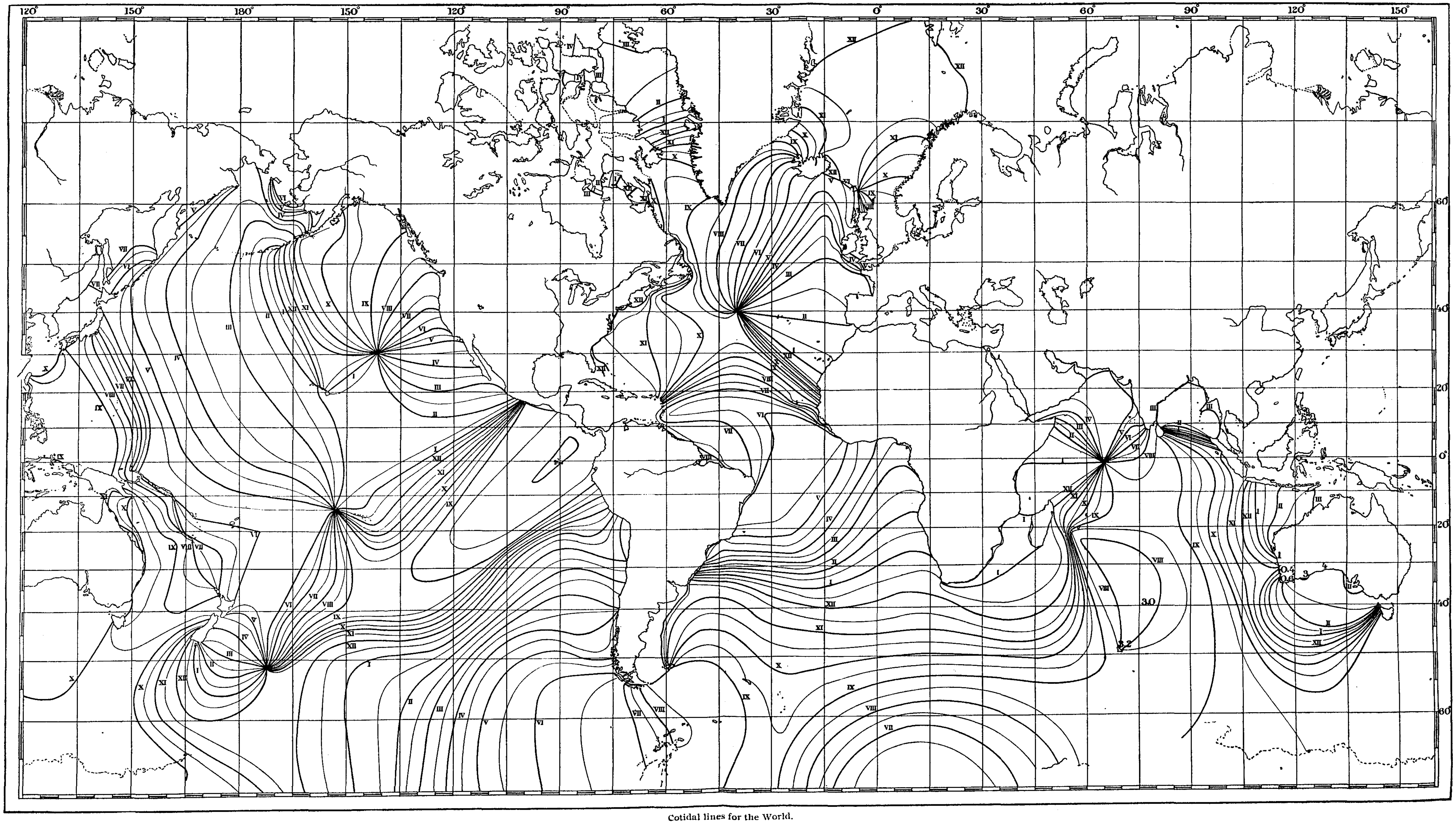
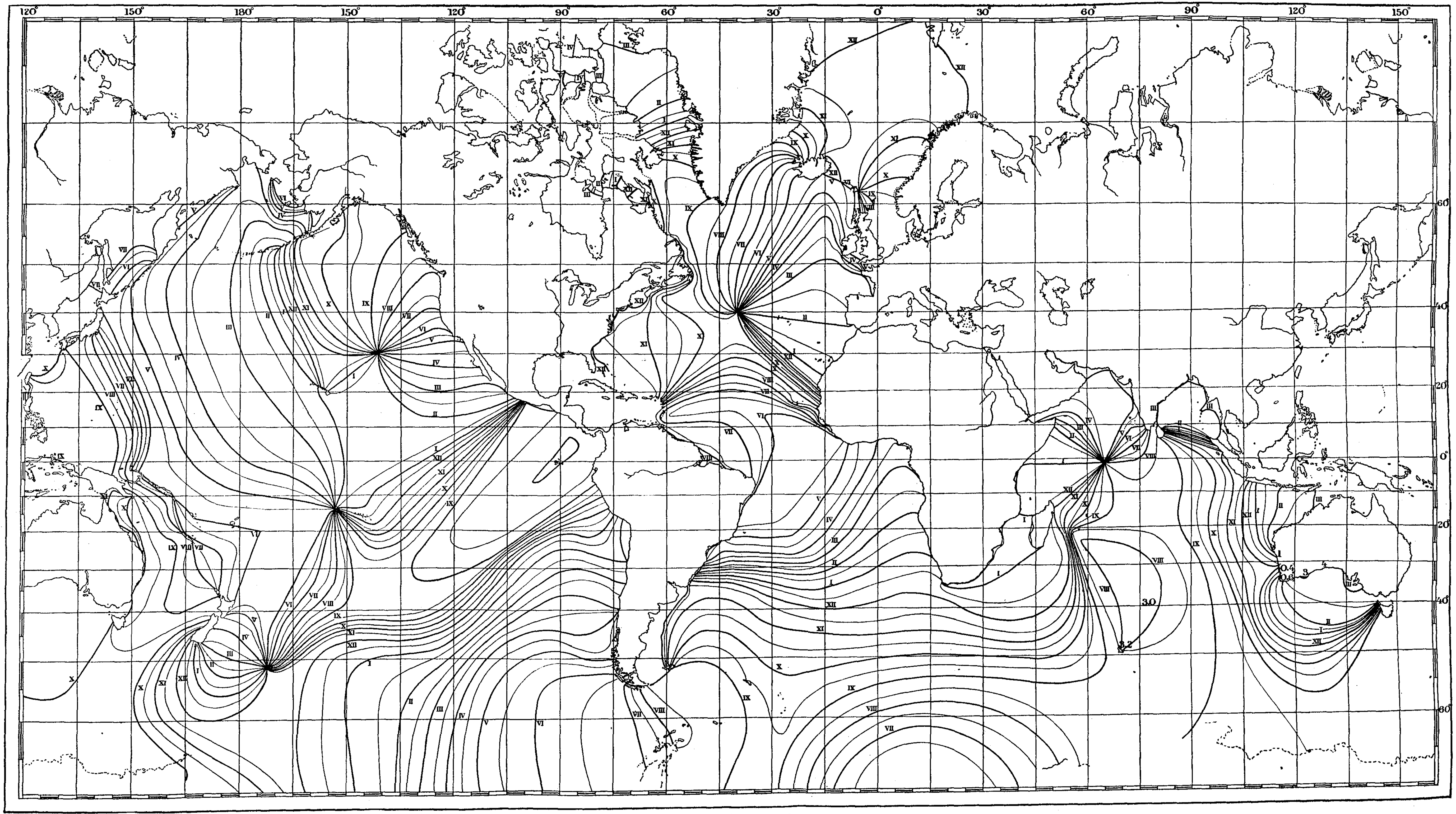
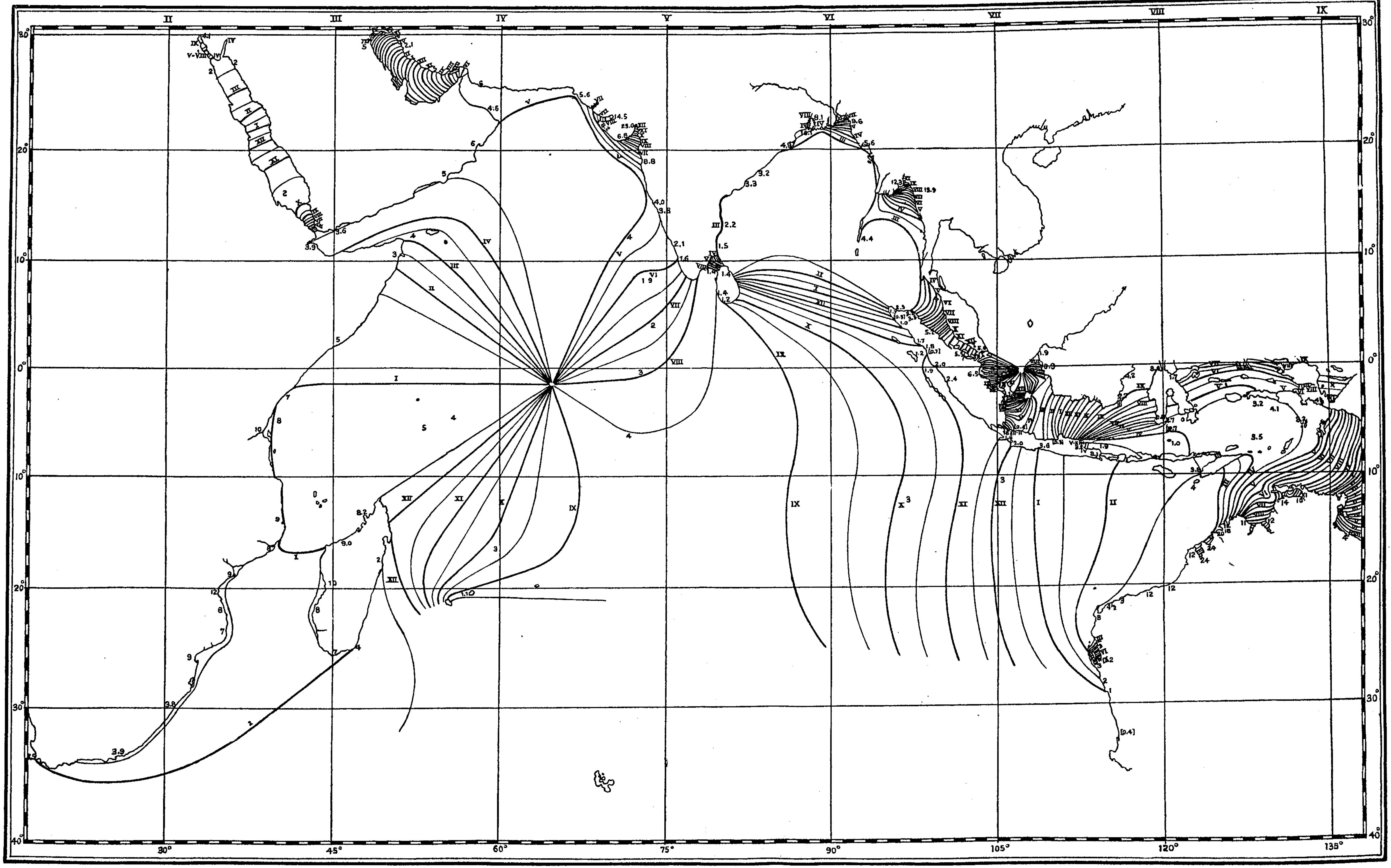


Cotidal lines for the World.

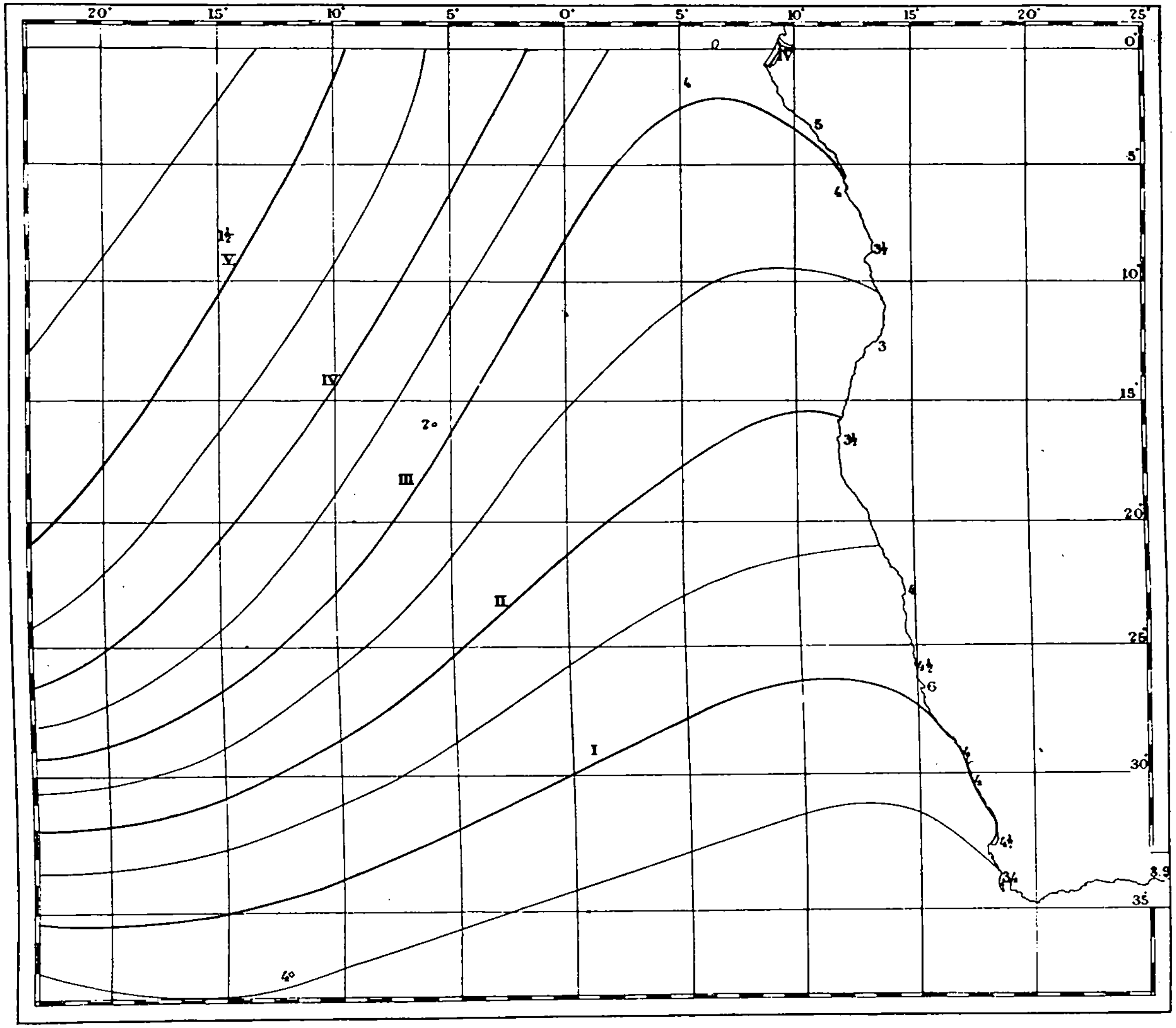
No. 6.



Cotidal lines for the World.

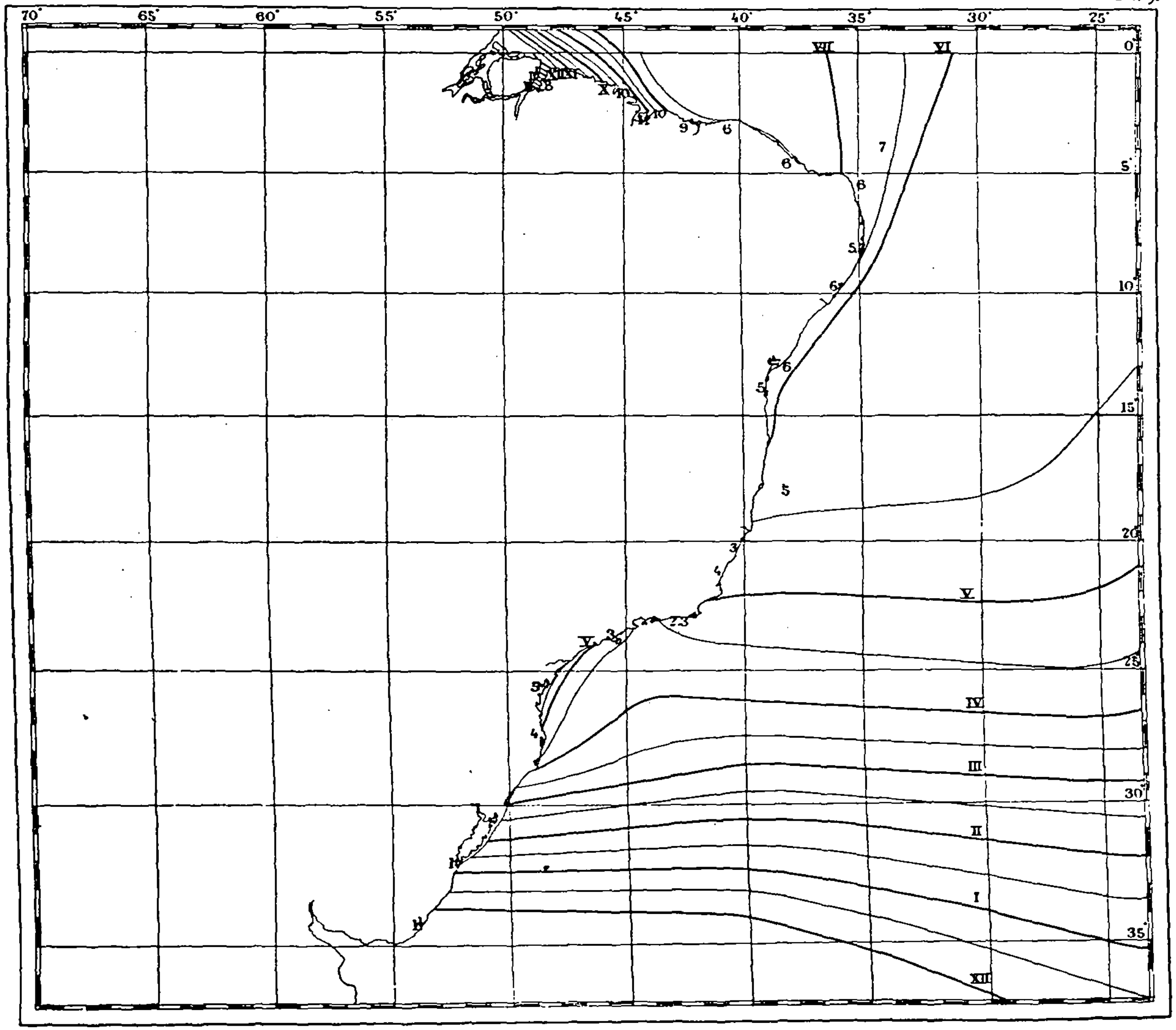


Cotidal lines for the northern part of the Indian Ocean.

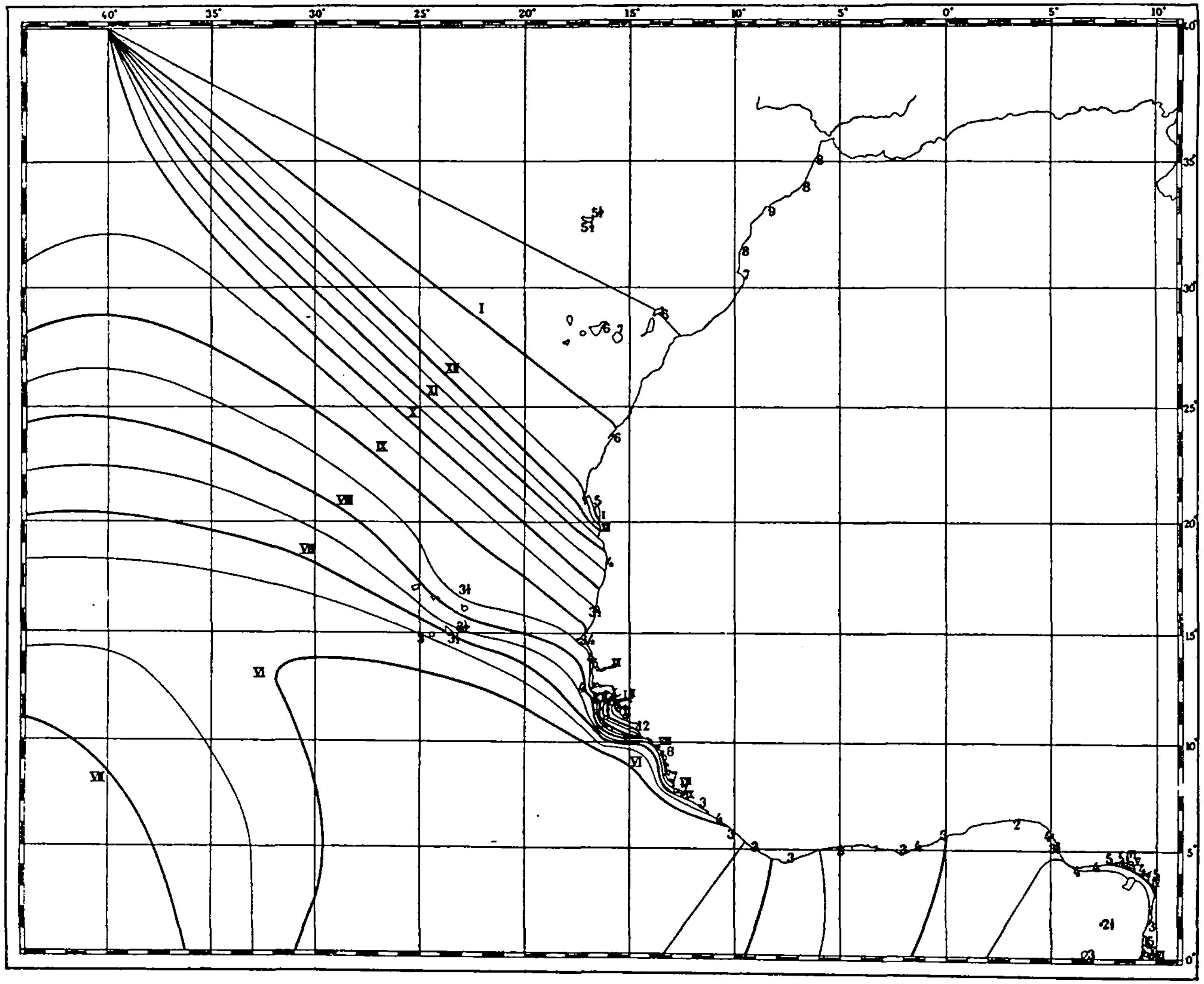


Cotidal lines west of Southern Africa.

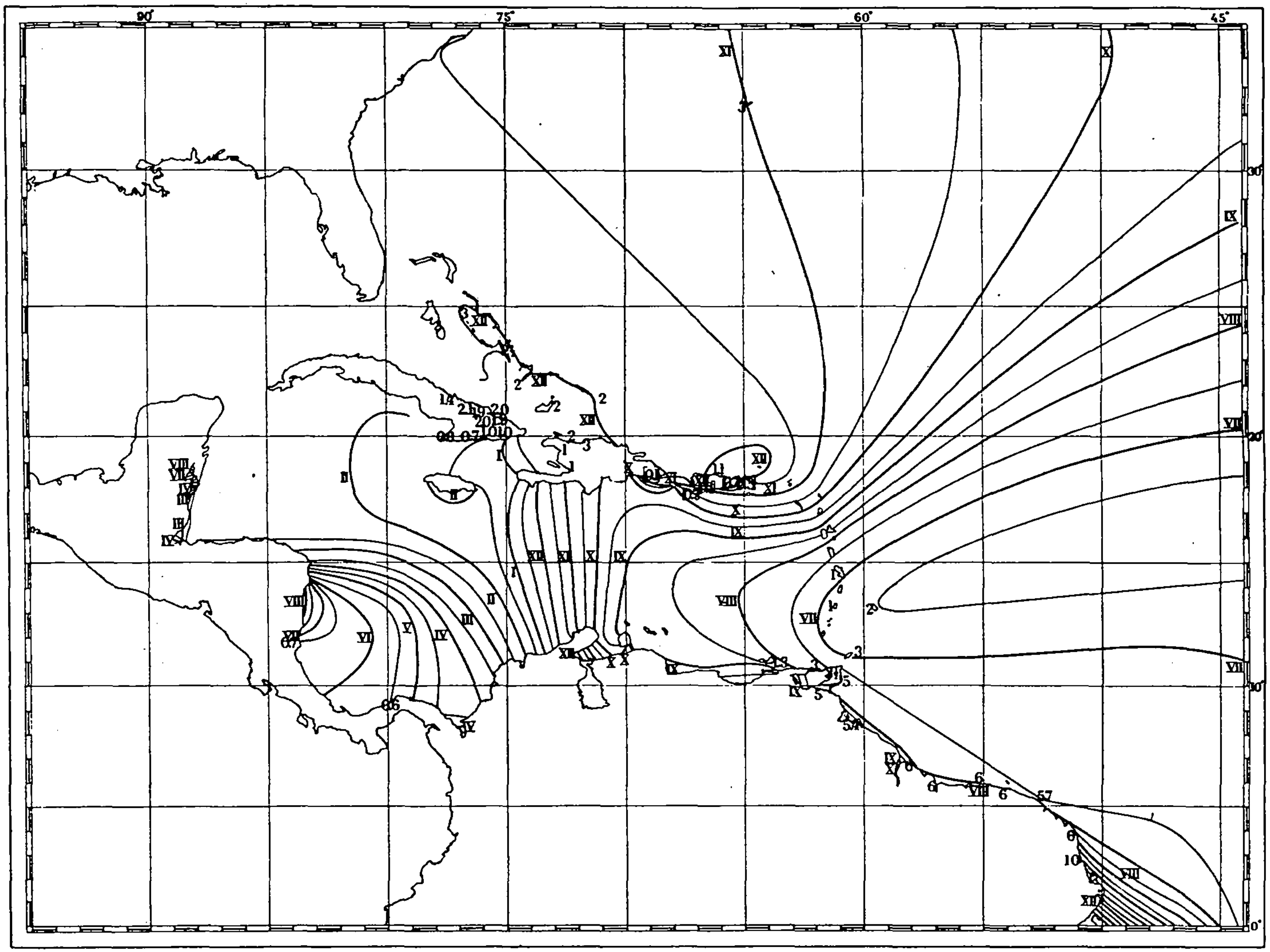
No. 9.



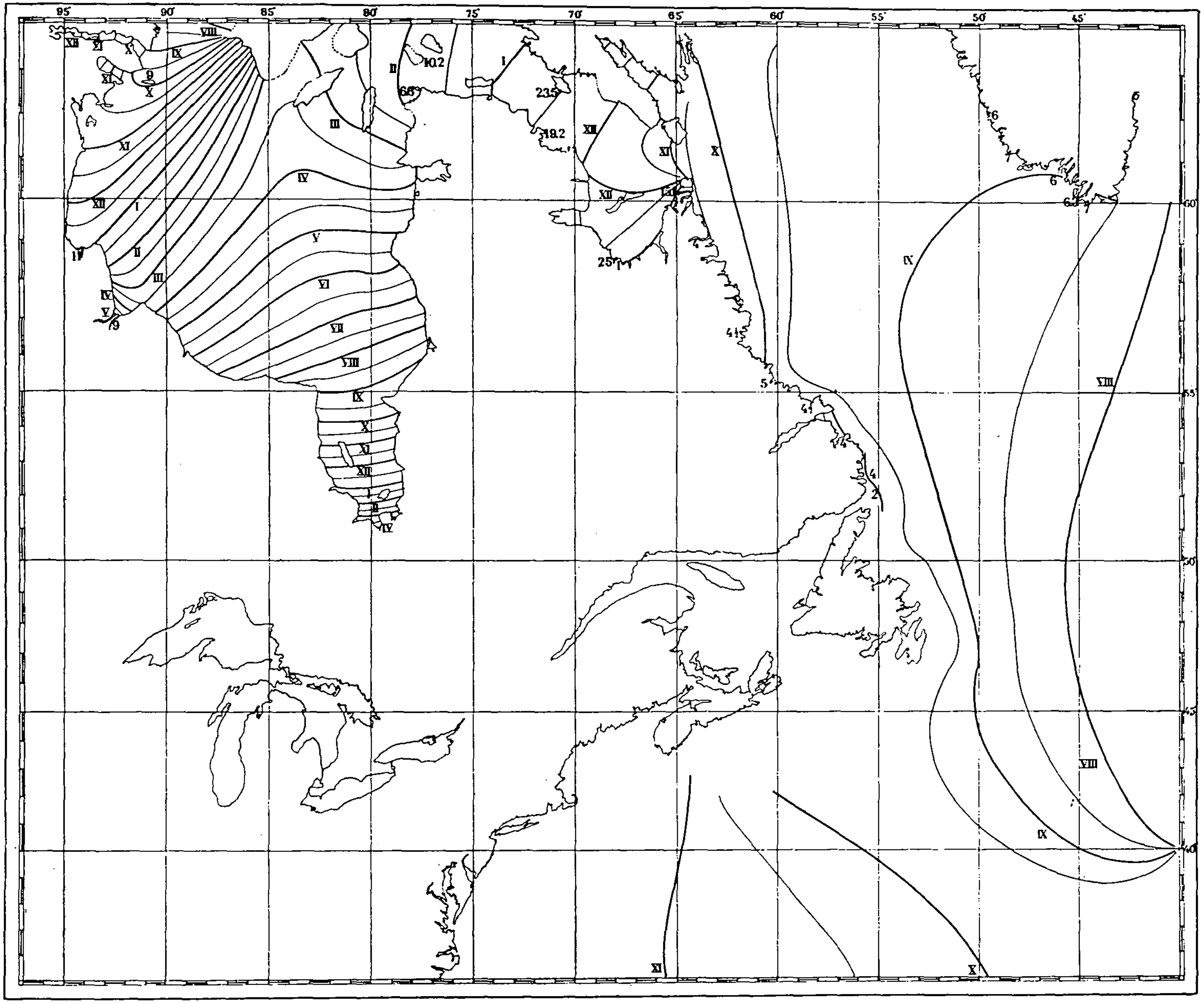
Cotidal lines east of Brazil.



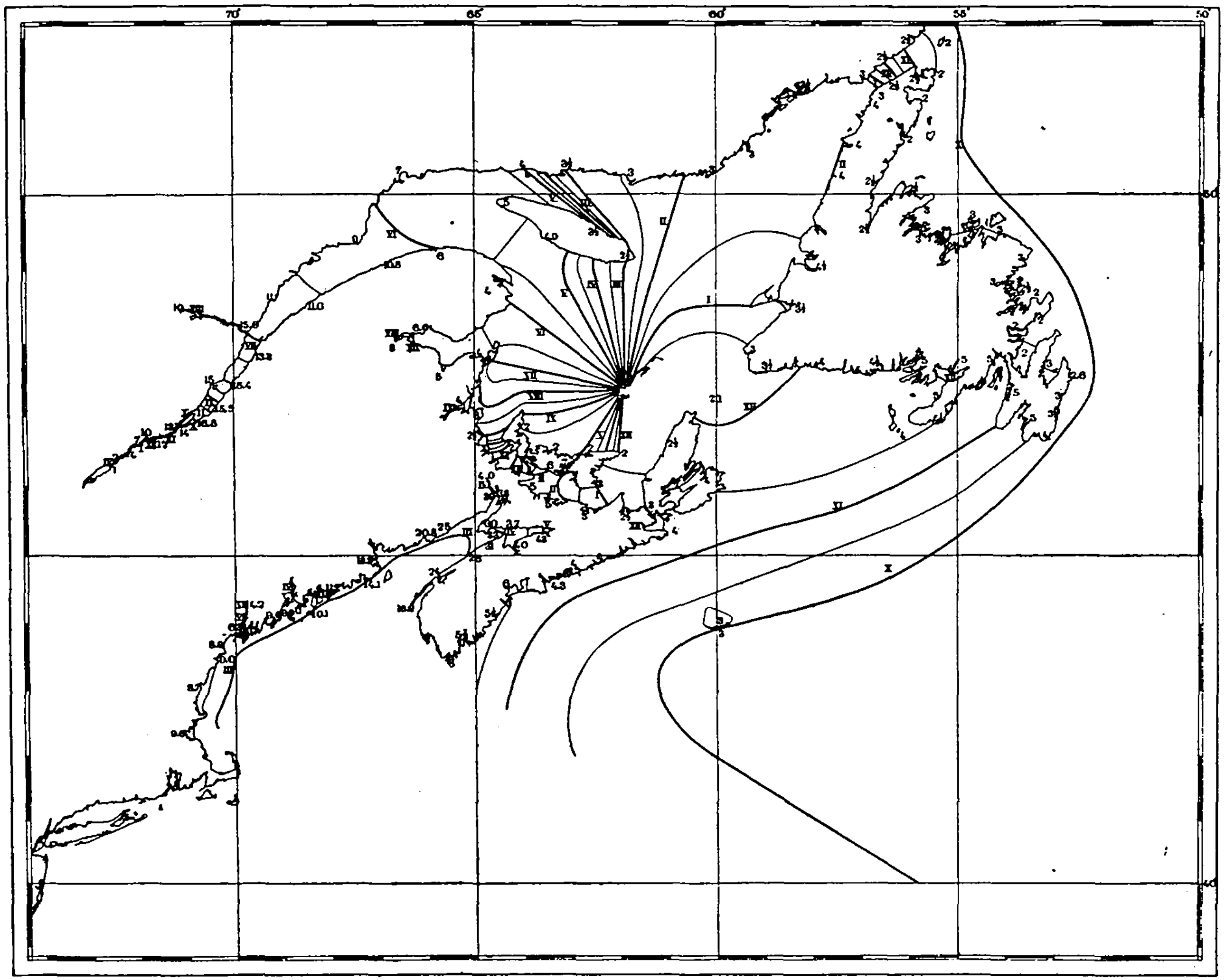
Cotidal lines west of Northern Africa.



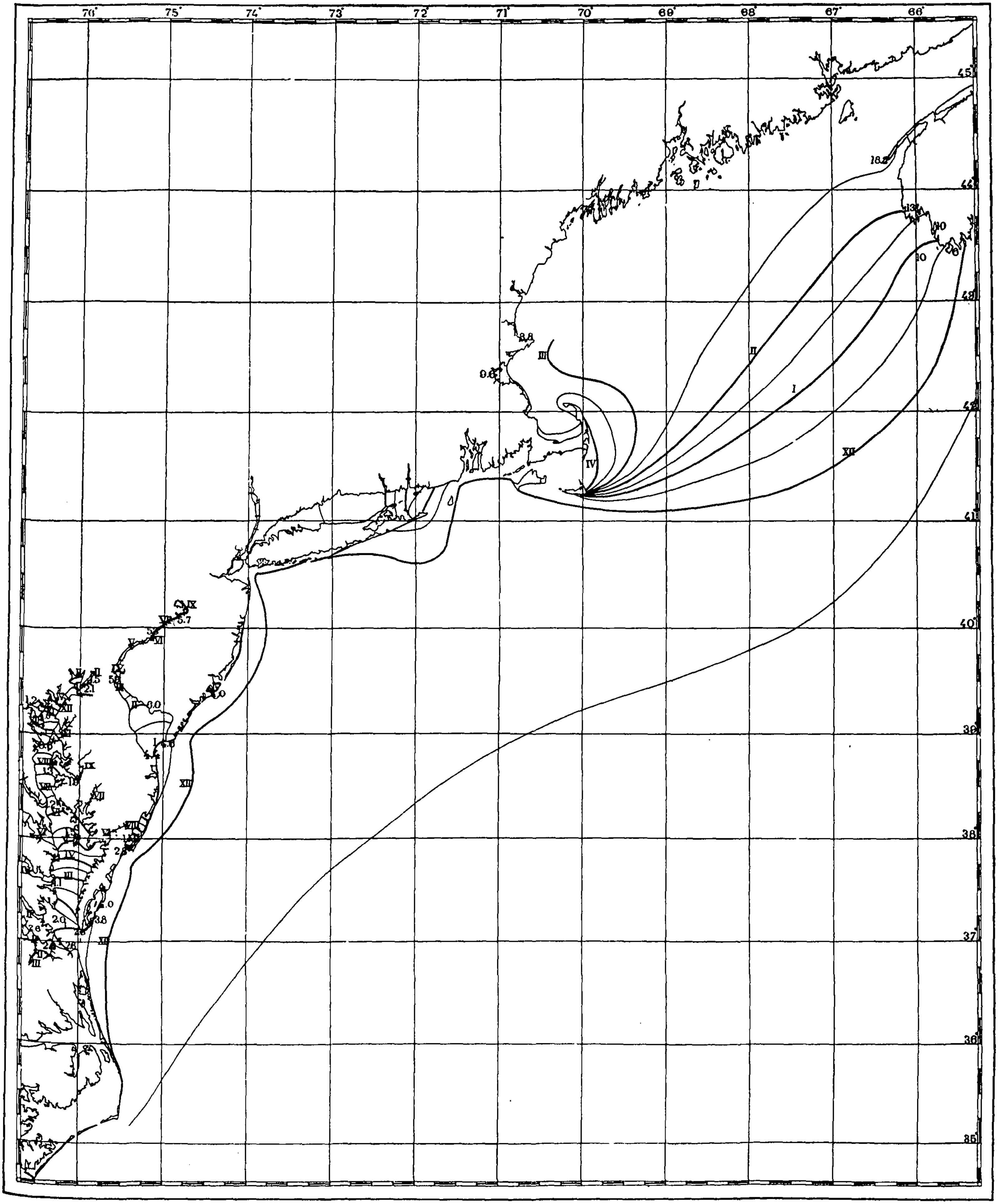
Cotidal lines north of South America.



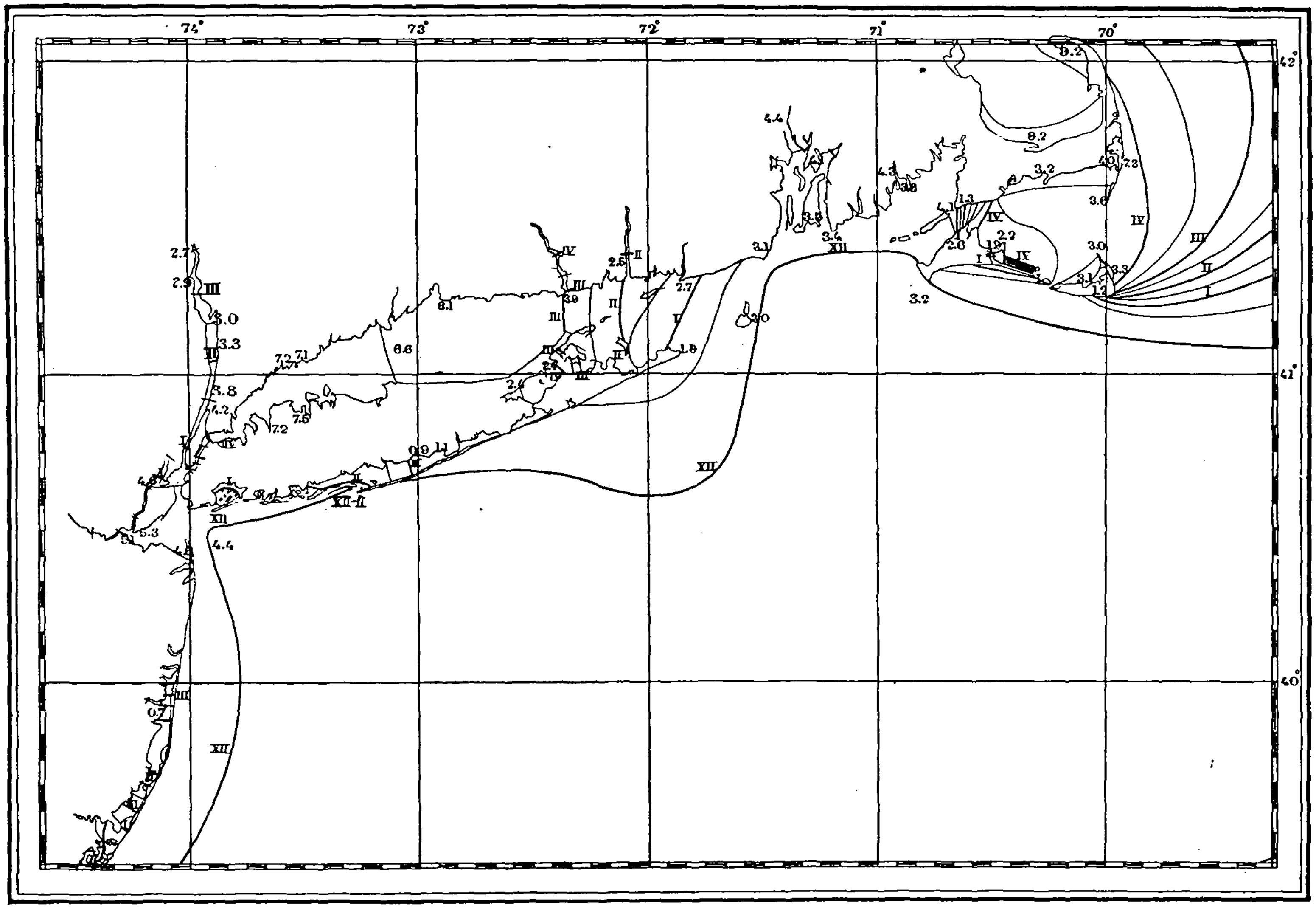
Cotidal lines east of Canada.



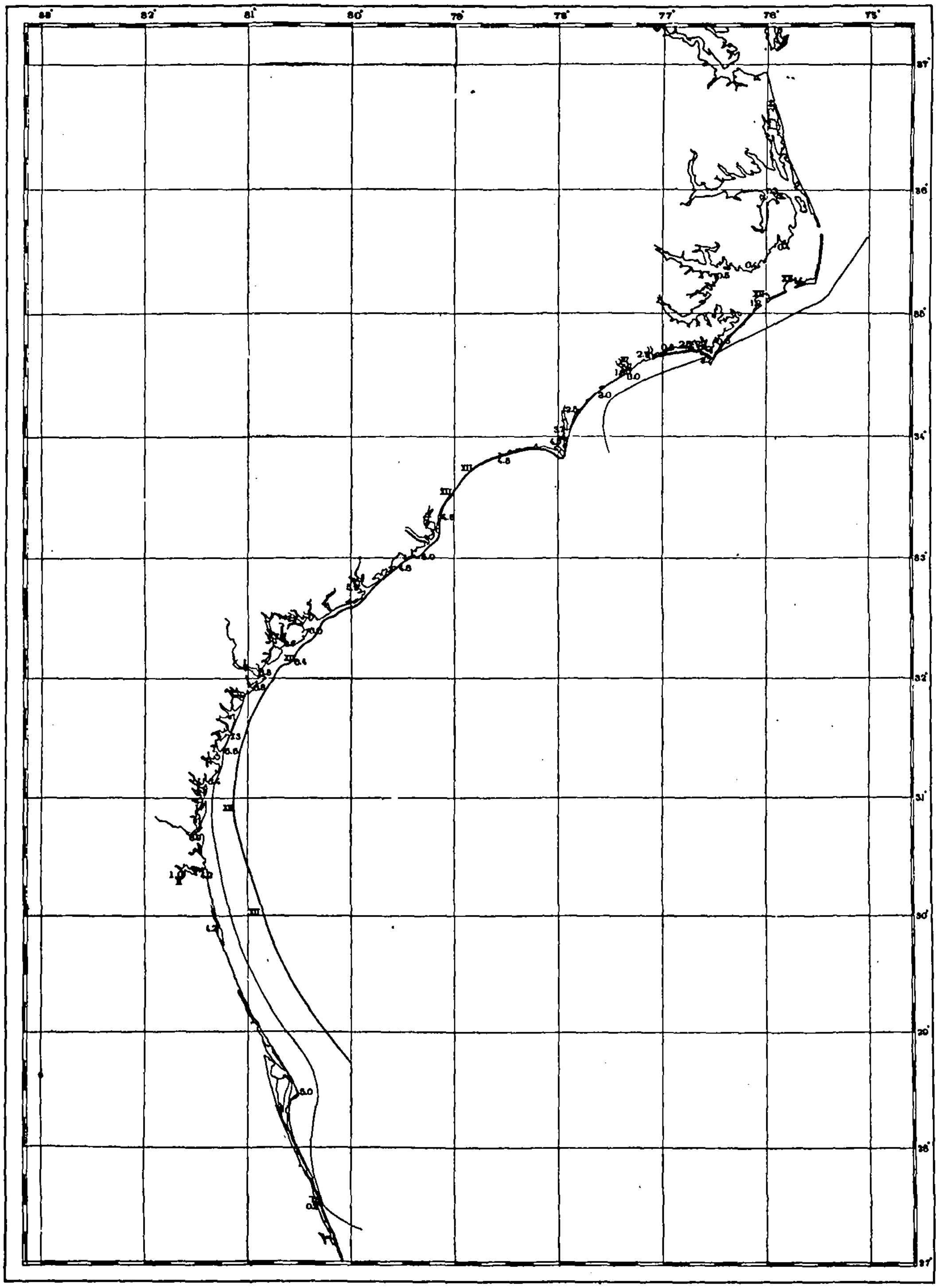
Cotidal lines for the Gulf of St. Lawrence.



Cotidal lines for the Northern Atlantic States.

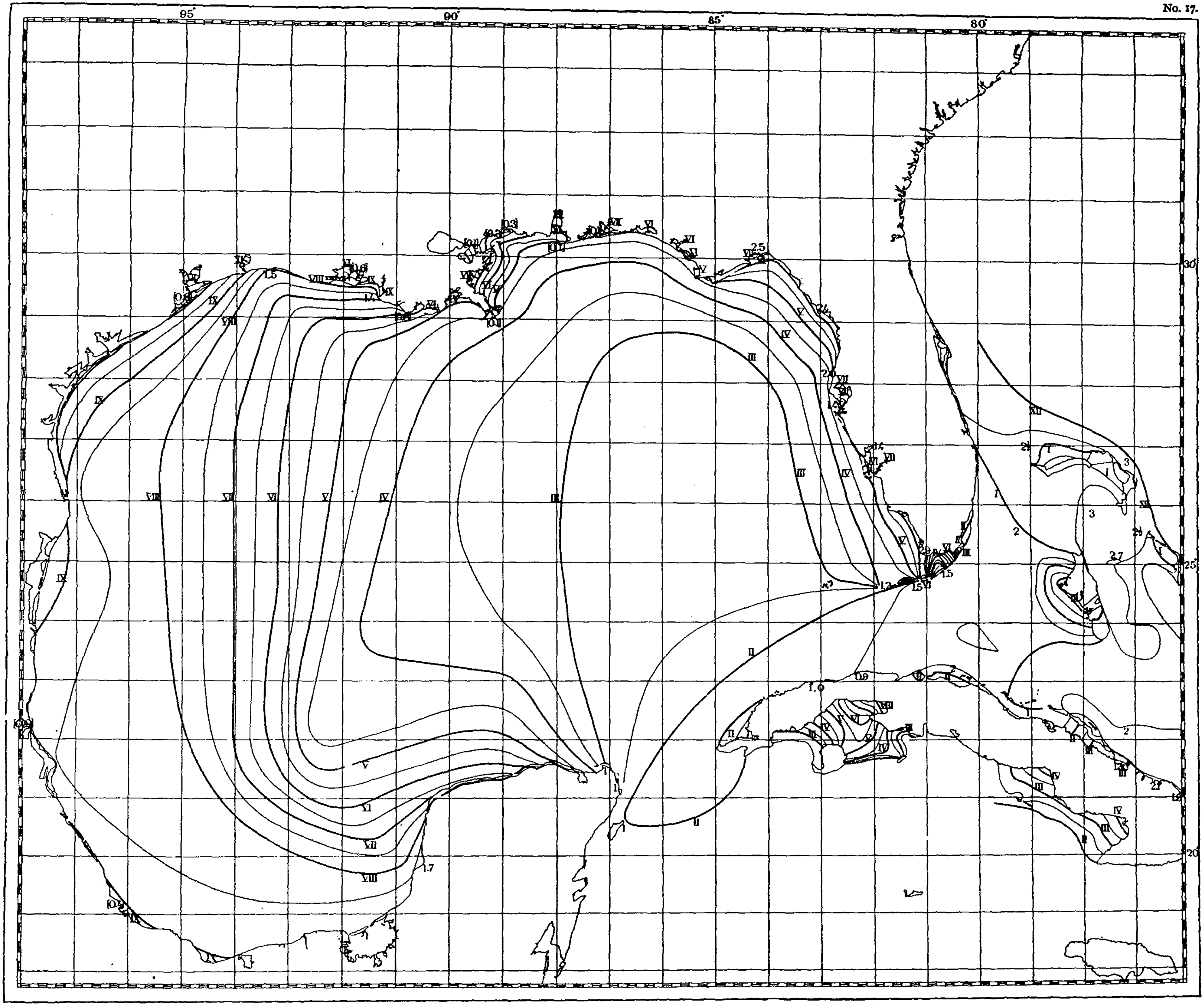


Cotidal lines for New York Harbor and approaches.

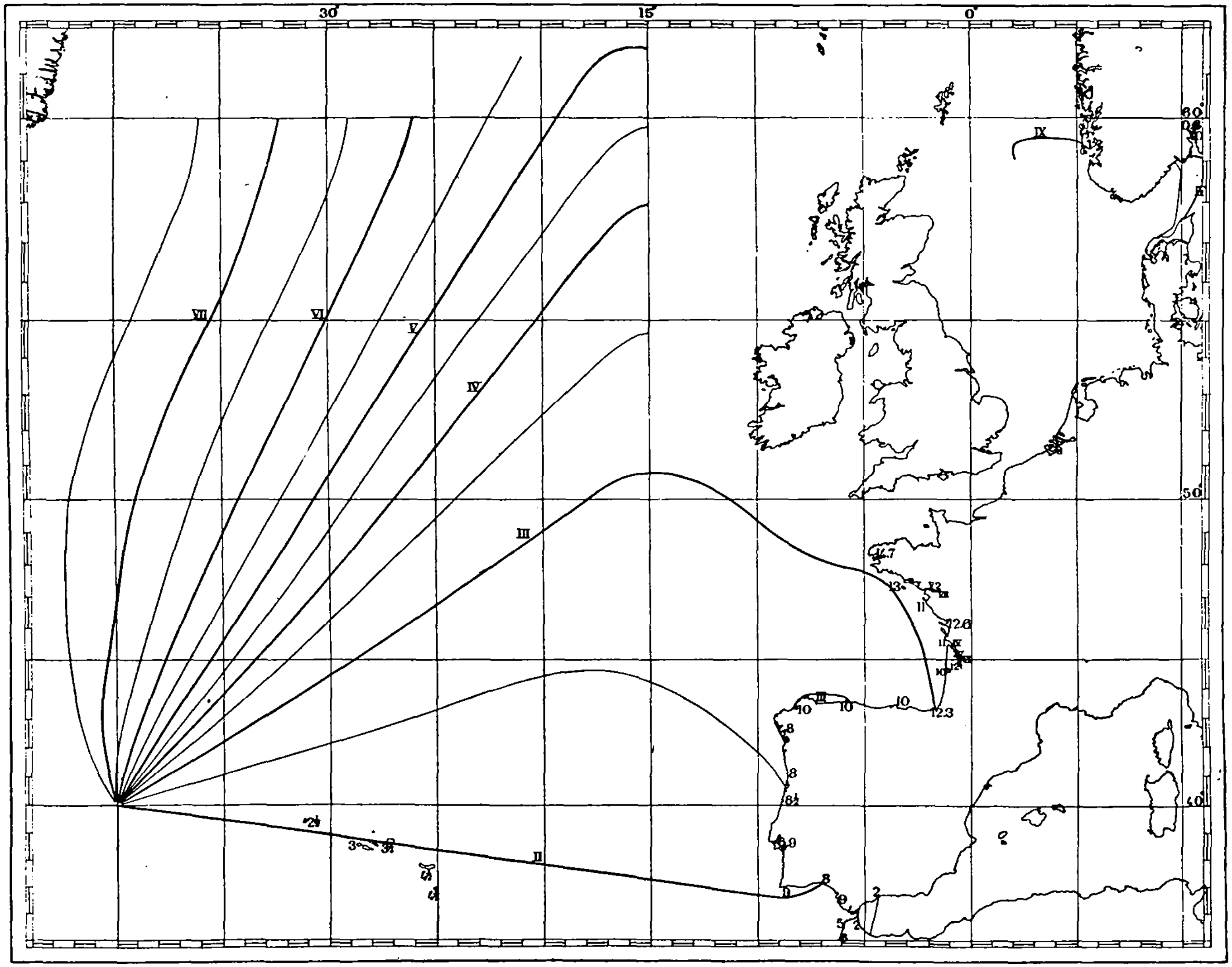


Cotidal lines for the Southern Atlantic States.

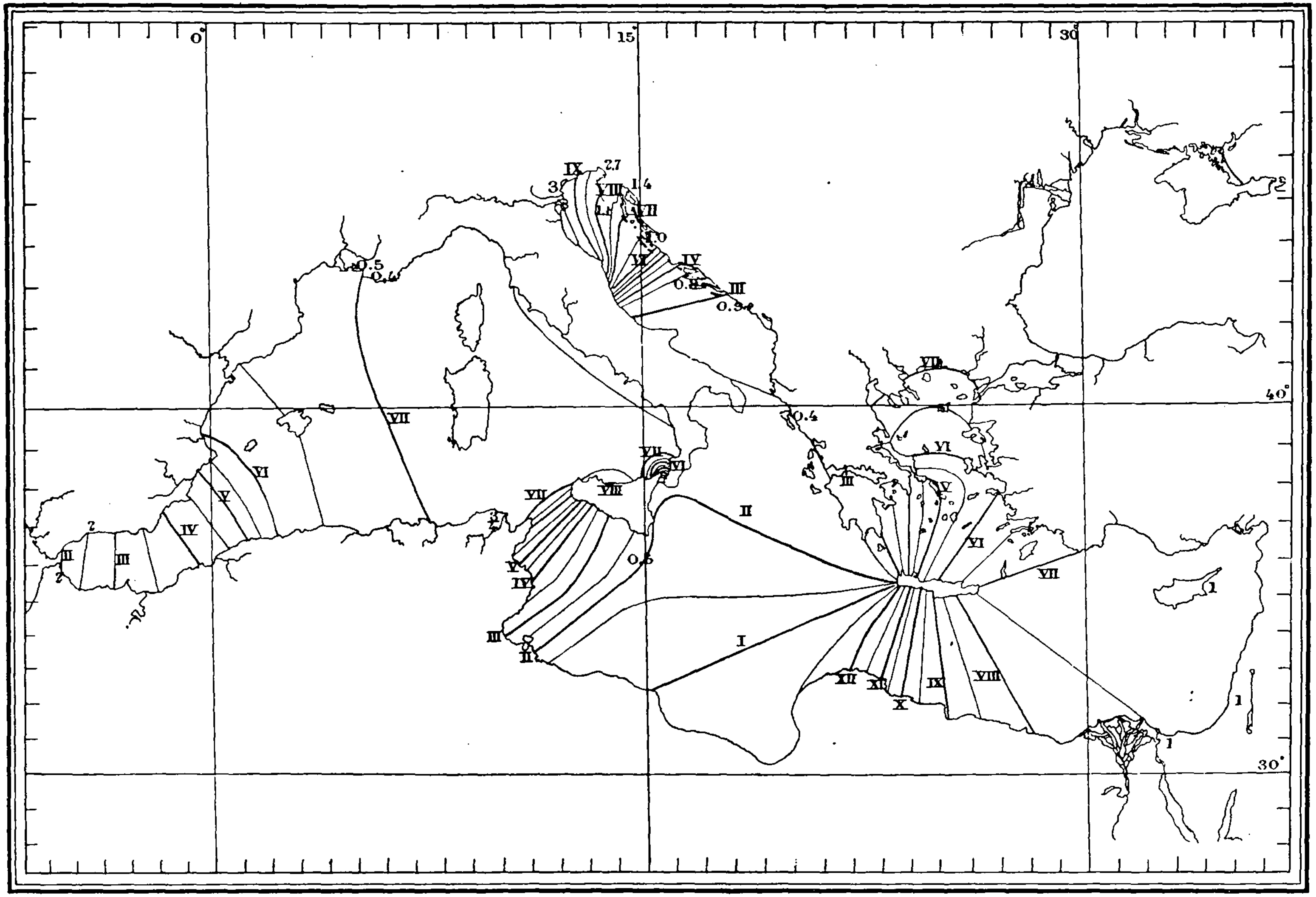
No. 17.



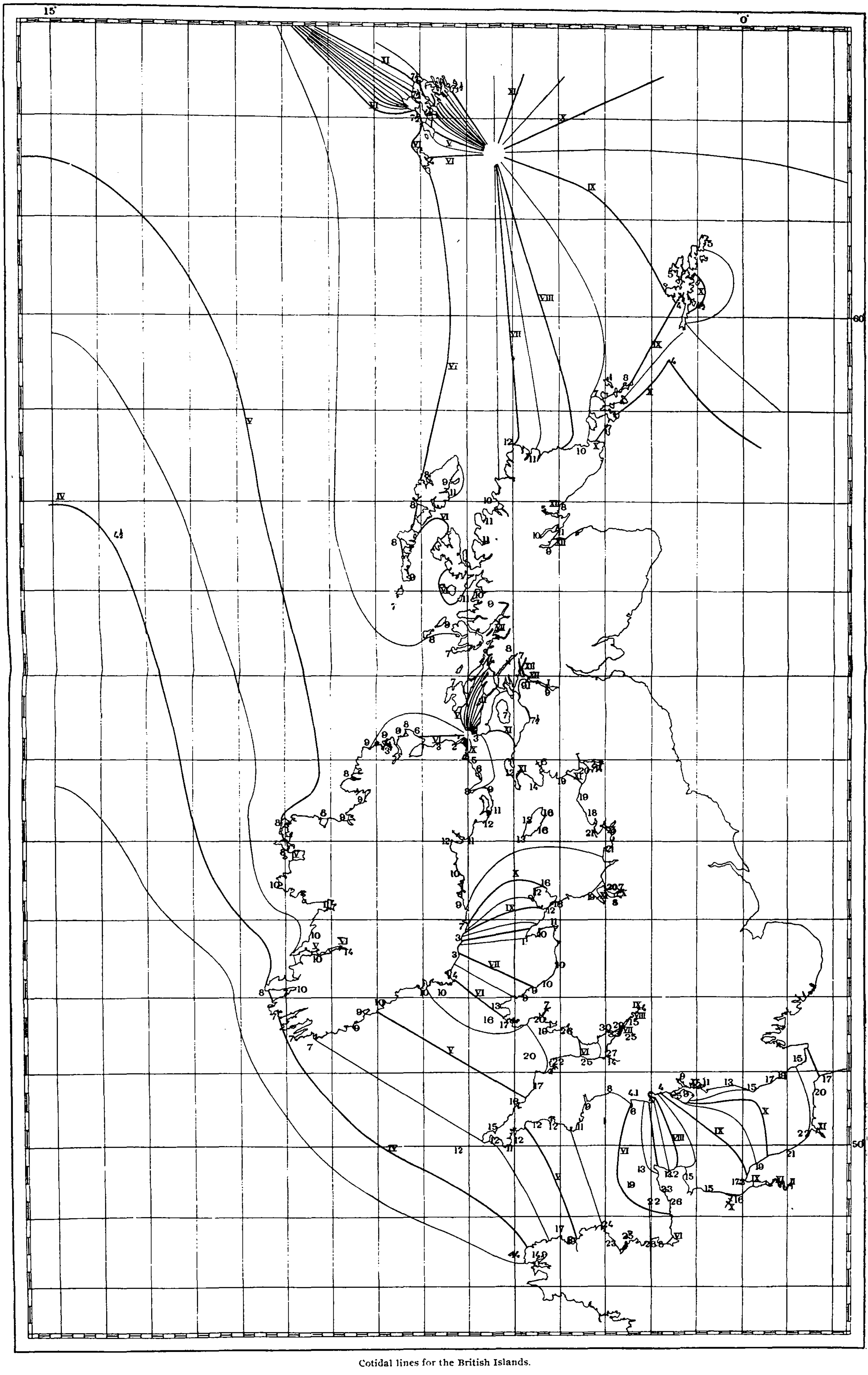
Cotidal lines for the Gulf of Mexico.



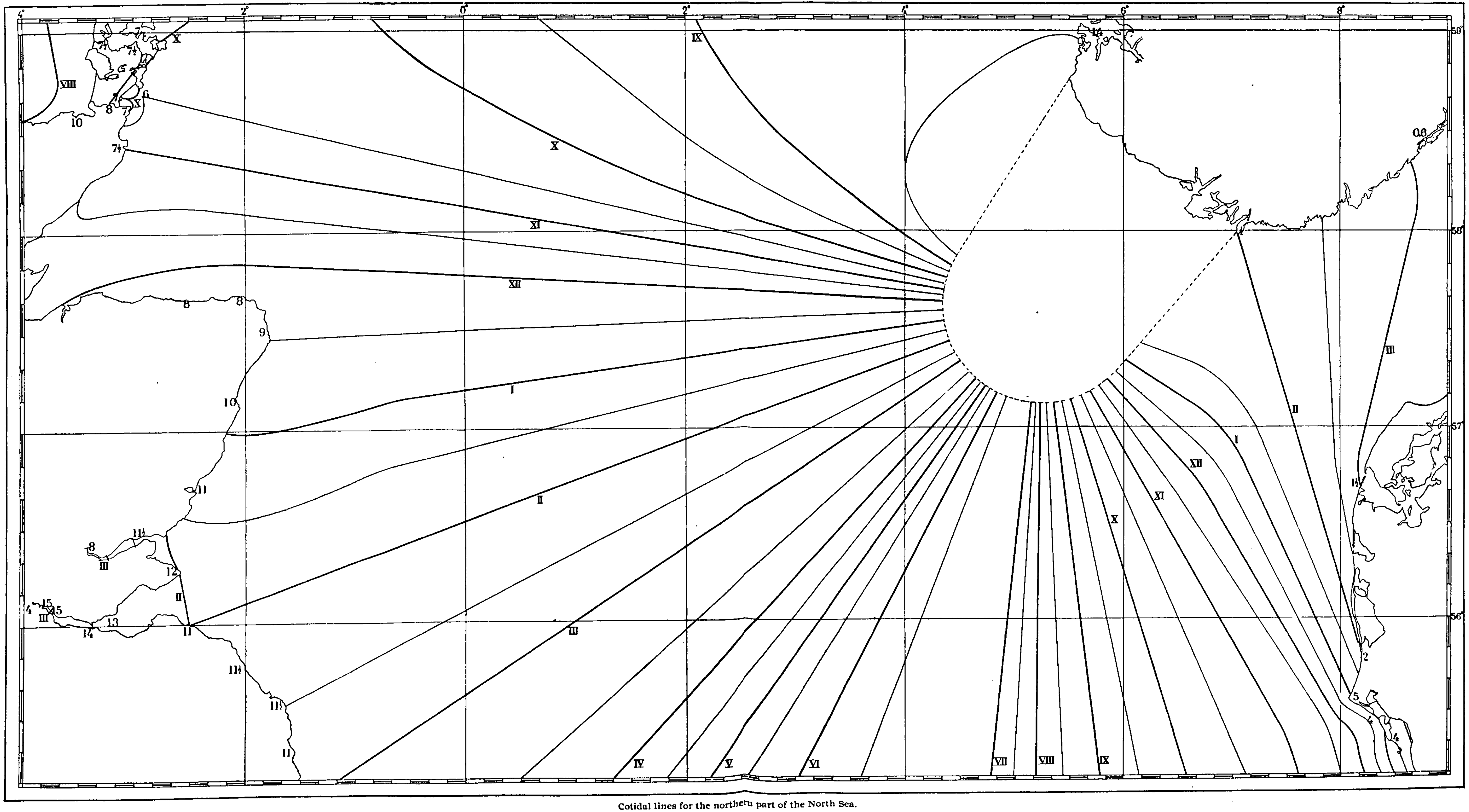
Cotidal lines west of Europe.



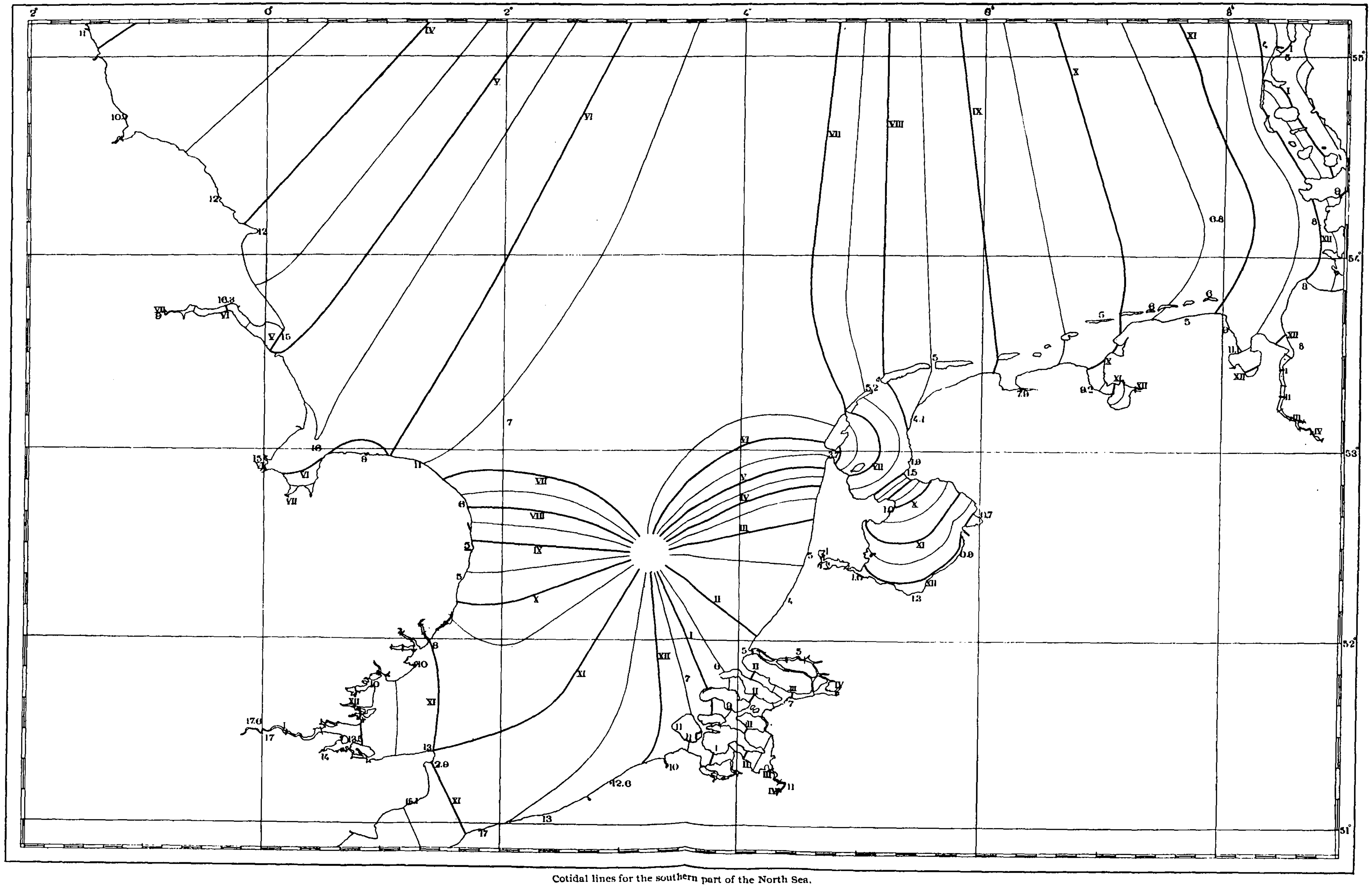
Cotidal lines for the Mediterranean Sea.



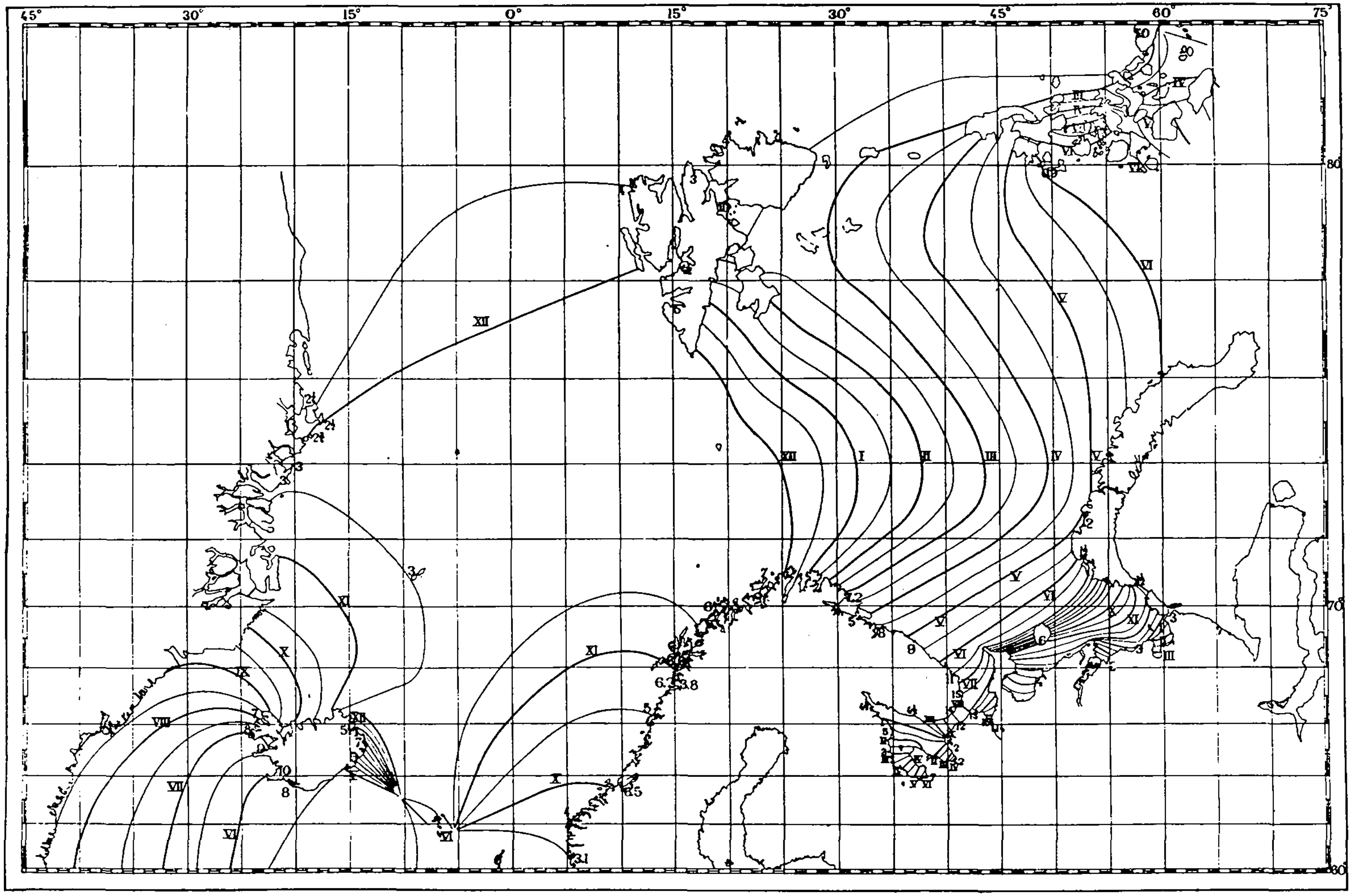
Cotidal lines for the British Islands.



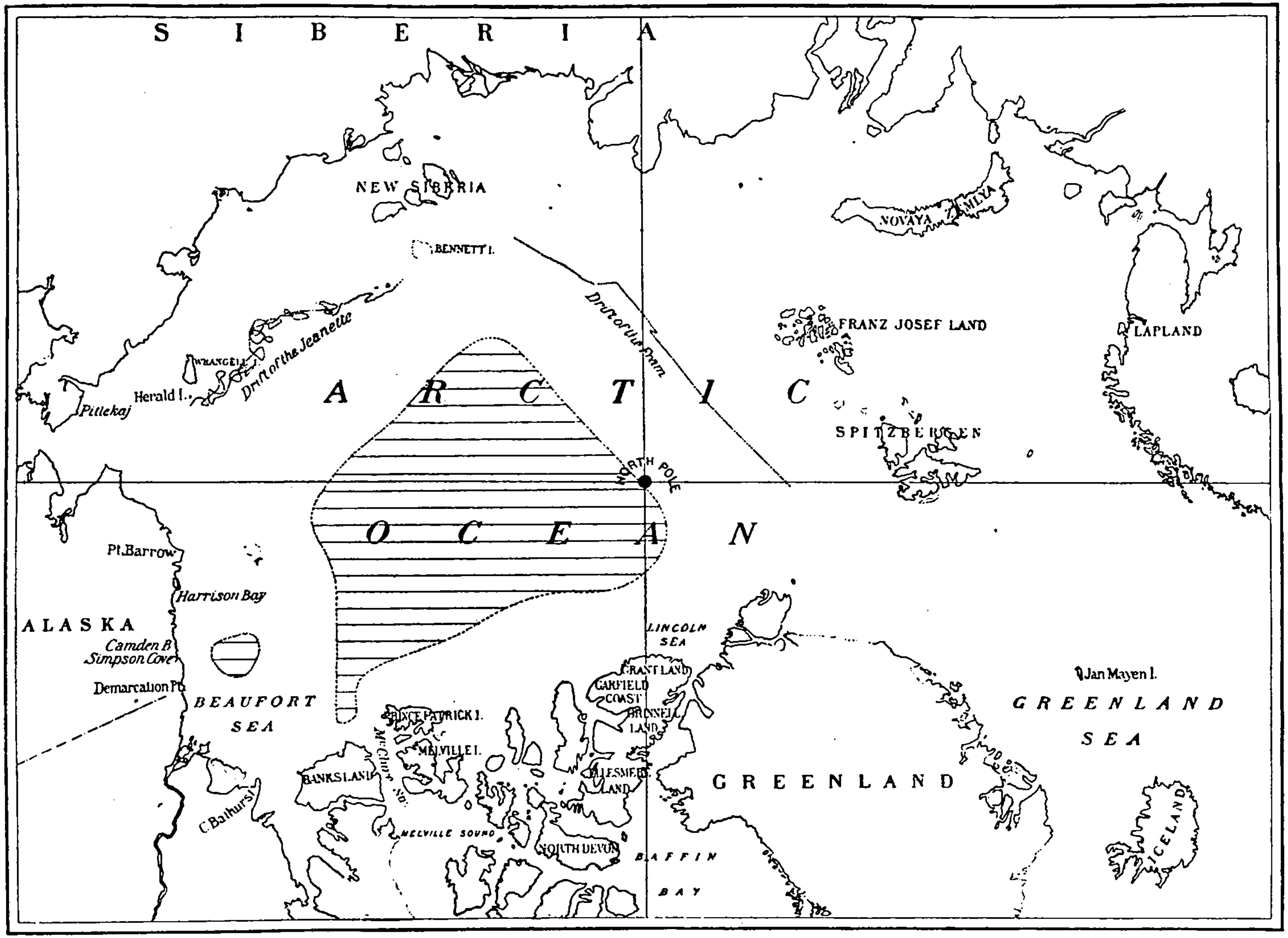
Cotidal lines for the northern part of the North Sea.



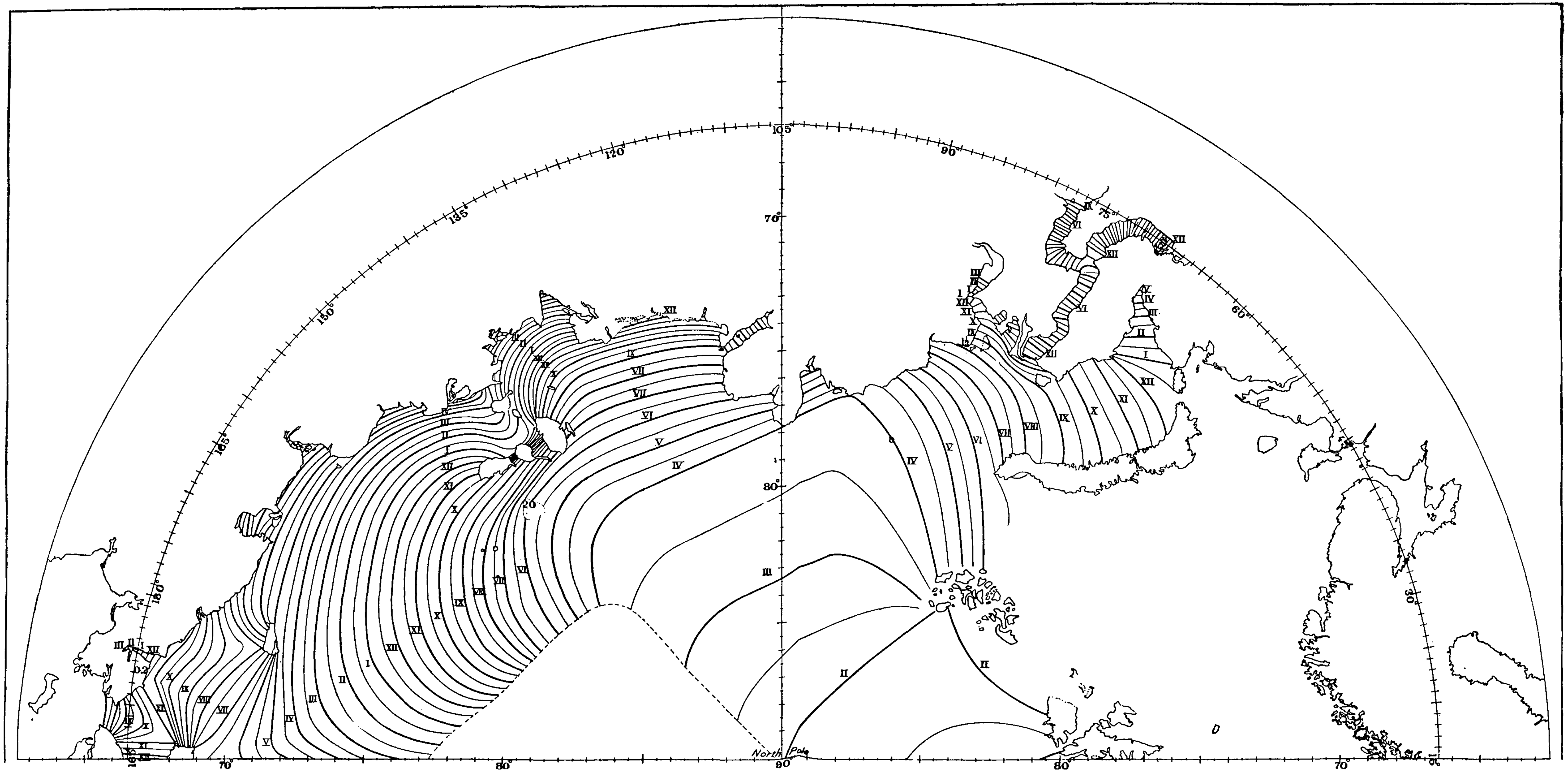
Cotidal lines for the southern part of the North Sea.



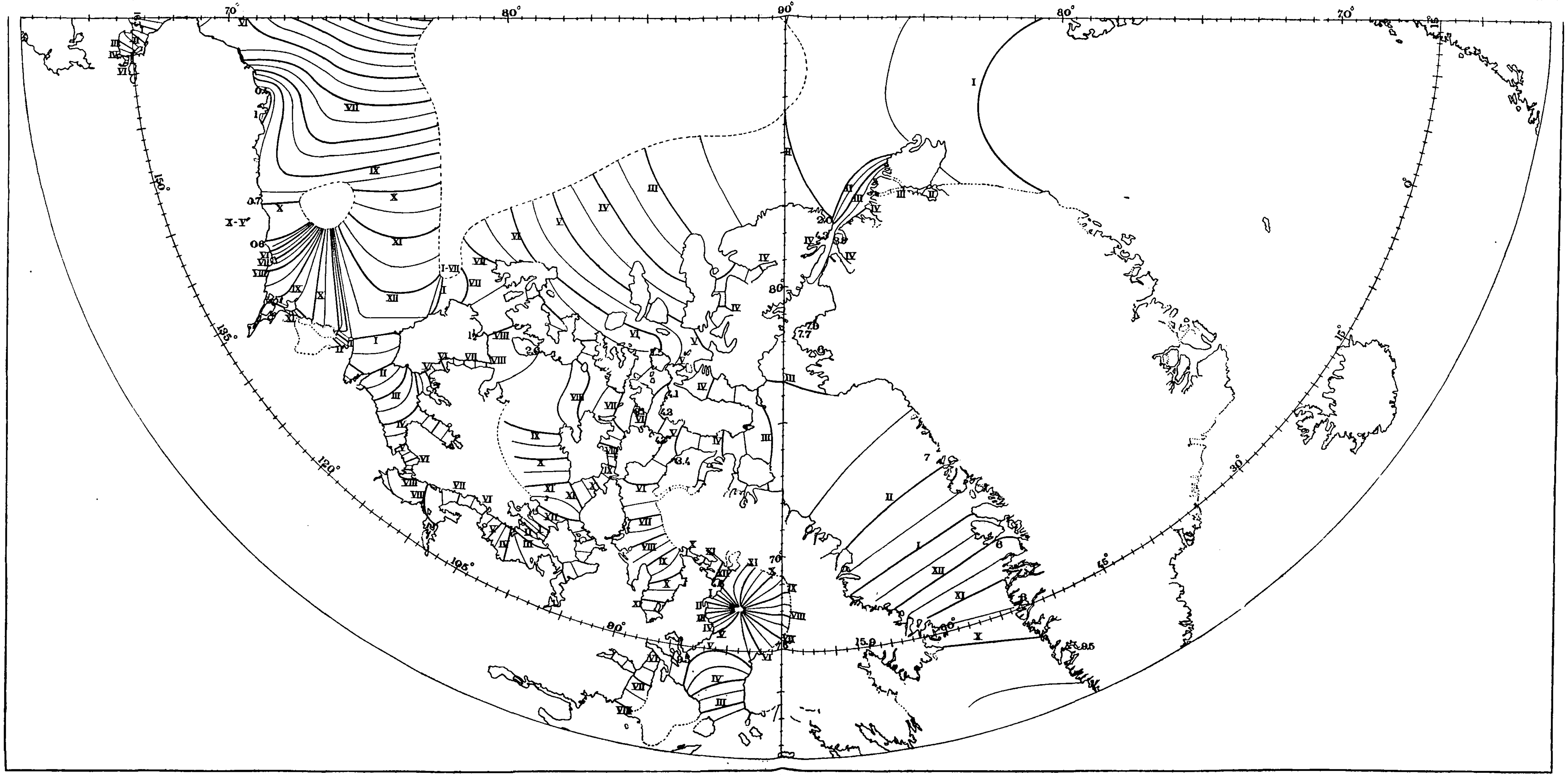
Cotidal lines for Greenland and Barents seas.



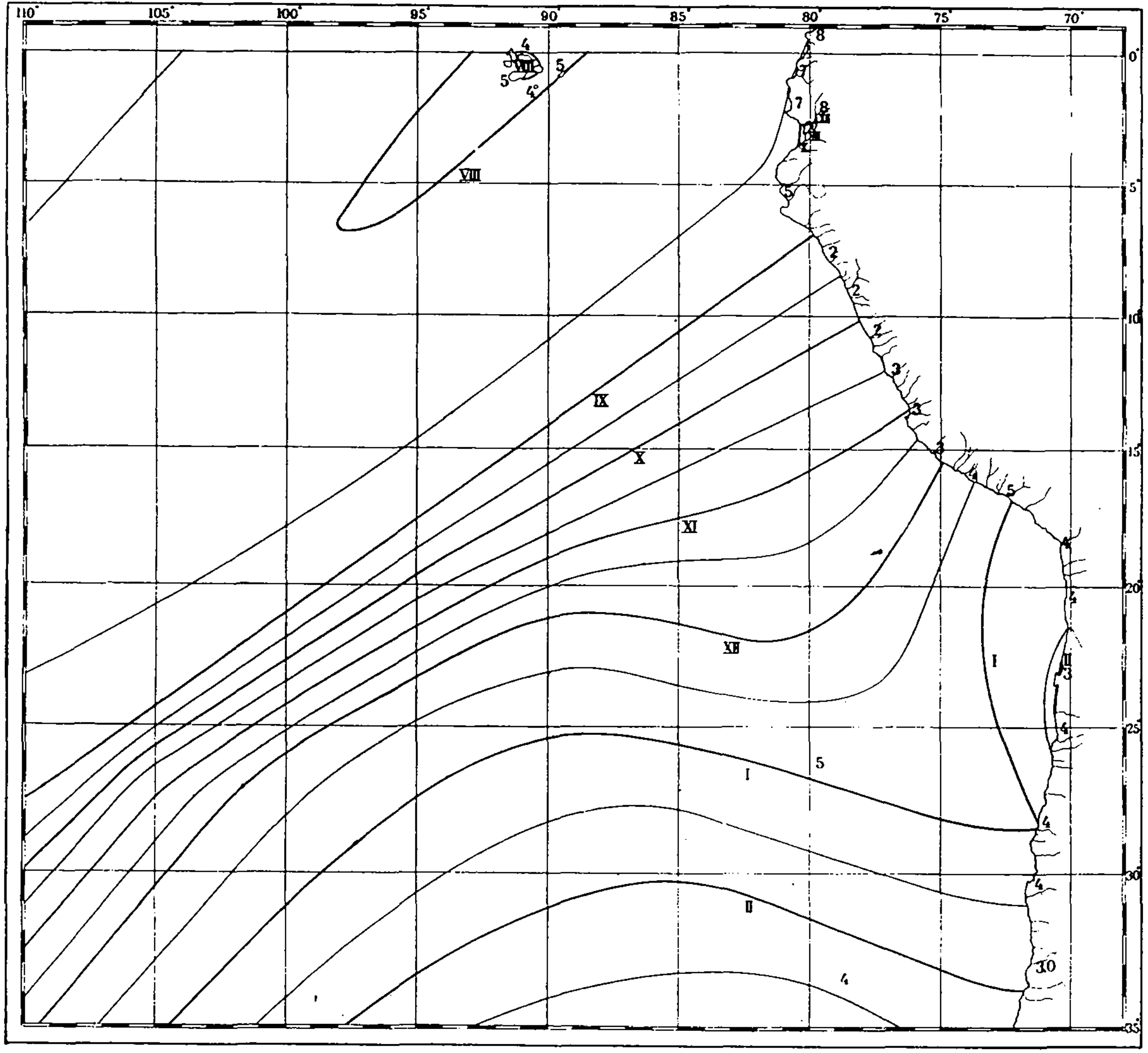
Sketch of Polar Regions.



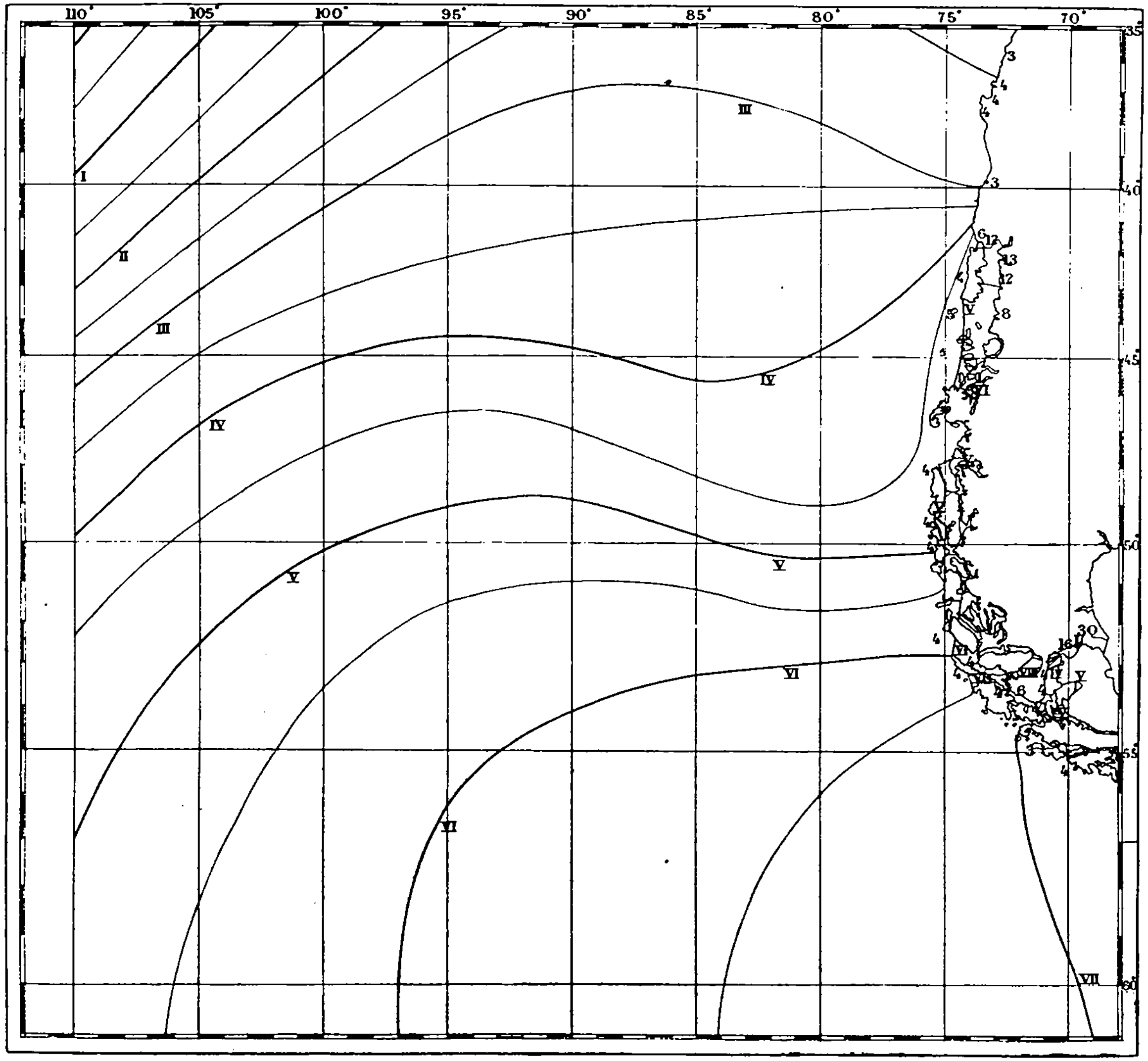
Cotidal lines for the Arctic Regions. Siberian side.



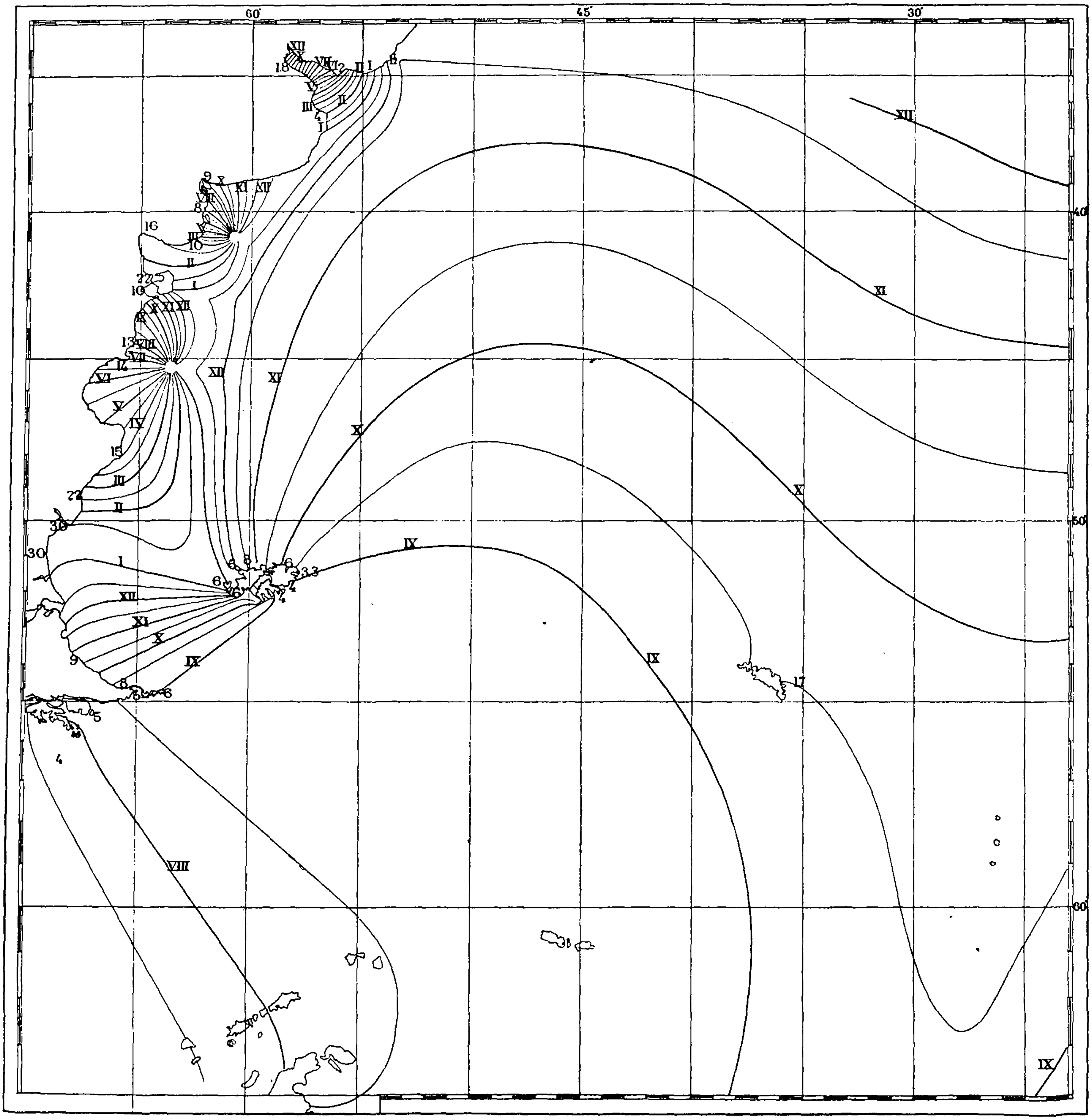
Cotidal lines for the Arctic Regions. American side.



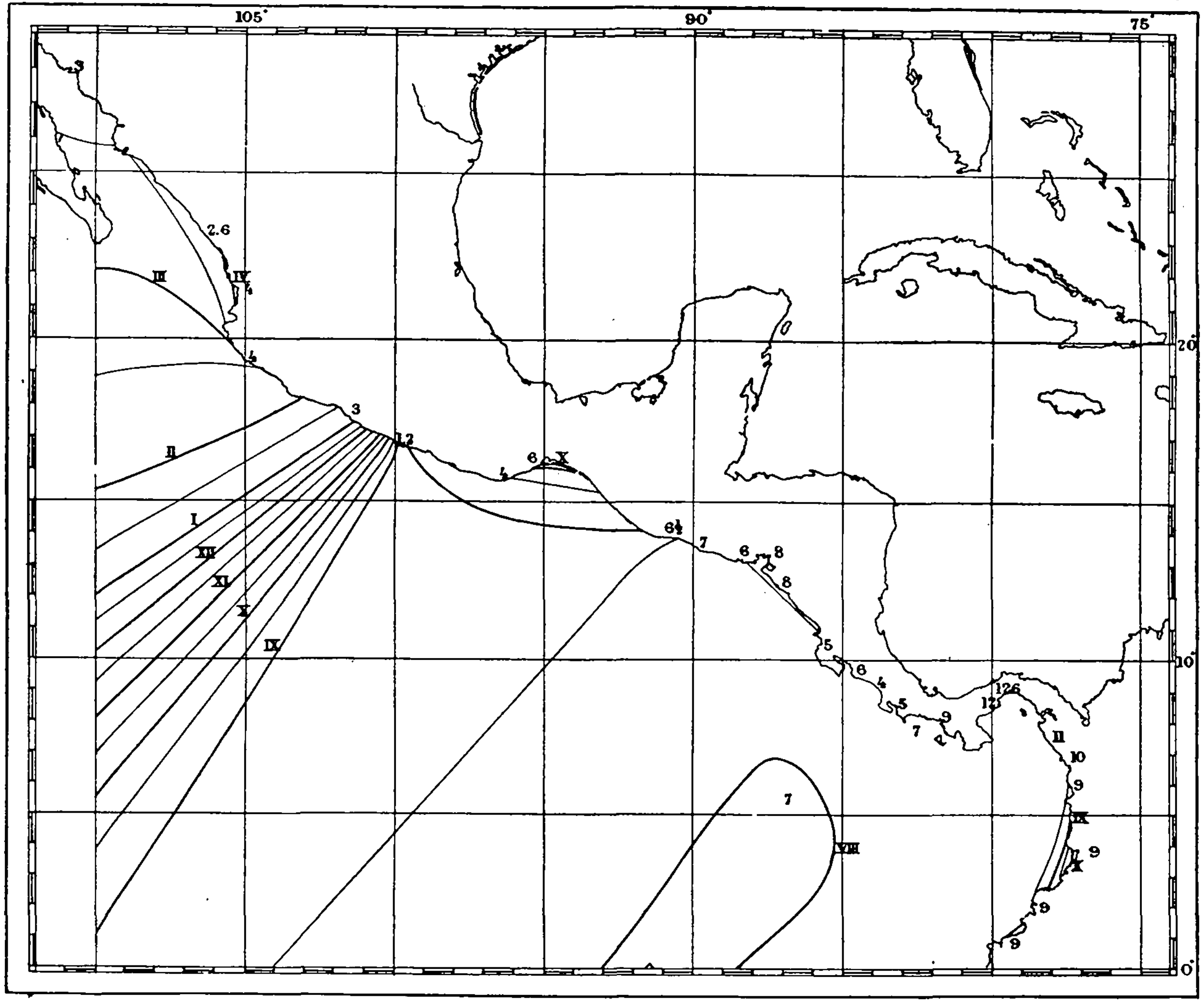
Cotidal lines west of Peru.



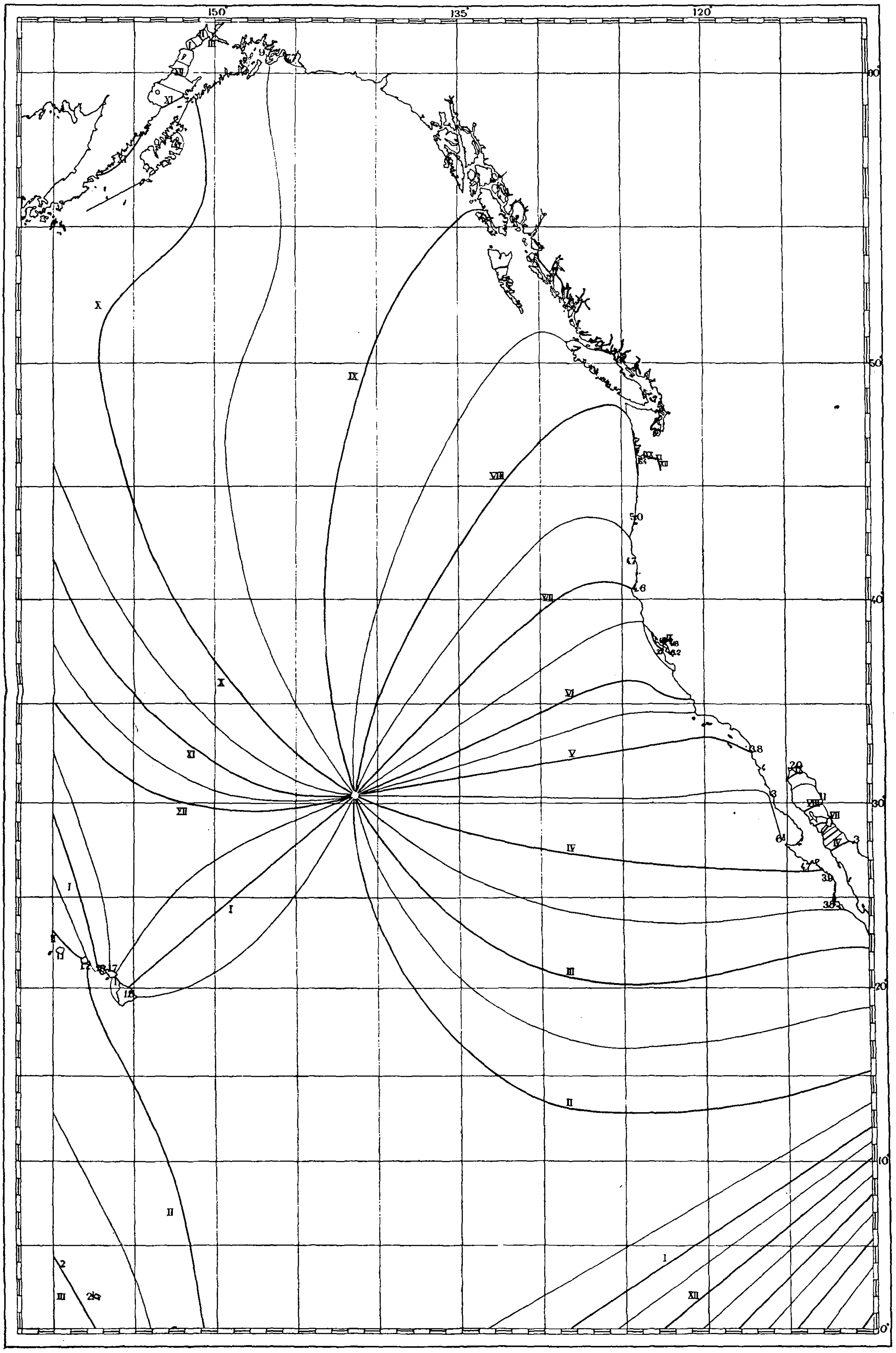
Cotidal lines west of Chile.



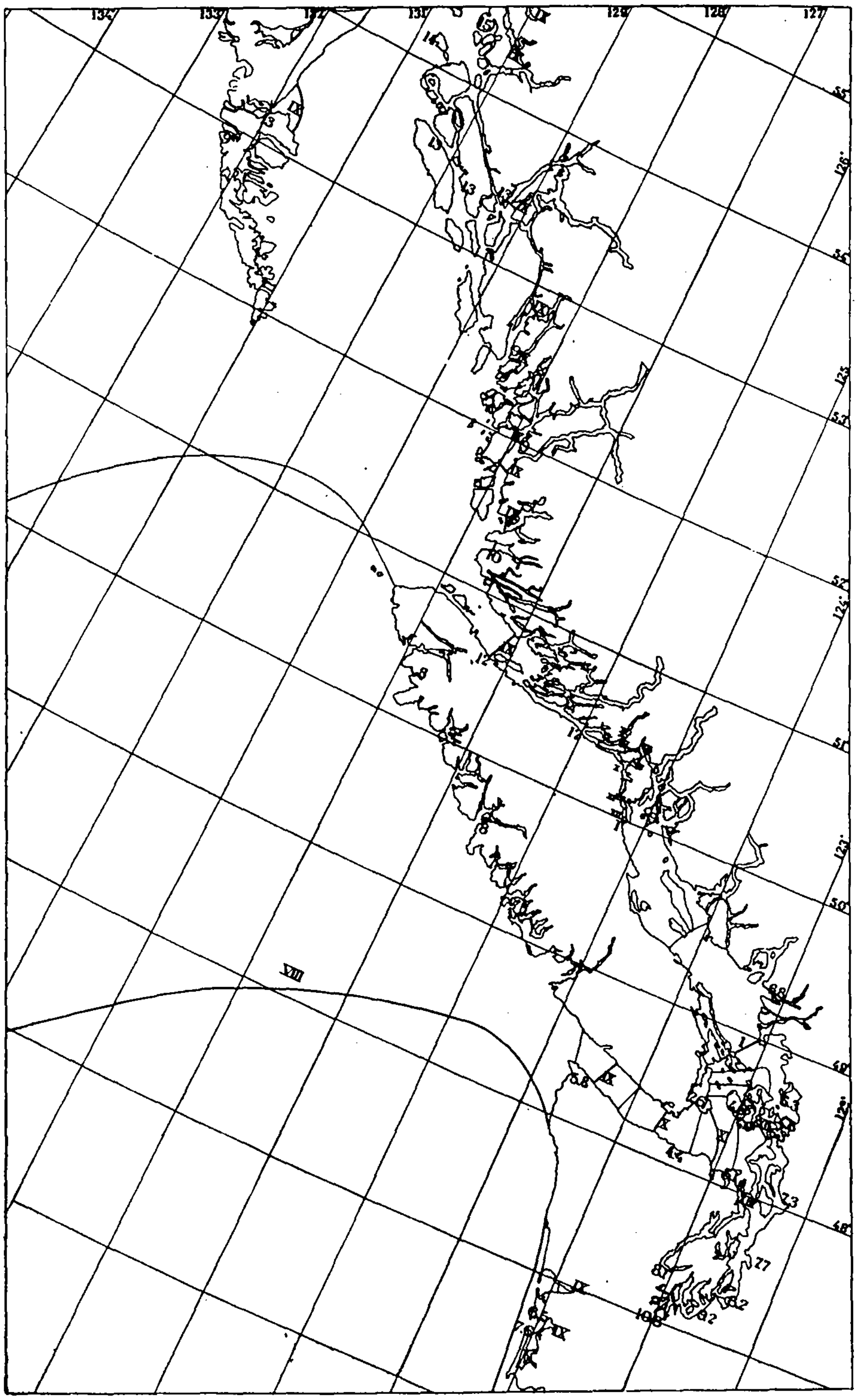
Cotidal lines east of Patagonia.



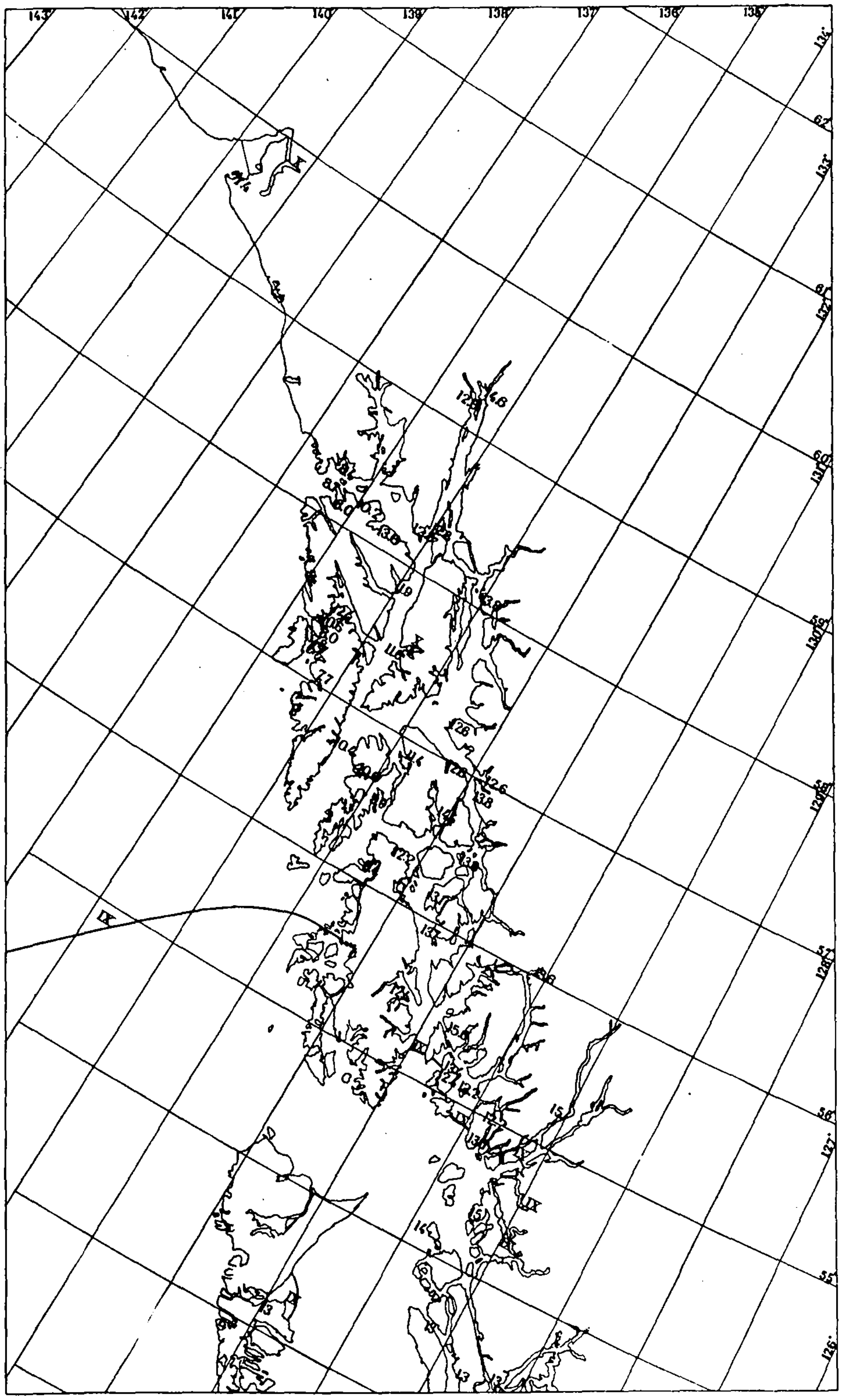
Cotidal lines south of Mexico.



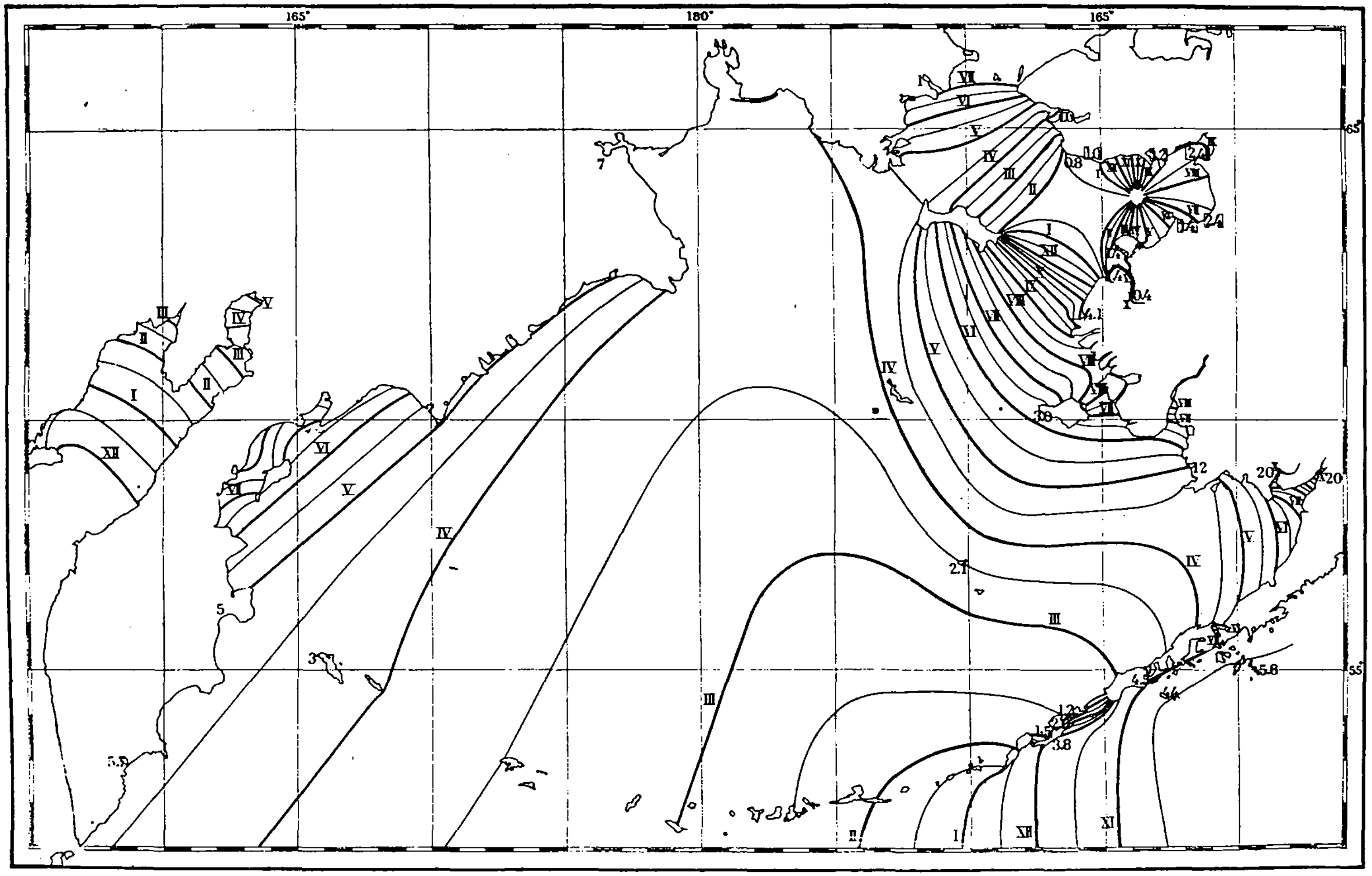
Cotidal lines west of the United States.



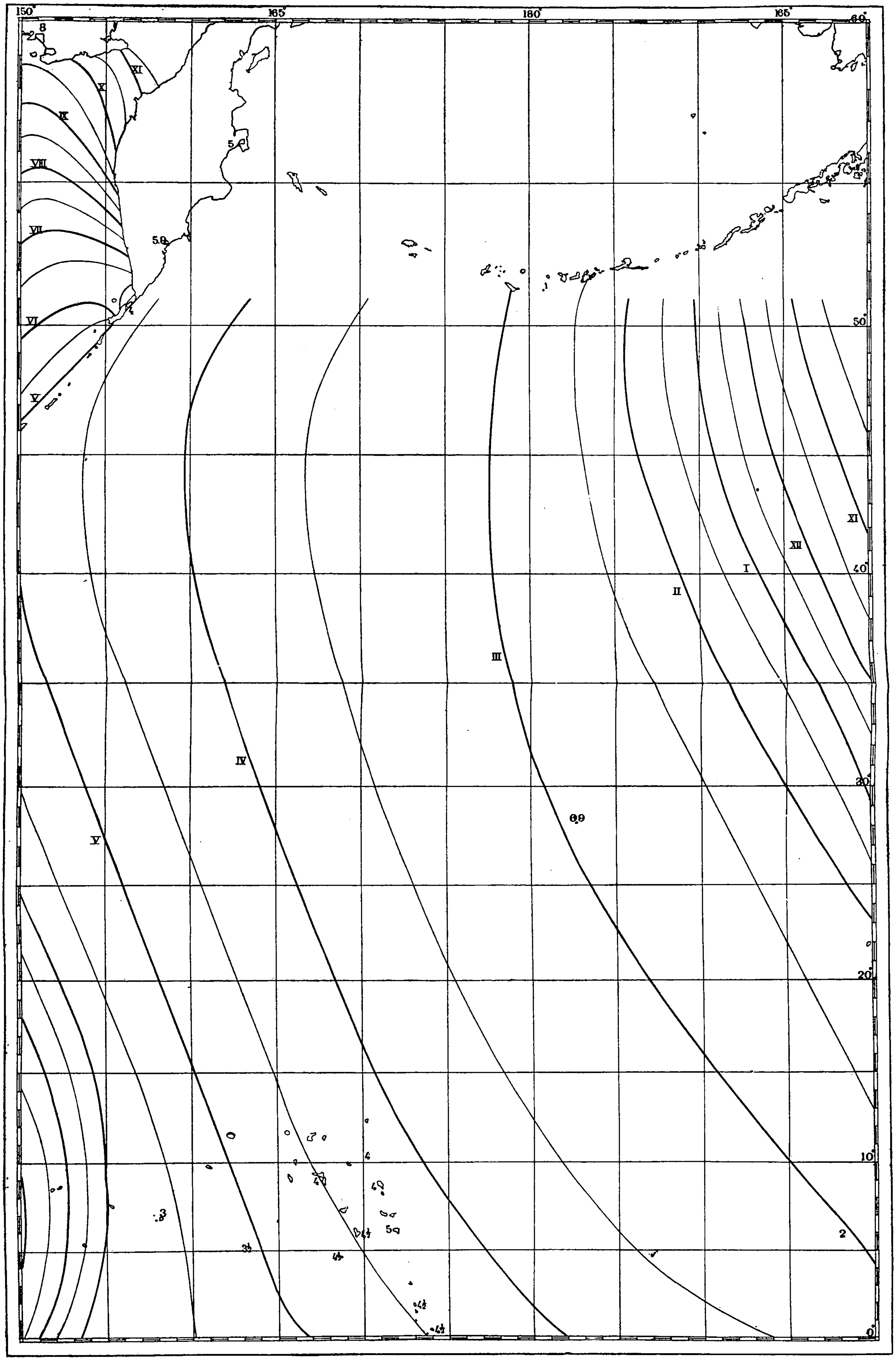
Cotidal lines for British Columbia.



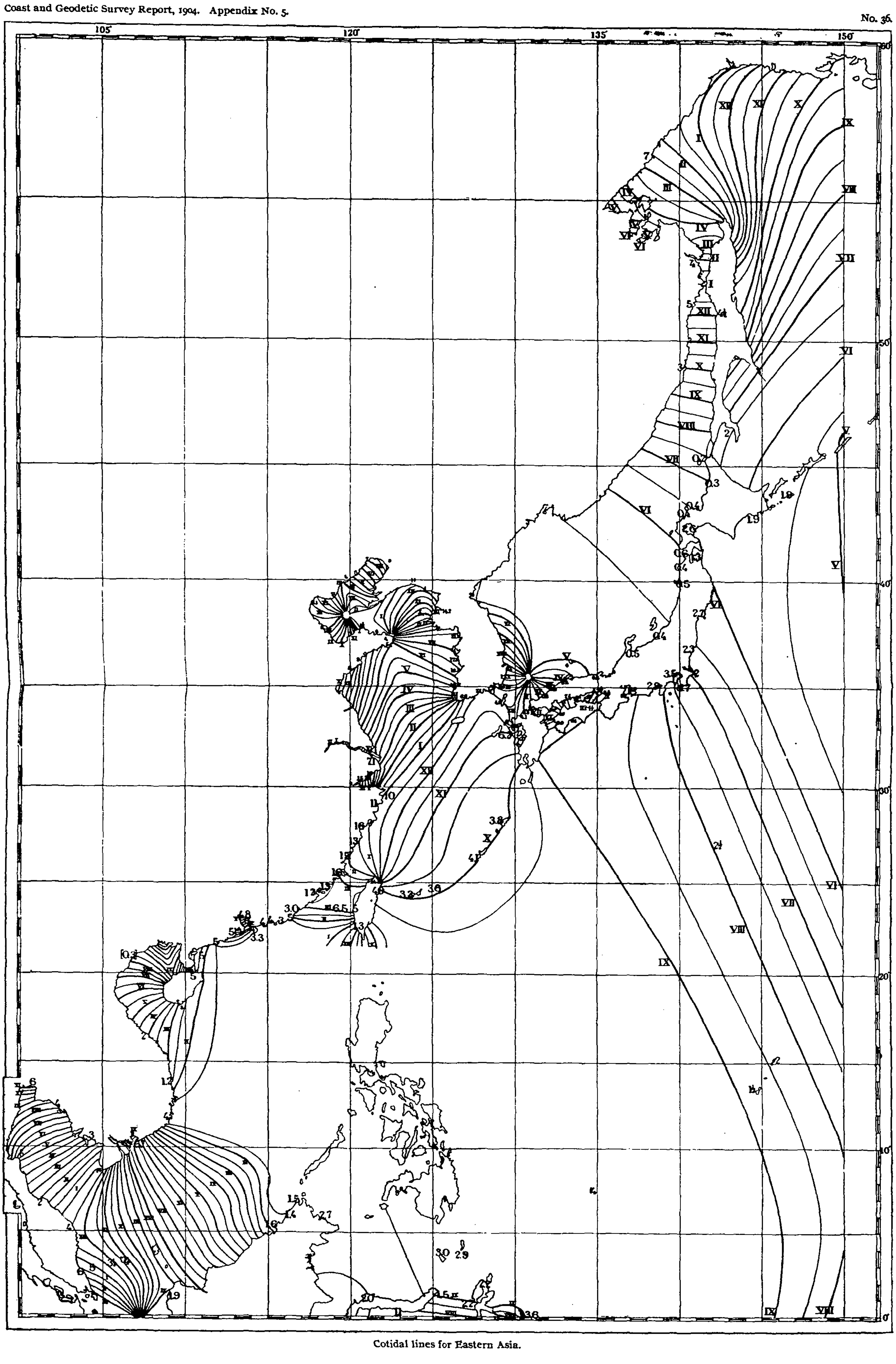
Cotidal lines for Southeastern Alaska.



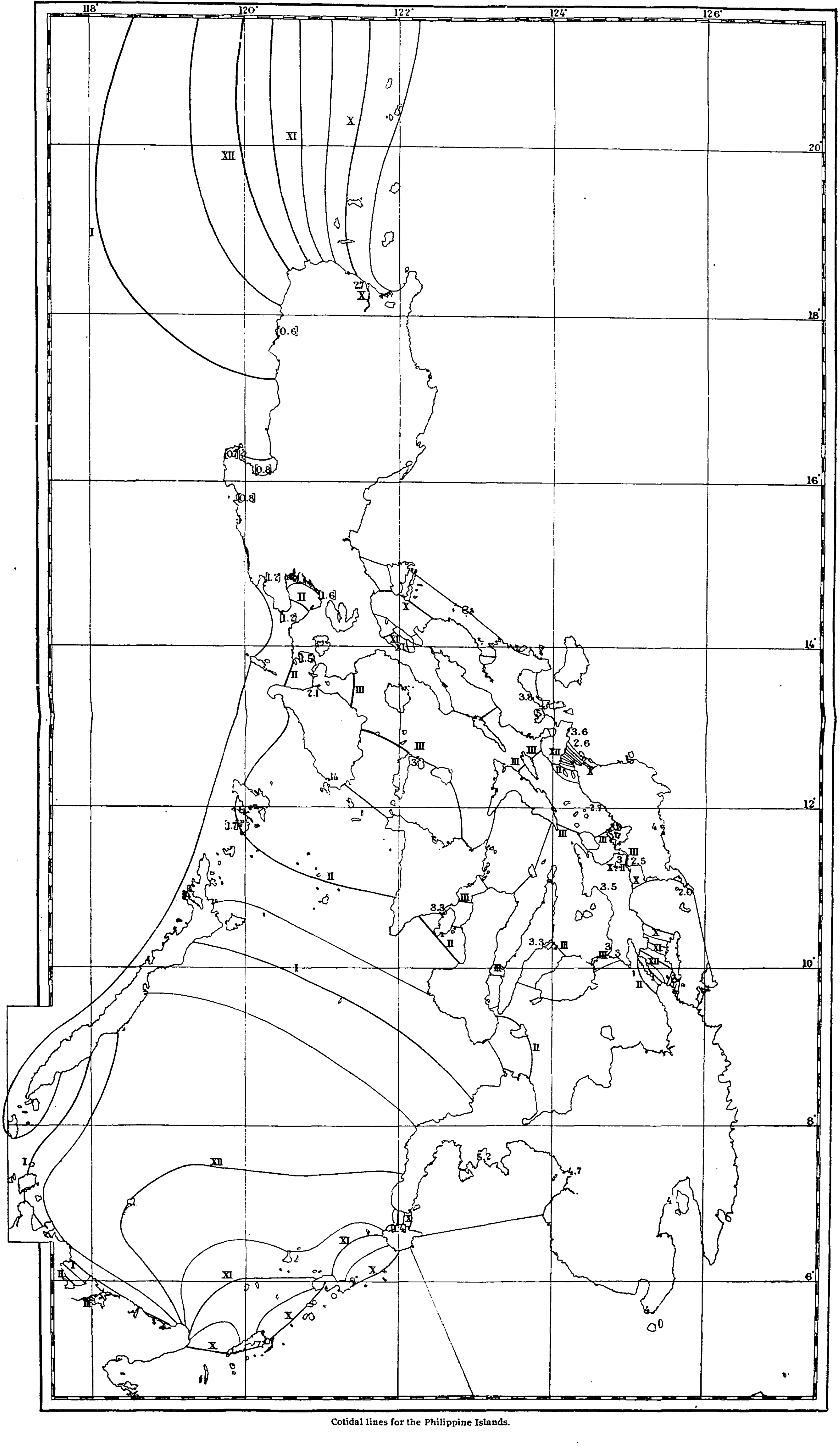
Cotidal lines for Bering Sea.



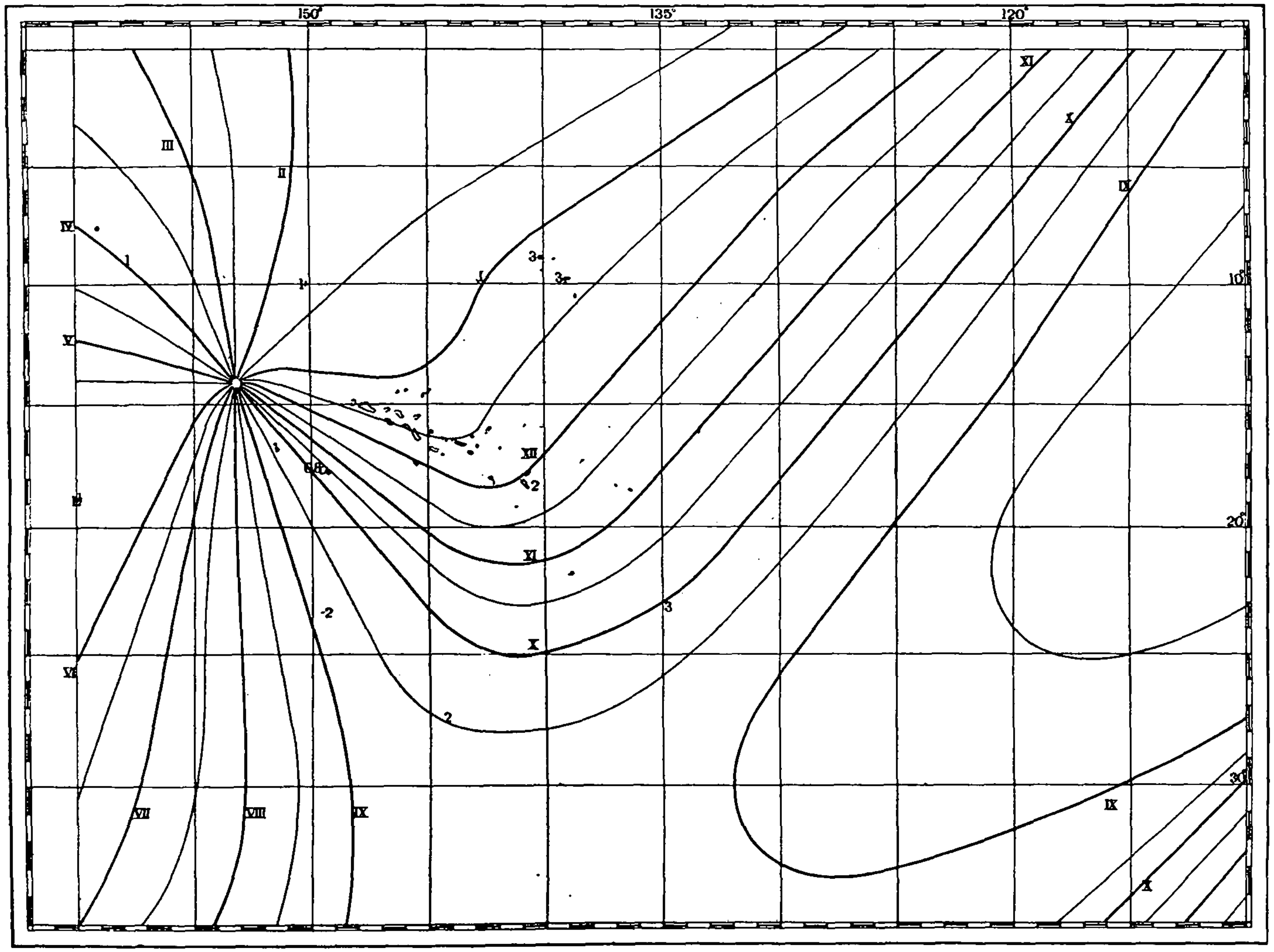
Cotidal lines west of Hawaii.



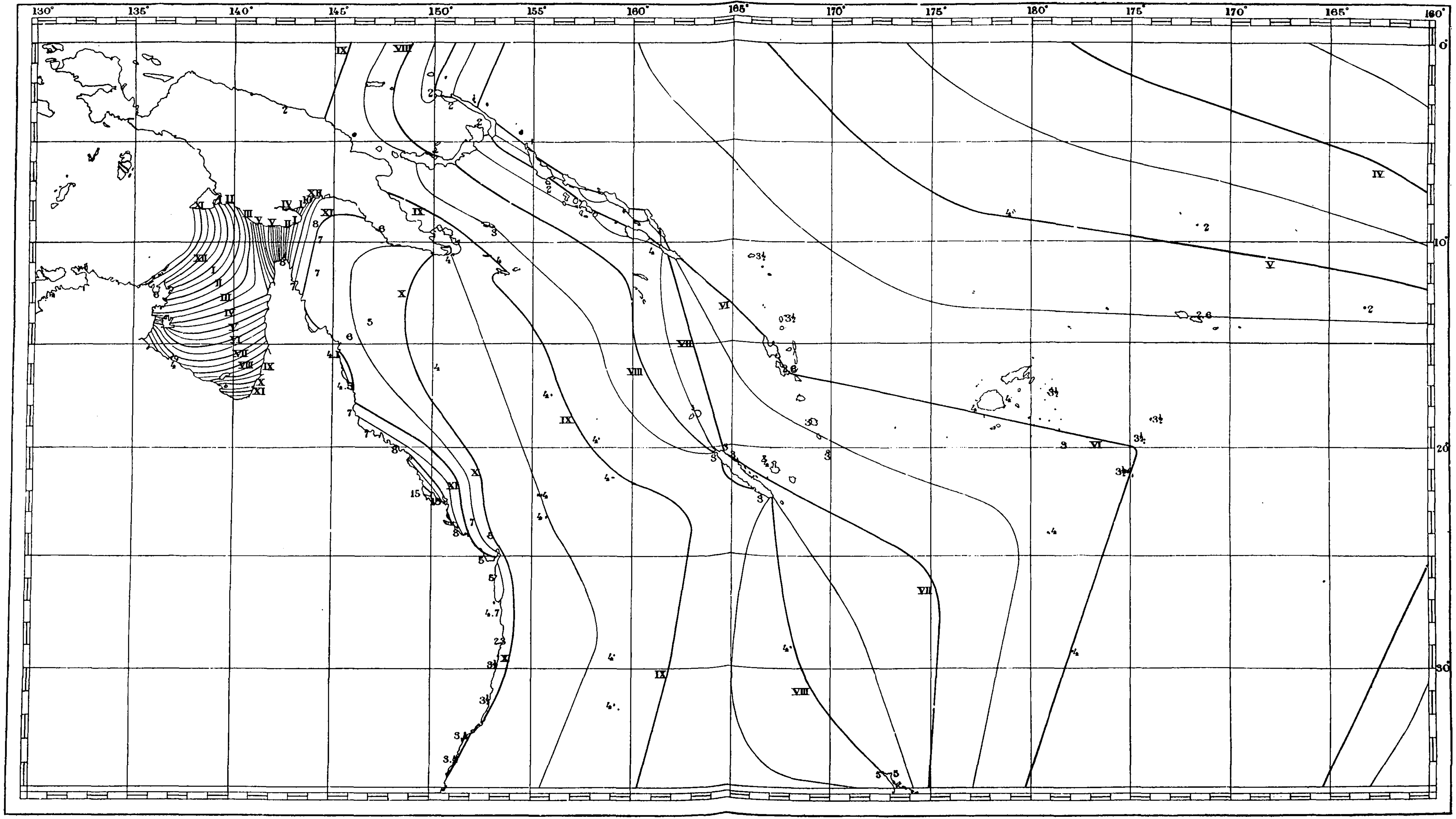
Cotidal lines for Eastern Asia.



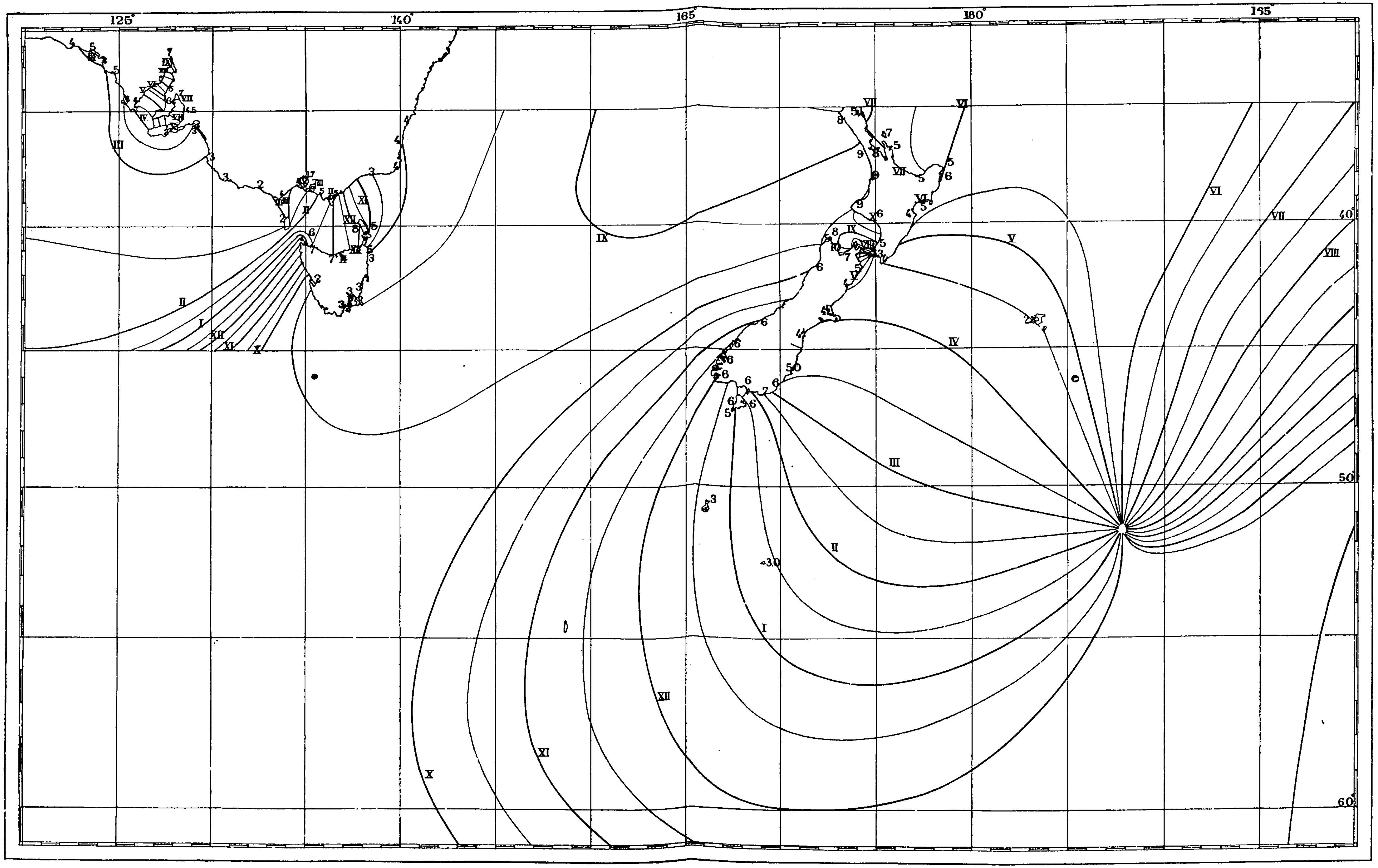
Cotidal lines for the Philippine Islands.



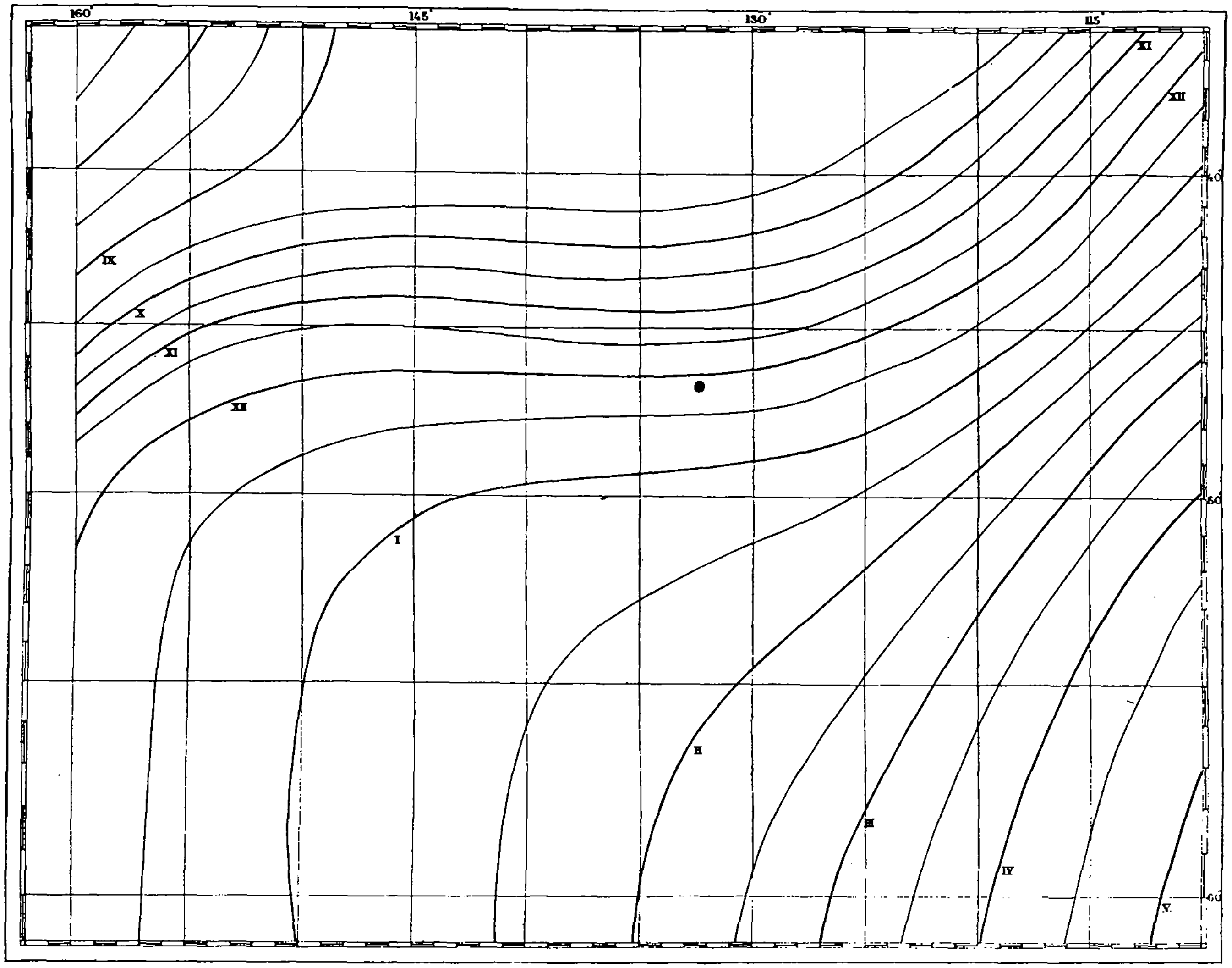
Cotidal lines for Paumotu Group.



Cotidal lines for Western Polynesia.



Cotidal lines for New Zealand.



Cotidal lines for a portion of the South Pacific.

APPENDIX 6

REPORT 1904

PRECISE LEVELING

FROM RED DESERT, WYOMING, TO OWYHEE, IDAHO, 1903

By JOHN F. HAYFORD

Inspector of Geodetic Work; Assistant, Coast and Geodetic Survey

CONTENTS.

PRECISE LEVELING FROM RED DESERT, WYOMING, TO OWYHEE, IDAHO.

By John F. Hayford,

Inspector of Geodetic Work; Assistant, Coast and Geodetic Survey.

This line was leveled in four sections, namely, from Red Desert to Azusa, Wyo., by Harold D. King, Aid, May 20–July 31, 1903; Ogden, Utah, to Azusa, Wyo., by Ralph L. Libby, Aid, May 2–July 31, 1903; Ogden, Utah, to Pocatello, Idaho, by Mr. Libby, August 5–September 28, 1903; and Pocatello to Owyhee, Idaho, by Mr. King, August 4–October 24, 1903. The line follows the Union Pacific Railroad from Red Desert to Ogden, and the Oregon Short Line from Ogden to Owyhee. This line is connected at its eastern end at Red Desert, Wyo., with the precise level net shown in Appendix 3 of the Report for 1903, "Precise Leveling in the United States, 1900–1903." It is expected that the extension of this line will connect with Pacific sea level at Seattle, Wash., and thus furnish the first connection by precise leveling between the Atlantic and the Gulf of Mexico on the one hand and the Pacific on the other.

Instruments and Rods.

Mr. Libby used precise level No. 8. Mr. King used precise level No. 7, except as noted below. Both these instruments are of the most recent type and are fully described in Appendix 3 of the Report for 1903, pages 200–211. On July 8 level No. 7 was accidently dropped from the railway bridge into Green River, at Greenriver, Wyo., and the telescope broken. Level No. 5 of the intermediate type described on page 418 of Appendix 8 of the Report for 1899, "Precise Leveling in the United States," was immediately sent from Washington to the party and was used from July 17 to July 31 over the line from Greenriver to Azusa, Wyo.

The value of a 2-millimeter division on the level vial of either instrument, No. 7 or No. 8, is slightly less than 2″. The telescope of each of these instruments has a clear aperture of 4.2 centimeters and a focal length of 41 centimeters.

Mr. King used rods T and U. Mr. Libby used rods R_2 and S. These rods are of the type described on pages 418–419 of Appendix 8 of the Report for 1899. The rods are of the direct reading type and carry a centimeter graduation on which readings are made to millimeters by estimation.

The lengths of the 3-meter interval marked on each of the rods, by a fine graduation on metallic plugs in its face, as determined by the Bureau of Standards, before and after the field work, and reduced to 0° Centigrade, are as follows:

	Rod T	Rod U		Rod R_2	Rod S
May 13, 1903	$3^{m}+1^{mm}.5$	$3^{m}+1^{mm}.3$	Dec. 13, 1902	$3^{m}+0^{mm}.8$	$3^{m}+1^{mm}.3$
Jan. 9, 1904	3 +1 .0	3 +0 .9	Oct. 17, 1903	3 +0 .8	3 +1 .2

Each rod was measured with a steel tape at least twice each month while in the field. The reading of the rod thermometer was always noted in connection with these measurements and care was taken that the rods and tape should be at the temperature of the atmosphere so that reliable comparisons could be made. These measurements were made in order to detect, if possible, any change in the lengths of the rods during the season. They do not give the absolute lengths of the rods at any time, as the error of the tape with which the measurements were made is not known.

The field measurements tabulated below indicate clearly that the change in length of rods T and U indicated by the measurements at the Bureau of Standards took place at about the time Mr. King moved from Azusa, Wyo., to Pocatello, Idaho, August 1. These were well-seasoned rods which had been in use since 1899 and a change in length was unexpected. These rods T and U were, in 1899, before being sent to the field for the first time, $3^{m}+0^{mm}.7$ and $3^{m}+0^{mm}.4$ long, respectively. As is frequently the case with such rods, made of pine impregnated with paraffin, they increased in length during the first season of use to $3^{m}+1^{mm}.5$ and $3^{m}+1^{mm}.3$, respectively. They then remained practically constant in length until the end of July, 1903, when, as noted above, they shortened to a length about midway between their original length and the constant length held in 1900–1902.

In accordance with the evidence of the field measurements of the rods, the computation was made for the line Red Desert to Azusa, Wyo., by using the lengths as determined at the Bureau of Standards on May 13, 1903, and for the line Pocatello to Owyhee, Idaho, by using the lengths as determined on January 9, 1904, on the supposition that the change in length occurred while moving from one line to the other. For the first line the mean excess of length of the two rods at 0° used in the computation was 0.47 millimeter per meter and in the computation of the second line 0.31 millimeter per meter.

Neither the field measurements nor the Bureau of Standards' measurements indicated any change in the lengths of R_2 and S during the season. The computation was made with the mean excess from the four measurements of the two rods as shown above, namely, 0.35 millimeter per meter. The total range in the field measurements of the 3-meter interval on rod R_2 was 0.6 millimeter, and on rod S, 0.8 millimeter, after rejecting one measurement in each case which was evidently in error.

The index corrections for the rods, as determined at Washington before and after the field work, were as follows, in millimeters: for rod T, −0.6 and rod U, −0.5 on April 29, 1903; for rod T, −0.6 and rod U, −0.7 on January 15, 1904; for rod R_2, −0.4 and rod S, −0.7 on April 6, 1903; and for rod R_2, −0.5 and rod S, −0.7 on October 13, 1903.

RESULTS AND THEIR ACCURACY.

The methods of observation are stated in detail on pages 211–222 of Appendix 3 of the Report for 1903.

The direct results of the leveling are shown in the following tables, in which all the permanent bench marks are given.

If no distance is given in the fourth column, the bench mark is in the main line of levels. If a distance is given in the fourth as well as the third column, the bench mark is on a spur and the distance given in the fourth column shows the point at which the spur branches from the main line.

Each short section, usually from 1 to 2 kilometers long, into which the line was divided by permanent and temporary bench marks, was leveled at least twice, once in the forward and once in the backward direction. On each section upon which a forward and backward measure differed by more than $4^{mm}\sqrt{K}$ (in which K is the distance leveled between adjacent bench marks in kilometers), both the forward and backward measures were repeated until two such measures fell within the limit stated. The fifth column gives the total discrepancy accumulated at each permanent bench mark between the elevation as computed from the backward lines and from the forward lines separately.

The elevations given in the last column are referred to mean sea level on the Atlantic and the Gulf of Mexico, and are based upon the adjustment of the precise level net as given in Appendix 3 of the Report for 1903.

These are the best values of the elevations for these bench marks which are available at the date of the preparation of this report. They are given to tenths of millimeters. This does not imply that the tenths are free from error. For bench marks not more than 4 kilometers apart the difference of elevation is uncertain in the millimeters and tenths; for bench marks from 4 to 400 kilometers apart the centimeters are also uncertain, and for those a greater distance apart the decimeters are uncertain.

The initial elevation for this line at Red Desert, Wyoming, may possibly be an error by 300 millimeters, but it is an even chance that it is within 61 millimeters of the truth.

Expressed in more precise and technical terms, these uncertainties are as follows: the probable error of the elevation above mean sea level of bench mark B_3 at Red Desert, Wyoming, is ± 61 millimeters, and of bench mark W_4 at Owyhee, Idaho, is ± 69 millimeters, and for any intermediate bench mark it lies between these two values. The probable error of the difference of elevation of any two bench marks in millimeters is $1.04\ \sqrt{K}$, in which K is the distance between the bench marks in kilometers measured along the level line. The value ± 1.04 millimeters used above for the probable error of the single completed kilometer of leveling of this class was derived from the adjustment of the level net. See Appendix 3 of the Report for 1903, page 379.

RED DESERT TO AZUSA, WYO., LINE.

When commencing work at Red Desert, Wyoming, in 1903, a level line was run between bench marks A_3 and B_3. The observed difference of elevation was $A_3-B_3=+1.2330$ meters. The difference A_3-B_3 as determined in 1902 was $+1.2326$. (See pages 345, 580, of Appendix 3 of the Report for 1903.) This small discrepancy, 0.4 millimeters, between two bench marks 0.5 kilometers apart was interpreted as indicating that the bench marks were undisturbed. No change was made in the adopted elevation of A_3 indicated by the above reference, and the leveling was continued westward from B_3, using its elevation as fixed by the leveling of the preceding year.

Bench marks Z_2 and A_3 were also connected by leveling in 1903. The difference A_3-Z_2 from the 1903 observations was -1.9990 meters, and from the 1902 leveling, -2.0051. This discrepancy of 6.1 millimeters on 0.4 kilometers was interpreted as meaning that Z_2 had changed slightly in elevation with reference to A_3 and B_3 during the year. Accordingly a new value for the elevation of Z_2 was adopted as shown in the following table.

Results of leveling, Red Desert to Azusa, Wyo.

Place	Permanent bench mark	Distance to bench mark *	Distance to base of spur *	Total discrepancy (B–F) at bench mark	Elevation
		km.	*km.*	*mm.*	*m.*
Near Red Desert, Wyo.	Z_2	−1.0			† 2050.9061
Red Desert, Wyo.	B_3	0.0		0.0	‡ 2047.6741
Tipton, Wyo.	C_3	11.7		+ 5.4	2132.5399
Near Table Rock, Wyo.	D_3	20.4		+15.6	2087.8008
Near Monell, Wyo.	U. P. 779	30.0	29.1	§	2057.1249
Monell, Wyo.	E_3	30.6		+34.8	2056.5452
Bittercreek, Wyo.	F_3	38.7		+58.0	2040.4953
Near Black Buttes, Wyo.	G_3	49.9		+53.0	2020.4359
Black Buttes, Wyo.	U. P. 793	53.2	52.7	§	2016.6834
Hallville, Wyo.	H_3	62.0		+55.9	1998.2346
Hallville, Wyo.	U. P. 799	62.2	62.0	+53.7	1998.4713
Near Point of Rocks, Wyo.	U. P. 804	70.2	70.1	+48.1	1985.0710
Near Point of Rocks, Wyo.	I_3	72.7		+51.0	1983.9406
Near Point of Rocks, Wyo.	U. P. 810	79.9	79.7	+43.7	1968.4864
Near Salt Wells, Wyo.	J_3	87.0		+37.3	1948.4257
Near Baxter, Wyo.	U. P. 823	100.6	100.3	+59.7	1920.4722
Baxter, Wyo.	K_3	101.3		+62.7	1921.9076
Rock Springs, Wyo.	L_3	111.8		+64.3	1909.3503
Rock Springs, Wyo.	M_3	111.9		+63.9	1908.4995
Rock Springs, Wyo.	N_3	112.0	111.9	+63.7	1912.8302
Rock Springs, Wyo.	O_3	112.2	111.9	+63.0	1916.5712
Ah Say, Wyo.	U. P. 835	120.2	120.0	+57.9	1895.3612
Near Wilkins, Wyo.	P_3	123.6		+60.6	1890.0678
Wilkins, Wyo.	U. P. 839	126.6	126.5	+60.4	1884.3311
Greenriver, Wyo.	Q_3	136.0	135.9	+64.2	1855.0536
Greenriver, Wyo.	R_3	136.2	135.9	+65.6	1864.7786
Greenriver, Wyo.	S_3	136.1	135.9	+64.5	1858.3998
Greenriver, Wyo.	T_3	136.7		+61.0	1855.2436
Near Peru, Wyo.	U_3	147.3		+60.3	1941.1731
Near Bryan, Wyo.	V_3	159.5		+82.3	1884.1850
Near Marston, Wyo.	W_3	164.1		+80.6	1883.2550
Near Marston, Wyo.	X_3	172.0		+85.2	1901.9158
Near Azusa, Wyo.	Y_3	176.0		+77.9	1897.1105
Near Azusa, Wyo.	‖105	176.9		+76.8	1901.5869

Principal maximum values of total discrepancy (B–F) in main line.

Distance	B-F	B-F per kilometer
km.	*mm.*	*mm.*
2.0	− 4.9	−2.45
38.7	+58.0	+1.50
107.1	+64.6	+0.60
170.5	+89.1	+0.52
At end 176.9	+76.8	+0.43

* From bench mark B_3 at Red Desert.

† This elevation supersedes that given on page 580 of Appendix 3 of the Report for 1903.

‡ This is the adopted initial elevation for this line. It is taken from page 580 of Apendix 3 of the Report for 1903.

§ The spur was a single line of levels, that is, run in one direction only.

‖ This is a temporary bench mark which is identical with temporary bench mark 160 of the line Ogden, Utah, to Azusa, Wyo.

OGDEN, UTAH, TO AZUSA, WYO., LINE.

This line was leveled in the direction Ogden to Azusa, and the tabulation is therefore given in that order. In making the computation the observed differences of elevation were combined in the reverse order, starting with the elevation fixed by the Red Desert to Azusa line for the temporary bench mark numbered 105 in that line and 160 in this line.

Results of leveling, Ogden, Utah, to Azusa, Wyo.

Place	Permanent bench mark	Distance to bench mark*	Distance to base of spur*	Total discrepancy (B-F) at bench mark	Elevation
		km.	*km.*	*mm.*	*m.*
Ogden, Utah	B	0.0		0.0	1309.8520
Ogden, Utah	A	0.8	0.0	− 2.0	1308.8588
Ogden, Utah	†Transit	1.6	0.0	− 0.6	1331.5447
Ogden, Utah	C	0.2		+ 0.7	1310.5028
Uinta, Utah	D	12.4		+ 8.4	1370.2906
Near Devils Gate, Utah	E	21.6		+14.2	1468.4360
Near Strawberry, Utah	F	23.2		+14.3	1473.2076
Near Morgan, Utah	G	37.3		+ 5.5	1534.8343
Morgan, Utah	H	39.4		+ 3.9	1542.6755
Near Croydon, Utah	I	51.2		+13.6	1596.1208
Echo, Utah	J	64.5		+27.8	1664.3951
Echo, Utah	Geol. Echo	64.9	64.9	+30.0	1665.8418
Near Emory, Utah	K	72.5		+43.4	1748.8870
Emory, Utah	L	79.8	79.7	+40.5	1802.5713
Castle Rock, Utah	M	91.1		+29.7	1899.1592
Wasatch, Utah	N	104.7		+26.4	2077.0235
Wyuta, Utah	O	113.3	112.2	+18.3	2051.7570
Evanston, Wyo.	6770 Evanston	122.5		+14.0	2055.4599
Evanston, Wyo.	A_6	122.6	122.5	+13.5	2056.8023
Evanston, Wyo.	6779 Evanston	123.0	122.5	+14.9	2058.1170
Knight, Wyo.	B_6	136.6	136.5	+20.8	2152.0971
Altamont, Wyo.	C_6	144.2		+30.2	2200.0837
Springvalley, Wyo.	D_6	154.7	154.7	+38.2	2136.8874
Leroy, Wyo.	E_6	166.3		+40.5	2040.1089
Bridger, Wyo.	F_6	174.1		+43.2	2020.3063
Near Bridger, Wyo.	G_6	178.9		+44.6	2005.7702
Carter, Wyo.	H_6	190.3	190.2	+41.4	1980.6998
Carter, Wyo.	I_6	190.5	190.2	+42.4	1981.4967
Elkhurst, Wyo.	J_6	200.1	200.0	+38.1	1958.9540
Near Hampton, Wyo.	K_6	203.6	203.0	+39.3	1951.2577
Church Buttes, Wyo.	L_6	217.3		+37.4	1935.1996
Church Buttes, Wyo.	M_6	217.5		+35.4	1936.1780
Garrett, Wyo.	N_6	224.9		+20.3	1932.8922
Near Granger, Wyo.	O_6	234.9		+ 9.6	1911.1951
Granger, Wyo.	P_6	236.0	235.8	+11.5	1909.9982
Near Granger, Wyo.	‡160	242.7		+14.7	1901.5869

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*From bench mark B at Ogden.

†The elevation of this bench mark, as fixed by the vertical angles measured in connection with the triangulation along the thirty-ninth parallel and spanning the long interval from Pikes Peak to the Pacific, was 1338.1±2.5 meters. See "The Transcontinental Triangulation," pages 339–340. The correction now necessary to this elevation, namely, 1331.5−1338.1=6.6 meters, is well within the allowable limit fixed by the probable error of 2.5 meters.

‡This is a temporary bench mark which is identical with the temporary bench mark numbered 105 in the line Red Desert to Azusa.

Principal maximum values of total discrepancy (B–F) in main line.

Distance	B-F	B-F per kilometer
km.	*mm.*	*mm.*
19.2	+15.6	+0.81
81.5	+46.9	+0.58
182.2	+50.0	+0.27
At end 242.7	+14.7	+0.06

OGDEN, UTAH, TO POCATELLO, IDAHO, LINE.

When commencing this line at Ogden, a level line was run between bench marks B and C. The observed difference was C−B=+0.6526 meters. This same difference observed three months earlier (see page 409) was +0.6508. This small discrepancy, 1.8 millimeters, between bench marks 0.2 kilometer apart, was interpreted as indicating that these bench marks were undisturbed. The level computation was continued toward Pocatello, using the elevation for B, shown on page 409.

Results of leveling, Ogden, Utah, to Pocatello, Idaho.

Place	Permanent bench mark	Distance to bench mark*	Distance to base of spur*	Total discrepancy (B-F) at bench mark	Elevation
		km.	*km.*	*mm.*	*m.*
Ogden, Utah	B	0.0			1309.8520
Hot Springs, Utah	P	14.1		−12.7	1301.3750
Willard, Utah	Q	22.8	22.8	−29.1	1299.7616
Brigham, Utah	R	34.8		−32.5	1308.6707
Honeyville, Utah	S	48.7	48.7	−23.4	1298.1642
Dewey, Utah	T	57.7		−35.6	1317.0955
Bear River	U	71.7		−47.9	1370.0458
Cache Junction, Utah	V	78.6		−35.6	1355.5697
Cache Junction, Utah	W	78.9		−34.8	1353.3253
Ransom, Utah	X	92.0	91.9	−42.5	1358.8935
Near Cornish, Utah	Y	100.3		−41.0	1378.6045
Weston, Idaho	A	104.8	104.7	−44.9	1403.0582
Dayton, Idaho	B	114.6	114.6	−49.1	1445.7993
Garner, Idaho	C	120.9		−46.3	1447.6636
Garner, Idaho	D	121.0		−46.3	1446.1971
Near Oxford, Idaho	E	130.8		−54.2	1446.7948
Near Swan Lake, Idaho	F	141.8		−63.0	1455.5997
Downey, Idaho	G	152.7		−48.7	1480.2214
March Valley, Idaho	H	164.9		−48.1	1445.6716
McCammon, Idaho	I	179.1		−43.9	1448.8462
Near Onyx, Idaho	J	188.2		−44.6	1407.8990
Inkom, Idaho	K	196.5		−39.1	1378.8024
Inkom, Idaho	L	196.6		−37.6	1377.3778
Portneuf, Idaho	M	205.7		−41.6	1367.2810
Pocatello, Idaho	A_3	216.1		−30.4	1358.4231
Pocatello, Idaho	B_3	216.6		−30.3	1360.0109

* From bench mark B at Ogden, Utah.

Principal maximum values of total discrepancy (B–F) in main line.

Distance	B-F	B-F per kilometer
km.	*mm.*	*mm.*
37.4	−34.6	−0.93
71.7	−47.9	−0.67
138.4	−63.9	−0.46
At end 216.6	−30.3	−0.14

POCATELLO TO OWYHEE, IDAHO, LINE.

When commencing this line at Pocatello, Mr. King ran a level line between bench marks B_3 and A_3. The observed difference of elevation was $B_3-A_3=+1.5881$ meters. The same difference observed by Mr. Libby on the line Ogden to Pocatello (see p. 410) was +1.5878. This small discrepancy, 0.3 millimeter on the distance of 0.4 kilometer, was interpreted as meaning that these bench marks were undisturbed. The level computation was continued toward Owyhee, using the elevation for B_3 shown on page 410.

Results of leveling, Pocatello to Owyhee, Idaho.

Place	Permanent bench mark	Distance to bench mark *	Distance to base of spur *	Total discrepancy (B−F) at bench mark	Elevation
		km.	*km.*	*mm.*	*m.*
Pocatello, Idaho	B_3	0.0			1360.0109
Pocatello, Idaho	C_3	0.2	0.0	− 1.4	1363.2993
Pocatello, Idaho	City	0.2	0.0	†	1359.9874
Pocatello, Idaho	D_3	1.0	0.1	+ 3.1	1360.4577
Pocatello, Idaho	E_3	1.1	0.1	+ 2.3	1361.7103
Near Pocatello, Idaho	F_3	6.6	6.4	+ 0.6	1343.7149
Near Michaud, Idaho	G_3	17.2	17.2	−14.2	1349.7748
Bannock, Idaho	H_3	26.5		−22.6	1344.4073
Near American Falls	I_3	36.2		−11.1	1336.2591
American Falls, Idaho	O. S. L.	40.8		−15.3	1321.5038
Snake River Bridge, Idaho	O. S. L.	41.4	40.8	†	1319.886
American Falls, Idaho	J_3	41.9		−15.8	1319.2248
Near Napati, Idaho	K_3	52.7		− 6.5	1364.2599
Near Wapi, Idaho	L_3	63.3	63.2	−16.4	1347.4214
Wapi, Idaho	O. S. L.	68.1		−13.3	1341.0995
Near Wapi, Idaho	M_3	72.8		−18.0	1316.0037
Near Yale, Idaho	N_3	82.5		−18.5	1297.8298
Minidoka, Idaho	O. S. L.	94.4		−17.4	1305.1422
Minidoka, Idaho	O_3	94.6		−16.9	1303.5344
Near Colburne, Idaho	P_3	104.4		−22.5	1298.0632
Near Colburne, Idaho	Q_3	113.1		−24.9	1321.9904
Kimama, Idaho	O. S. L.	121.3		−13.9	1302.1868
Kimama, Idaho	R_3	121.5	121.3	−15.2	1299.2164
Senter, Idaho	S_3	132.0	131.9	−18.0	1284.9038
Owinza, Idaho	T_3	144.2		−20.8	1281.4945
Near Owinza, Idaho	U_3	150.9		−22.8	1260.2493
Dietrich, Idaho	V_3	161.1		−32.2	1240.6111
Shoshone, Idaho	W_3	173.4		−23.8	1209.4807
Shoshone, Idaho	X_3	173.8	173.4	−22.3	1208.0095
Shoshone, Idaho	Y_3	173.9	173.4	−22.6	1209.1371
Near Tunupa, Idaho	Z_3	186.2		−39.9	1141.9470
Near Tunupa, Idaho	A_4	188.9	188.8	−40.7	1129.5857
Gooding, Idaho	B_4	199.2		−48.5	1087.9545
Fuller, Idaho	C_4	209.9	209.8	−41.3	1036.3805
Bliss, Idaho	D_4	219.9		−46.3	993.2193
Ticeska, Idaho	E_4	230.9		−44.8	938.5376
King Hill, Idaho	F_4	243.7		−39.0	772.4007
Glenns Ferry, Idaho	G_4	257.5	257.4	−27.9	779.7057
Glenns Ferry, Idaho	H_4	258.0	257.4	−28.9	785.2471
Near Glenns Ferry, Idaho	I_4	264.8		−29.4	759.7866
Medbury, Idaho	J_4	275.6	275.5	−40.9	778.8807
Chalk Spur, Idaho	K_4	284.3	284.3	−47.2	879.4133
Near Mountain Home, Idaho	L_4	295.4		−52.7	937.2135
Mountain Home, Idaho	M_4	305.1		−47.9	958.4987
Mountain Home, Idaho	N_4	305.2	305.1	−47.0	956.5221
Mountain Home, Idaho	O_4	305.4	305.1	−47.1	957.7475
Near Mountain Home, Idaho	P_4	314.1	314.0	−53.5	969.6170
Cleft, Idaho	Q_4	322.8		−51.7	981.1317
Near Orchard, Idaho	R_4	334.2		−46.0	962.9716
Near Orchard, Idaho	S_4	343.6		−46.6	958.4451
Near Owyhee, Idaho	T_4	356.5		−53.2	912.0282
Near Owyhee, Idaho	U_4	357.0		−55.4	909.0921
Owyhee, Idaho	V_4	358.1		−56.9	903.4415
Owyhee, Idaho	W_4	358.3		−58.5	903.6997

* From bench mark B_3 at Pocatello, Idaho.

† The spur was a single line of levels.

Principal maximum values of total discrepancy (B–F) in main line.

Distance	B–F	B–F per kilometer
km.	*mm.*	*mm.*
26.2	−22.9	−0.87
113.1	−24.9	−0.22
165.3	−33.9	−0.21
200.6	−50.7	−0.25
236.7	−52.9	−0.22
315.5	−55.9	−0.18
358.3	−58.5	−0.16
At end 358.3	−58.5	−0.16

RAIL ELEVATIONS.

The following elevations for the top of the rail in front of each of the railroad stations named were determined during the progress of the leveling, usually by a single rod reading taken from one of the instrument stations on the main line of levels. They are computed upon the same basis as the elevations in the preceding tables.

Elevation of top of rail in front of railroad station.

	Meters.
Hillside, Wyo	2 092.52
Tipton, Wyo	2 133.38
Robinson, Wyo	2 106.89
Table Rock, Wyo	2 085.19
Monell, Wyo	2 055.66
Bittercreek, Wyo	2 041.34
Patrick, Wyo	2 029.20
Black Butte, Wyo	2 016.22
Hallville, Wyo	1 999.39
Point of Rocks, Wyo	1 983.76
Thayer, Wyo	1 967.94
Salt Wells, Wyo	1 942.19
Baxter, Wyo	1 922.55
Ah Say, Wyo	1 895.83
Wilkins, Wyo	1 884.69
Greenriver, Wyo	1 853.93
Riview, Wyo	1 906.12
Peru, Wyo	1 943.02
Bryan, Wyo	1 883.38
Marston, Wyo	1 893.83
Azusa, Wyo	1 905.41
Granger, Wyo	1 911.00
Church Buttes, Wyo	1 935.97
Hampton, Wyo	1 952.33
Carter, Wyo	1 980.20
Bridger, Wyo	2 020.32
Leroy, Wyo	2 044.70
Springvalley, Wyo	2 136.42
Altamont, Wyo	2 202.08

	Meters.
Knight, Wyo	2 159.63
Evanston, Wyo	2 055.59
Wasatch, Utah	2 076.15
Echo, Utah	1 663.88
Henefer, Utah	1 626.01
Croydon, Utah	1 593.85
Morgan, Utah	1 544.82
Peterson, Utah	1 489.54
Uinta, Utah	1 370.60
Ogden, Utah	1 309.56
Hot Springs, Utah	1 302.56
Willard, Utah	1 299.72
Brigham, Utah	1 312.40
Honeyville, Utah	1 300.09
Dewey, Utah	1 317.89
Collinston, Utah	1 346.20
Cache Junction, Utah	1 354.93
Weston, Idaho	1 403.59
Dayton, Idaho	1 446.52
Oxford, Idaho	1 447.93
Swan Lake, Idaho	1 453.21
Downey, Idaho	1 479.67
Arimo, Idaho	1 443.08
Inkom, Idaho	1 378.61
Pocatello, Idaho	1 359.81
Michaud, Idaho	1 362.76
Bannock, Idaho	1 345.78
American Falls, Idaho	1 321.46
Napati, Idaho	1 364.60
Wapi, Idaho	1 340.80
Yale, Idaho	1 295.61
Minidoka, Idaho	1 304.65
Colburne, Idaho	1 299.61
Kimama, Idaho	1 301.71
Senter, Idaho	1 285.87
Owinza, Idaho	1 281.11
Dietrich, Idaho	1 240.08
Tunupa, Idaho	1 132.14
Gooding, Idaho	1 088.88
Fuller, Idaho	1 037.67
Bliss, Idaho	993.93
Ticeska, Idaho	939.37
King Hill, Idaho	772.78
Glenns Ferry, Idaho	779.24
Medbury, Idaho	777.43
Reverse, Idaho	939.65
Mountain Home, Idaho	957.67
Cleft, Idaho	983.32
Orchard, Idaho	960.55
Owyhee, Idaho	903.71

STATISTICS OF LINES.

The principal items of information in regard to the four lines are given in the tables below in the same form as the tables on pages 224–225 of Appendix 3 of the Report for 1903, arranged in such a manner as to be conducive to comparison between lines.

The number of permanent bench marks includes all with which the leveling was directly connected, regardless of whether they are new bench marks or bench marks previously established by some other party or organization.

The average distance between bench marks was obtained by dividing the total length of the main line by the number of permanent bench marks.

The speed was obtained by dividing the total length of the line by the interval in months from the date of the first leveling to the date of the last, inclusive. The expression "total length" refers to the completed line. Each completed section of the line was leveled at least twice, and in some cases four or more times. To obtain the speed in terms of single line one must therefore multiply the speed here given by a factor somewhat greater than two.

The discrepancy in millimeters per kilometer was obtained by dividing the total discrepancy on the main line by the length of the main line..

The probable error of the mean result for a section was computed by the formula

$$r''=0.674\sqrt{\frac{\Sigma d^2}{4s}}$$

in which d is the discrepancy between the forward and backward leveling over a section and s is the number of sections. The probable error for 1 kilometer, r_1, was derived by assuming that the average length of a section is to 1 kilometer as $(r'')^2$ is to r_1^2.

	Red Desert to Azusa, Wyo.	Ogden, Utah, to Azusa, Wyo.	Ogden, Utah, to Pocatello, Idaho	Pocatello to Owyhee, Idaho
Observer	H. D. K.	R. L. L.	R. L. L.	H. D. K.
Instrument	7 and 5	8	8	7
Rods	T & U	R_2 & S	R_2 & S	T & U
Date of first leveling	May 20, 1903	May 2, 1903	Aug. 5, 1903	Aug. 4, 1903
Date of last leveling	July 31, 1903	July 31, 1903	Sept. 28, 1903	Oct. 24, 1903
Length of main line, km.	177	243	217	358
Length of side lines, km.	4	4	0	4
Total length, km.	181	247	217	362
Total length, miles	112	153	135	225
Number permanent bench marks	34	34	27	55
Average distance between permanent B. Ms., in km.	5.2	7.1	8.0	6.5
Speed, km. per month	75	82	121	134
Speed, miles per month	47	51	75	83
Percentage run more than twice	28	24	17	15
Discrepancy (B-F), total, mm.	+76.8	+14.7	−30.3	−58.5
Discrepancy (B-F), in mm. per km.	+0.43	+0.06	−0.14	−0.16
Probable error for 1 km., in mm.	±0.8	±0.8	±0.7	±0.7
Velocipede cars used	Yes	Yes	*Yes	Yes

*Except between McCammon and Pocatello.

USE OF RAILROAD RAIL AS A ROD SUPPORT.

In August Mr. Libby found on the line Ogden to Pocatello that a discrepancy (B–F) of the minus sign was rapidly accumulating. The average rate of accumulation was −0.67 millimeters per kilometer for the first 71 kilometers of the line, during the period August 5–26. Previous experience indicated that such a result is in general due to systematic settling of rod supports. Mr. Libby therefore determined to try the effect of placing the foot of the rod on a spot marked in red on the top of the railroad rail.* He used the rail for the rod support during all the leveling done by him in September and ending at Pocatello. Up to the time that this experiment was commenced the rods had been supported on foot pins described on pages 211–212 of Appendix 3 of the Report for 1903. Soon after Mr. King was informed of the experiment, he also began using the railroad rails instead of the foot pins as rod supports. In their reports both chiefs of party claim that the use of the rails in place of the foot pins saved enough time to enable the party to run one or two miles more of single line per working day than they otherwise would have done. The saving results from the fact that, as the point on the rail is recoverable at any time, the rear rodman may come forward at once when the observations upon his rod are completed, whereas, if a foot pin or footplate is used, he must wait until the recorder has made certain that the observations check properly and he has received a signal to that effect before pulling up the pin or plate. Mr. Libby reported that the accuracy was also greatly increased. Mr. King reported that the accuracy was not increased. A careful examination of the office computation brings out the following corroboration of these reports.

During the period August 5–26 Mr. Libby completed 85 kilometers of line, the average speed being 117 kilometers per month, using foot pins. During the period September 1–16 he completed 70 kilometers of line, the average speed being 131 kilometers per month, using the top of the rail as a rod support. During the period September 17–28, while the party was leveling between McCammon and Pocatello, the party was not allowed to use velocipede cars on account of possible interference with the electric block signaling system there used. This made the leveling much slower than it otherwise would have been. Nevertheless, the average rate of progress was 87 kilometers per month, or a total of 35 kilometers in the period named, using the rail as a rod support. As to accuracy it may be noted that for the continuous line composed of sections run for the first time during the period August 5–26, when foot pins were being used, the percentage run more than twice was 22; and similarly for the period September 1–28 this percentage was 13. The rate of accumulation of the discrepancy between the forward and backward lines was, during the first of these periods, −41.6 millimeters on 75.6 kilometers, or −0.55 millimeter per kilometer; and during the second period, +18.9 millimeters on 98.8 kilometers, or +0.19 millimeter per kilometer. The probable error of a single kilometer of completed leveling for the first of these periods was ±0.77 millimeter and for the second ±0.74 millimeter.

Mr. King stated that he began using the rail as a rod support in September, but did not name the exact date. For the purpose of investigating the effect of the change a

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*This method of support had been, unknown to Mr. Libby, tried years before with complete success on the precise level line, St. Paul to Duluth, Minn., by Mr. James A. Paige. (See Chief of Engineers' Report for 1892, part 4, pp. 3075, 3077.)

comparison is here made between the period August 4–September 15 and the remainder of the season September 16–October 24. During the first period Mr. King completed 174 kilometers of line, the average speed being 124 kilometers per month; and during the second period 189 kilometers, the average speed being 145 kilometers per month. For the continuous line composed of sections run for the first time during the first-named period, the percentage run more than twice was 17, and similarly for the second period it was 11. The rate of accumulation of discrepancy between the forward and backward lines during the first of these periods was −32.2 millimeters on 161 kilometers, or −0.20 millimeter per kilometer; and during the second period −33.6 millimeters on 180.7 kilometers, or −0.19 millimeter per kilometer. It is worthy of note in this connection that the accumulated discrepancy on the last 157.7 kilometers of the line, all run after September 23, 1903, was only −7.8 millimeters, or only −0.05 millimeter per kilometer. The probable error of a single kilometer of completed leveling for the first of these periods was ±0.65 millimeter, and for the second period ±0.70 millimeter.

The most prominent effect of changing from the foot pins to the rail for the support of the rods was to change the rate of accumulation of discrepancy between the forward and the backward lines. This is a clear confirmation of the theory that the accumulated discrepancy is due mainly to systematic rising or settling of rod supports. This theory is based upon the frequently observed fact that when a change is made in the method of rod support, or in the habits of the rodman, a change is apt to take place in the rate of accumulation of discrepancy between the forward and backward lines.

The evidence shows clearly that the use of the rail for the rod support increased both the speed and the accuracy of the leveling. Corresponding credit is due Mr. Libby for introducing this practice.

Two uncertainties in connection with this method of rod support will occur to any one who considers it carefully, namely, the uncertainty as to whether the rodman holds the foot of the rod for both foresight and backsight on precisely the same point on the slightly rounding and sometimes inclined surface of the top of the rail, and the uncertainty as to the recovery by the rail of its former elevation after a train has passed over it.

The first of these uncertainties is very small, provided the rodman is careful. No difficulty was found in marking the exact spot on the rail which was used in such a way, with chalk or kiel, that the mark was recoverable, even after a train had passed over it.

Direct observations have indicated that as a rule the rail rises to sensibly its former elevation quickly after a train passes. Doubtless there are exceptional cases. The best proof available that such cases are comparatively rare for the conditions under which the rail was used as a rod support, and that the systematic permanent settling of the rail caused by the passage of the train is exceedingly small, is furnished by the above comparison of the accuracy of the leveling by each party before and after beginning the use of the rail as a rod support. A systematic settling of the rod supports tends to produce an accumulated discrepancy (B–F) with a minus sign. This sign is found in Mr. King's leveling on the rail, but during Mr. Libby's leveling on the rail the accumulated discrepancy had a plus sign indicating a systematic rising of the rod supports between each foresight and the corresponding backsight. The foot pins were carried along with each party during the progress of the leveling and were used whenever a train was known to be approaching, or when there were special reasons for supposing that the track was not in as stable a condition as usual. The results are not subject therefore to the possible uncertainty arising from the action of every train.

COMMENTS ON THE LEVELING.

As already noted on page 405, Mr. King used level No. 5 during the period July 17–31 on the line Red Desert to Azusa. This affords an unusually good opportunity to compare the results as to speed and accuracy with two different types of instruments used by the same observer under similar conditions. The progress in completed kilometers during the period July 17–31 was 41, or at the rate of 83 kilometers per month. This agrees closely with the average rate of progress for the whole season, 85 kilometers per month, after deducting the period of eight days, July 9–16, when no leveling was done because the party was without an instrument. The comparison will be more fair, however, if the leveling with the older instrument, No. 5, is compared with that of the newer instrument, No. 7, in the one month June 9–July 8, just preceding the accident, thus eliminating from the comparison the period May 20–June 8 at the beginning of the season when the party was comparatively unfamiliar with its work and the rate of progress unusually slow for that and other reasons. During the month June 9–July 8 the progress in completed kilometers was 95. The percentage run more than twice for the sections which were leveled for the first time with the older instrument, July 17–31, is 31, whereas the corresponding percentage for the whole season is 28. The accumulated discrepancy for the continuous line, composed entirely of sections run with the older instrument, is +13.8 millimeters on 38.7 kilometers, or +0.36 millimeter per kilometer. Similarly, for the continuous line composed of sections run for the first time with the newer level, the accumulated discrepancy was +54.5 millimeters on 130.6 kilometers, or +0.42 millimeter per kilometer. The probable error of a single kilometer of completed line for the former portion, run with the older instrument, was ±0.93 millimeter; and for the latter portion, with the newer level, was ±0.79 millimeter.

The superiority of the newer type of level over the older type is shown in slightly greater speed and accuracy.

Mr. Libby expressed the opinion in his report on the season's leveling, in connection with the work in June through the Echo Canyon, on steep grades, that the errors were greater on steep grades than on moderate grades. This opinion has frequently been expressed by other levelmen. To test its validity all sections between successive temporary or permanent bench marks during this season on which the measured difference of elevation was greater than 10 meters were examined. Of the four portions of the line, in order from east to west, the combined lengths of such sections were 27, 85, 27, and 40 kilometers. The sum of these is 179 kilometers, or about 18 per cent of the season's leveling. The percentage run more than twice out of these is 25. The probable error of a single kilometer of completed line as computed from these sections alone is ±0.81 millimeter. A comparison of these two values with the corresponding values in the table on page 415 does not indicate clearly that any greater or less degree of accuracy was obtained on steep grades than on comparatively level track.

The line Ogden to Azusa, run by Mr. Libby, was one on which it was difficult to make rapid progress. The grades were unusually steep over much of the line between Ogden and Leroy, a distance of 166 kilometers. Between these points the level line rises more than 1 000 meters and descends nearly 300 meters. Over a considerable portion of the distance the railroad is so crooked that it was necessary to use one man of the party as a watchman to warn the others of trains approaching from above. Heavy winds were encountered which made it difficult to pull the velocipede cars, especially when the wind blew down grade. Four tunnels were encountered on this portion of the line. The levels were run through two of these with sights shortened to about 10 meters in length on account of the difficulty of illuminating the rods. The leveling was done over the top of the other tunnels. To climb over the Aspen Tunnel it was necessary to rise 127 meters and descend 145 meters in a distance measured along the level line of 3.8 kilometers, or less than 2 kilometers measured along the track through the tunnel. On the first forward line between these points there were 114 instrument stations, as many as there were on the next 16 kilometers to the eastward. In spite of all these difficulties the average rate of progress from Ogden to Leroy, Wyo., May 2–July 9, was 74 kilometers of completed line per month.

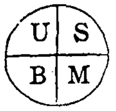
On the line Red Desert to Azusa between bench marks C_3 and F_3, a distance of only 27 kilometers, the accumulated discrepancy between the forward and backward lines was +52.6 millimeters, or at the rate of +1.95 millimeters per kilometer. The percentage run more than twice between these points was very large, namely, 49. The observer was diligent in searching for the cause of the trouble. About the time when the line was completed to bench mark F_3 he reached the conclusion that the rapidly accumulating discrepancy was probably due to the systematic rising of the foot pins between each foresight and the corresponding backsight. He acted upon this supposition by taking extreme care in locating and driving the pins. The rate of accumulation of discrepancy at once became small and remained so.

The number of rejections on the whole line from Red Desert, Wyo., to Owyhee, Idaho, under the rule that "if any measure over a section gives a result differing by more than six millimeters from the mean of all the measures over that section, this measure shall be rejected" was 42, or one rejection for each 24 kilometers of completed line.

DESCRIPTIONS OF BENCH MARKS.*

GENERAL NOTES DESCRIBING DIFFERENT FORMS AND MARKING OF BENCH MARKS.

NOTE 1.—The intersection of cross lines on the head of a copper bolt set horizontally in stone or brick, flush with the surface, and marked on the head



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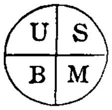
*Any person who finds that one of the bench marks here described is disturbed, or that the description no longer fits the facts, is requested to send such information to the Superintendent, Coast and Geodetic Survey, Washington, D. C.

NOTE 2.—The bottom of a square hole cut in the top of a red sandstone post, 3 feet long and 6 inches square, projecting 6 inches above the ground, the top dressed and lettered

U S
□
B M

NOTE 3.—A bench mark of the Union Pacific Railroad; a spike in a milepost, the number of which is part of the designation of the bench mark.

NOTE 4.—The intersection of cross lines on the head of a copper bolt set vertically into stone or brick and lettered



NOTE 5.—The bottom of a square hole, cut in stone or brick, and lettered

U S
□
B M

NOTE 6.—The bottom of a square hole in the top of a stone post, 4½ feet long, 6 inches square at the top, set at least 4 feet in the ground. The top is lettered

U S
□
B M

NOTE 7.—The bottom of a square hole cut in the top of a post of black lava, very hard and tough, 4 feet long, and set about 3 feet 6 inches in the ground. The top is 6 inches square and lettered

U S
□
B M

NOTE 8.—The intersection of cross lines on the end of a copper bolt, about 2¾ inches long, leaded into stone or brick and marked

U S
⊕
B M

DESCRIPTIONS OF PERMANENT BENCH MARKS FROM RED DESERT TO AZUSA, WYO.

Z_2—Near *Red Desert*, *Sweetwater County*, *Wyo.* (Appendix 3, Report for 1903, p. 805).—The bench mark has been moved slightly since it was determined in 1903.

B_3—*Red Desert*, *Sweetwater County*, *Wyo.* (Appendix 3, Report for 1903, p. 805).

C_3— *Tipton*, *Sweetwater County*, *Wyo.*, 75 feet north of the center of the main tracks in line with the west end of the depot. (Note 6, p. 420.)

D_3—About 1 mile east of *Table Rock*, *Sweetwater County*, *Wyo.*, on the first deck plate girder bridge east of Table Rock, about 4½ telegraph poles west of mile pole 773, on the south end of the east abutment (concrete), a square hole about 18 inches from retaining wall and 16 feet from outer edge and end of horizontal surface. (Note 5, p. 420.)

U. P. 779—Near *Monell*, *Sweetwater County*, *Wyo.* (Note 3, p. 420.)

E_3—*Monell, Sweetwater County, Wyo.*, directly opposite the station sign, 12 feet west of the second telegraph pole east of mile pole 779½, 42 feet south of the main tracks. (Note 6, p. 420.)

F_3—*Bittercreek, Sweetwater County, Wyo.*, in the station park, 18 feet from the south fence and 18 feet from the east fence, 2 rails west of the west end of the depot, and 53 feet north of the center of the main track. (Note 6, p. 420.)

G_3—About 2 miles east of *Black Buttes, Sweetwater County, Wyo.*, about 2 telegraph poles east of the half-mile post No. 791½, on a through plate girder bridge, on the south side of the east wall, on the top of the stone extending from under the retaining wall. (Note 5, p. 420.)

U. P. 793—*Black Buttes, Sweetwater County, Wyo.* (Note 3, p. 420.)

H_3—*Hallville, Sweetwater County, Wyo.*, directly opposite mile pole No. 799, about 100 yards west of the section house and 4 rails east of the car house, 78 feet south of the center of the main track and 34 feet south of the fence. (Note 6, p. 420.)

U. P. 799—*Hallville, Sweetwater County, Wyo.* (Note 3, p. 420.)

U. P. 804—Near *Point of Rocks, Sweetwater County, Wyo.* (Note 3, p. 420.)

I_3—One mile west of *Point of Rocks, Sweetwater County, Wyo.*, between the fourth and fifth telegraph poles west of mile pole No. 805½, 4 rails west of the station whistle post and 7 rails east of a small trestle at the point of curvature of the first curve west of Point of Rocks, 45 feet north of the track and 8 feet south of the fence. (Note 6, p. 420.)

U. P. 810—Near *Point of Rocks, Sweetwater County, Wyo.* (Note 3, p. 420.)

J_3—Two miles east of *Salt Wells, Sweetwater County, Wyo.*, 9 rails west of mile pole No. 814½, which also marks the junctions of sections 45 and 46, near the middle of the first curve east of Salt Wells, 75 feet south of the center of the track. (Note 6, p. 420.)

U. P. 823—Near *Baxter, Sweetwater County, Wyo.* (Note 3, p. 420.)

K_3—*Baxter, Sweetwater County, Wyo.*, 5 rails west of the telegraph station, and 1 rail east of the third telegraph pole east of mile pole 823½, 132 feet south of the main track. (Note 6, p. 420.)

L_3—*Rock Springs, Sweetwater County, Wyo.*, on the north side of the depot, in the water table, 22 inches above the surface of the ground, and 22 inches from the northwest corner of the bay window; a square cut lettered U. S. □ B. M.

M_3—*Rock Springs, Sweetwater County, Wyo.*, in the west end of the Union Pacific Railroad park, west of the passenger depot, about 12 feet from the west fence, in line with the three hydrants of the park. (Note 6, p. 420.)

N_3—*Rock Springs, Sweetwater County, Wyo.*, in the stone wall of the City Hall, 6 inches from the pillar at the north side of west entrance, 4 feet above the surface of the ground. (Note 8, p. 420.)

O_3—*Rock Springs, Sweetwater County, Wyo.*, in the stone wall of the high school school building, on the north side, 40 feet west of the northeast corner, and 6 feet west of the north entrance; 6 feet above the surface of the ground, and 16 inches above and to the left of the first window west of the north entrance. (Note 8, p. 420.)

U. P. 835—*Ah Say, Sweetwater County, Wyo.* (Note 3, p. 420.)

P_3—About 1¾ miles east of *Wilkins*, *Sweetwater County*, *Wyo.*, 15 rails east of the east side of pump house, and 45 feet south of the center of the track, in line with the telegraph poles. (Note 6, p. 420.)

U. P. 839—*Wilkins*, *Sweetwater County*, *Wyo.* (Note 3, p. 420.)

Q_3—*Greenriver*, *Sweetwater County*, *Wyo.*, in the west end of the Union Pacific Railroad park, about equidistant from north and south sides and 12 feet from the fence. (Note 6, p. 420.) Stone broken in shipment and cemented together.

R_3—*Greenriver*, *Sweetwater County*, *Wyo.*, in the sandstone water table of the county court-house, 4 feet north of the southeast corner, about 4 feet above the surface of the ground. (Note 8, p. 420.)

S_3—*Greenriver*, *Sweetwater County*, *Wyo.*, in the west wall of the Sweetwater Brewing Company's stone office and saloon, about 16 inches from the southwest corner, and about 4 feet from the ground. (Note 8, p. 420. except the letters U. S. B. M. were below the bolt.)

T_3—*Greenriver*, *Sweetwater County*, *Wyo.*, on the Union Pacific Railroad bridge over Green River, on south end of the middle red sandstone pier. (Note 5, p. 420.)

U_3—Near *Peru*, *Sweetwater County*, *Wyo.*, between the sixth and seventh telegraph poles east of the office pole at Peru, 45 feet south of the center of the track, 5 feet from the railroad fence, and 5 feet from the crossing fence. (Note 6, p. 420.) The stone post is 3 feet 6 inches in the ground, and of this depth 16 inches is rock.

V_3—Two miles west of *Bryan*, *Sweetwater County*, *Wyo.*, two telegraph poles east of C signpost, three rails east of a small stone culvert, and between the eighth and ninth telegraph poles west of mile pole 860; 70 feet north of the railroad track and 30 feet south of the railroad fence. (Note 6, p. 420.)

W_3—Between *Bryan* and *Marston*, *Sweetwater County*, *Wyo.*, about 4 telegraph poles west of mile pole 863, at the north end of the sandstone abutment of the Union Pacific Railroad bridge over Black River, on the top stone of the retaining wall, 8 inches from the west side of the stone and 6 inches from the north end. (Note 5, p. 420.)

X_3—Two and one-eighth miles west of *Marston*, *Sweetwater County*, *Wyo.*, 1⅜ miles east of Azusa, Wyo., 10 feet south of the fourth telegraph pole west of mile pole 868, 3 poles west of the station sign for Azusa, 55 feet south of track, 45 feet from the railroad fence. (Note 6, p. 420.)

Y_3—Four and three-fourths miles east of *Granger* and 1¼ miles west of *Azusa*, *Sweetwater County*, *Wyo.*, on the north end of the red sandstone retaining wall of the Union Pacific Railroad bridge over Black River, in the top of the stone, 10 inches from the east edge and 10 inches from the capstone. (Note 5, p. 420.)

DESCRIPTIONS OF PERMANENT BENCH MARKS BETWEEN OGDEN, UTAH, AND AZUSA, WYO.

Transit.—On a low hill west of *Ogden*, *Weber County*, *Utah*, near the Salt Lake, San Pedro and Los Angeles Railroad and about 2 000 feet from Weber River, on the site where Wheeler Observatory formerly stood. Two sandstone piers, about 5 feet above ground, are still standing, and the bench mark is a square cut on the top of the eastern one.

A—*Ogden*, *Weber County*, *Utah*, on the iron railway bridge across the Weber River, northeast of the site of Wheeler Observatory; a square cut on the northeast corner of the east abutment.

B—*Ogden*, *Weber County*, *Utah*, on the corner of Twenty-fourth street and Wall avenue, on the east side of the brick building occupied by F. J. Kiesel, wholesale grocer; near the southeast corner, in the stone water table. (Note 1, p. 419.)

C—*Ogden*, *Weber County*, *Utah*, on the corner of Twenty-fifth street and Wall avenue, on the brick and stone building occupied by the Healy Hotel; on the west side, 1 foot from the southwest corner. (Note 1, p. 419.)

D—*Uinta*, *Weber County*, *Utah*, 60 feet east of the large gate across the tracks from the railroad station, 30 feet south of the road and 4 feet north of the fence. (Note 2, p. 420.)

E—On the second iron bridge east of *Devils Gate*, *Morgan County*, *Utah*, ½ mile from the station sign; a square cut on the top of the northeast abutment.

F—On the second iron bridge west of *Strawberry*, *Morgan County*, *Utah*, a square cut in the top of the southeast corner of the east abutment.

G—One and one-third miles west of *Morgan*, *Morgan County*, *Utah*, at mile pole 1008; a square cut in the stone culvert on the south side of the Union Pacific Railroad tracks.

H—*Morgan*, *Morgan County*, *Utah*, 100 yards west of the depot, in the space south of the track, half way between the street and the track. (Note 2, p. 420.)

I—On the first iron bridge east of *Croydon*, *Morgan County*, *Utah*, at the foot of the "Devil's Slide"; a square cut in the top of the southeast corner of the east abutment.

J—*Echo*, *Summit County*, *Utah*, south of the tracks, directly opposite the water tank, in the field half way between the easterly section house and the white cottage of the station agent, three feet from the fence. (Note 2, p. 420.)

Geol. Echo—At *Echo*, *Summit County*, *Utah*, at the east side of a wagon road at the south end of the main street, just under a high hill; an iron post marked with a cross, established by the U. S. Geological Survey.

K—Four and one-half miles east of *Echo*, *Summit County*, *Utah*, and 4½ miles west of *Emory*, *Summit County*, *Utah*; a square cut in the northeast corner of the east abutment of an iron bridge. (Note 3, p. 420.)

L—*Emory*, *Summit County*, *Utah*, in a field 100 yards south of the water tank and 50 feet north of the railroad track. (Note 2, p. 420.)

M—*Castle Rock*, *Summit County*, *Utah*, near a fence, 200 feet north of the Union Pacific Railroad tracks and directly opposite the depot. (Note 2, p. 420.)

N—*Wasatch*, *Summit County*, *Utah*, on the side of a hill, a little north of the road, directly behind the depot, 100 yards north of the Union Pacific Railroad tracks. (Note 2, p. 420.)

O—A square cut in the first stone culvert west of *Wyuta*, *Rich County*, *Utah*, 200 yards west of the station sign, 25 feet south of the Union Pacific Railroad tracks.

6770 Evanston.—*Evanston*, *Uinta County*, *Wyo.*, in the front yard of the Pacific Hotel, in the corner of the yard west of the walk, about 19 feet south of the south rail of the south track; an iron post marked 6770, established by the U. S. Geological Survey.

6779 Evanston.—*Evanston, Uinta County, Wyo.*, in the south part of the court-house grounds, 6 feet north of the south fence, nearly in line with the east face of the court-house; a tablet set in the top of a stone post and marked 6779, established by the U. S. Geological Survey.

A_6—*Evanston, Uinta County, Wyo.*, in the stone corner post on the southeast corner of the depot, in the east face, a few inches from the corner, and 4 feet from the ground. (Note 1, p. 419.)

B_6—*Knight, Uinta County, Wyo.*, 100 yards east of the station and in line with the front of the section house, 150 paces south of the mail stand and the Union Pacific Railroad tracks. (Note 2, p. 420.)

C_6—*Altamont, Uinta County, Wyo.*, near the west entrance of the "Aspen Tunnel," south of the tracks, opposite a point on the track halfway between the station and the section house, about 100 yards from the track, near the right of way fence. (Note 2, p. 420.)

D_6—*Spring Valley, Uinta County, Wyo.*, 100 feet west of the water tank, 40 feet north of the Union Pacific Railroad tracks. (Note 2, p. 420.)

E_6—*Leroy, Uinta County, Wyo.*, 200 yards east of the section house, in the Union Pacific right of way south of the tracks, 2 feet from the fence, and nearly opposite the roadway which leads up the hill on the other side of the tracks. (Note 2, p. 420.)

F_6—*Bridger, Uinta County, Wyo.*, 200 feet northwest of mile pole 914, in the right of way, 80 feet north of the Union Pacific Railroad tracks and north of the station sign, 6 feet from the fence. (Note 2, p. 420.)

G_6—Three miles east of *Bridger, Uinta County, Wyo.*, in a culvert at mile pole 911; a square cut in the top stone on the arch north of the tracks.

H_6—*Carter, Uinta County, Wyo.*, west of the station and opposite mile pole 904; a square cut in the south-southeast base stone of the water tank.

I_6—*Carter, Uinta County, Wyo.*, on the west side of the roadway leading up the hill, 400 feet north of the Union Pacific Railroad tracks, 5 feet west of a telephone pole. (Note 2, p. 420.)

J_6—*Elkhurst, Uinta County, Wyo.*, in the Union Pacific right of way, 150 feet north of the tracks and at a deflection angle of 45° with the tracks from a point at the east switch of the siding. (Note 2, p. 420.)

K_6—One and two-thirds miles west of *Hampton, Uinta County, Wyo.*, in the south arch of a stone culvert; a square cut on the top of the southwest corner.

L_6—*Church Buttes, Uinta County, Wyo.*, southwest of the station, 4 feet south of the second telegraph pole west of the depot, 100 feet south of the Union Pacific Railroad tracks. (Note 2, p. 420).

M_6—*Church Buttes, Uinta County, Wyo.*; a square cut in the south-southwest base stone of the water tank.

N_6—*Garrett, Uinta County, Wyo.*, directly opposite the station sign, 200 feet north of the tracks, about halfway between the tracks and the fence. (Note 2, p. 420.)

O_6—On the first iron bridge west of *Granger, Sweetwater County, Wyo.*, over Black Fork, in the northeast red sandstone abutment; a square cut on a shelf about 1 foot below the track level.

P_6—*Granger, Sweetwater County, Wyo.*, 100 paces north of main tracks opposite a point 40 paces west of the west water tank. (Note 2, p. 420.)

DESCRIPTIONS OF PERMANENT BENCH MARKS BETWEEN OGDEN, UTAH, AND POCATELLO, IDAHO.

P—*Hot Springs*, *Boxelder County*, *Utah*, one-third of a mile south of mile pole 9, 400 feet south of the cattle guard south of the station, in the right of way of the Oregon Short Line Railroad, 40 feet east of the tracks. (Note 2, p. 420.)

Q—*Willard*, *Boxelder County*, *Utah*, behind the depot and on a line with the south side of the depot, 100 feet east of the tracks and 10 feet east of the wagon road. (Note 2, p. 420.)

R—*Brigham*, *Boxelder County*, *Utah*, 50 feet south of the second road crossing north of the station, in a field west of the tracks, inside and 2 feet from the fence, very nearly halfway between mile poles 21 and 22, 5 or 6 feet above the level of the tracks. (Note 2, p. 420.)

S—*Honeyville*, *Boxelder County*, *Utah*, 450 feet south of the south cattle guard and 30 feet north of the south switch, in the right of way of the Oregon Short Line Railroad, east of the tracks, 7 feet from the fence. (Note 2, p. 420.)

T—*Dewey*, *Boxelder County*, *Utah* (Post-office, Deweyville), 600 feet south of the depot, in the right of way of the Oregon Short Line Railroad, east of the tracks, 50 feet from the main tracks. (Note 2, p. 420.)

U—*Bear River*, *Boxelder County*, *Utah*, near the entrance to Bear River Canyon, behind the second telegraph pole north of the station sign, 75 feet west of the main tracks. (Note 2, p. 420.)

V—*Cache Junction*, *Cache County*, *Utah*, on the foundation of the water tank, in the northernmost of the two foundation stones parallel to the tracks. (Note 4, p. 420.)

W—*Cache Junction*, *Cache County*, *Utah*, opposite the north end of the long curve between the guy-wire pole and the telegraph pole, the first pole north of mile pole 49. (Note 2, p. 420.)

X—*Ransom*, *Cache County*, *Utah*, 300 feet south of the north switch of the siding, 8 feet back of the second telegraph pole south of mile pole 57, 35 paces west of the main tracks. (Note 2, p. 420.)

Y—In *Cache County*, *Utah*, about 150 feet south of the depot at *Cornish*, through which passes the State line between Utah and Idaho, in the foundation of the water tank; a square cut in the northernmost of the two foundation stones parallel to the tracks.

A—*Weston*, *Oneida County*, *Idaho*, 100 feet west of the tracks and 400 feet north of the road leading to the town. (Note 2, p. 420.)

B—*Dayton*, *Oneida County*, *Idaho*, in the northwest corner of a plat of ground adjacent to the station sign and mail stand, 10 feet east of the side track and nearly opposite the first pole north of mile pole 71, 100 feet east of the whistle post. (Note 2, p. 420.)

C—*Garner*, *Oneida County*, *Idaho*, in the foundation of the water tank; a square cut in the northernmost of the two foundation stones parallel to the tracks.

D—*Garner*, *Oneida County*, *Idaho*, 135 paces west of the tracks, opposite the station sign, 10 feet from the wire fence. (Note 2, p. 420.)

E—Near *Oxford*, *Bannock County*, *Idaho*, in the yard of an abandoned creamery, 12 feet south of the gate, 30 paces east of the main tracks. (Note 2, p. 420.)

F—3.7 miles north of *Swan Lake*, *Bannock County*, *Idaho*, at mile pole 88, 1 foot north of the white fence on the north side of the first road crossing the tracks south of the "hill," known as "Red Rock," in the angle made by the main right of way fence and the roadway fence, 100 feet east of the tracks. (Note 2, p. 420, except that the post is set nearly flush with the ground.)

G—*Downey*, *Bannock County*, *Idaho*, in the southwest corner of the Commercial Hotel yard, 5 feet from the south and west fences, 100 yards east of the railway station. (Note 2, p. 420.)

H—*Marsh Valley*, *Bannock County*, *Idaho*, opposite a point on the tracks 150 feet north of the station sign, 180 feet northwest of the semaphore, and 100 feet west of the tracks. (Note 2, p. 420.)

I—*McCammon*, *Bannock County*, *Idaho*, opposite a point on the tracks 150 feet north of the station, 20 feet southeast of the third telephone pole north of the schoolhouse, 225 feet west of the tracks, 4 feet from the fence on the west side of the main highway. (Note 2, p. 420.)

J—About 1 mile north of *Onyx*, *Bannock County*, *Idaho*, near the signboard "One mile to Onyx", west of the third telegraph pole south of mile pole 197, 24 feet west of the right of way fence on the west side of the tracks. (Note 2, p. 420.)

K—*Inkom*, *Bannock County*, *Idaho*, in the foundation of the water tank, in the westernmost of the two foundation stones parallel to the tracks; a square cut in the southeast corner.

L—*Inkom*, *Bannock County*, *Idaho*, near the first telegraph pole west of the station, 50 feet south of the tracks, between the guy wire and the main pole. (Note 2, p. 420.)

M—*Portneuf*, *Bannock County*, *Idaho*, 4 feet south of the telephone pole opposite the midpoint between the two east switches of the siding, 60 feet north of the tracks, 10½ feet north of the north right of way fence. (Note 2, p. 420.)

A_3—*Pocatello*, *Bannock County*, *Idaho*.

B_3—*Pocatello*, *Bannock County*, *Idaho*.

DESCRIPTIONS OF PERMANENT BENCH MARKS BETWEEN POCATELLO AND OWYHEE, IDAHO, 1903.

A_3—*Pocatello*, *Bannock County*, *Idaho*, in the south end of the railroad park east of the Oregon Short Line Railroad tracks, opposite the Oregon Short Line Hotel, about 35 feet south of the hydrant for the park, and about 12 feet from the south end fence, in line with the center row of trees. (Note 7, p. 420.)

B_3—*Pocatello*, *Bannock County*, *Idaho*, in the sloping surface of the white lavatic water table of the Masonic Temple, about 16 inches from the large side display window of the hardware store on the first floor of the building, about 12 feet from the northwest corner, and about 18 inches above the sidewalk; a square hole lettered thus: U. S. □ B. M.

C_3—*Pocatello*, *Bannock County*, *Idaho*, on the south end of the stone school-house west of the Oregon Short Line Railroad tracks, in the sandstone water table, 6 feet from the ground and 12 feet from the southeast corner. (Note 8, p. 420.)

City.—*Pocatello*, *Bannock County*, *Idaho*, on the rock sill of the entrance to the Pioneer Block on West Center street.

D_3—*Pocatello, Bannock County, Idaho*, in the lava foundation of the county courthouse, about 30 inches east of the northwest corner, opposite the corner of Fifth and Clark streets, about 4 inches above the surface of the ground; a square hole lettered thus: U. S. □ B. M.

E_3—*Pocatello, Bannock County, Idaho*, in the southwest corner of the public school building east of the Oregon Short Line Railroad tracks, about 5 feet east of the southwest corner, and about 5 feet 6 inches from the ground, opposite the corner of Sixth avenue and Clark street. (Note 8, p. 420.)

F_3—Four miles west of *Pocatello, Bannock County, Idaho*, on the top of the east retaining wall on the north side of the concrete abutment of a deck-plate girder bridge, the first bridge with concrete abutment west of Pocatello; 8 inches from the west edge of wall and 1 foot from the north end. (Note 5, p. 420.)

G_3—Two and one-half miles west of *Michaud, Oneida County, Idaho*, 15 feet west of the first pole east of mile pole 225, at the beginning of the first cut west of Michaud, 45 feet south of the center of the track, and 5 feet north of the railroad fence, in line with the telegraph poles. (Note 7, p. 420.)

H_3—*Bannock, Oneida County, Idaho*, 4 telegraph poles west of the station sign, and 25 rails east of west switch stand, 75 feet south of the center of the track, and 25 feet south of the fence. (Note 7, p. 420.)

I_3—About 2½ miles east of *American Falls, Oneida County, Idaho*, between the third and fourth telegraph poles east of mile pole 237, 40 feet north from the railroad fence, 60 feet south from the center of track, and 12 feet south of line of telegraph poles. (Note 7, p. 420.)

O. S. L.—*American Falls, Oneida County, Idaho*, on top of southeast corner of southeast capstone of water-tank foundation.

O. S. L.—Near *American Falls, Oneida County, Idaho*, on bridge 217, over Snake River, on southwest corner of stone abutment at east end.

J_3—About ¾ of a mile west of *American Falls, Oneida County, Idaho*, on the north side of the track, on the capstone of the west abutment of the Oregon Short Line Railroad bridge over Snake River, 10 inches from north end, and 1 foot from east edge of sandstone cap. (Note 5, p. 420.)

K_3—One-half mile east of *Napati, Blaine County, Idaho*, 20 feet west of mile pole 247, 50 feet south of the center of the track, and 50 feet from the fence, in line with the telegraph poles. (Note 7, p. 420.)

L_3—Three miles east of *Wapi, Blaine County, Idaho*, 150 feet north of the center of the track and 50 feet north of the railroad fence. (Note 7, p. 420.)

O. S. L.—*Wapi, Blaine County, Idaho*, on southeast corner of southeast capstone of tank foundation.

M_3—Three miles west of *Wapi, Blaine County, Idaho*, opposite the west end of the first curve west of Wapi, 85 feet north of the center of the track, 15 feet inside the Oregon Short Line Railroad fence. (Note 7, p. 420.)

N_3—One mile west of *Yale* (siding), *Blaine County, Idaho*, 70 feet south of the center of the tracks, 30 feet north of the railroad fence, and 21 feet south of the line of telegraph poles. (Note 7, p. 420.)

O. S. L.—*Minidoka, Lincoln County, Idaho*, on southeast corner of southeast capstone, tank foundation.

O_3—*Minidoka, Lincoln County, Idaho*, directly behind mile pole 273, which is also the boundary of sections 40 and 41, 4 telegraph poles west of the office pole, 54 feet south of the pole, and 100 feet south of the tracks. (Note 7, p. 420.)

P_3—About 6 miles west of *Minidoka, Lincoln County, Idaho*, and about 1½ miles east of *Colburn, Idaho*, opposite the second telegraph pole west of mile pole 279, about 60 feet north of the center of the tracks. (Note 7, p. 420.)

Q_3—Four miles west of *Colburn* and about 5 miles east of *Kimama, Lincoln County, Idaho*, 30 feet south of mile pole 284½, and 85 feet south of the center of the tracks. (Note 7, p. 420.)

O. S. L.—*Kimama, Lincoln County, Idaho*, on southeast corner of southeast capstone of water-tank foundation.

R_3—*Kimama, Lincoln County, Idaho*, 10 rails east of the station semaphore, 120 feet south of the center of the tracks, directly behind and 65 feet south of the pole marking the boundary line between sections 42 and 43. (Note 7, p. 420.)

S_3—*Senter, Lincoln County, Idaho*, 7½ poles west of mile pole 296, directly north of the station sign, 45 feet north of the center of the tracks. (Note 7, p. 420.)

T_3—*Owinza, Lincoln County, Idaho*, in the foundation of the Oregon Short Line Railroad water tank, in the top of the southwest corner of the southeast white sandstone cap. (Note 5, p. 420.)

U_3—About 4 miles west of *Owinza, Lincoln County, Idaho*, about 30 feet east of the second telegraph pole west of mile pole 308, about 9 feet south of the line of telegraph poles, and about 75 feet south of the railroad tracks. (Note 7, p. 420.)

V_3—*Dietrich, Lincoln County, Idaho*, directly opposite and 54 feet south of the station sign, 66 feet south of the center of the tracks, and 15 feet south of the line of telegraph poles. (Note 7, p. 420.)

W_3—*Shoshone, Lincoln County, Idaho*, in the sandstone capstone of the foundation of the Oregon Short Line Railroad water tank, in the northeast corner of the interior column on the north side. (Note 5, p. 420.)

X_3—*Shoshone, Lincoln County, Idaho*, in the northwest corner of the court-house yard, in line with the row of trees along the west side, about 50 feet south of the northwest corner, and 5 feet from the fence inclosing the yard. (Note 7, p. 420.)

Y_3—*Shoshone, Lincoln County, Idaho*, in the red lavatic water-table of the high-school building, 5 feet east of the northwest corner of the building, and 4 feet from the ground. (Note 8, p. 420.)

Z_3—One mile east of *Tunupa, Lincoln County, Idaho*, 12 feet south of mile pole 330, opposite the station signal for Tunupa, and 70 feet south of the center of tracks. (Note 7, p. 420.)

A_4—*Tunupa, Lincoln County, Idaho*, 14 rails west of the west end of the siding, 11 poles east of mile pole 332, on the first bridge west of Tunupa, a bridge of the through plate girder type, concrete abutments, and sandstone caps and steps; in a corner of the third step on the south side of the west abutment. (Note 5, p. 420.)

B_4—*Gooding, Lincoln County, Idaho*, 2 rails west of the station sign, 10 feet east of the second pole west of mile pole 338, 60 feet south of center of tracks. (Note 7, p. 420.)

C_4—*Fuller, Lincoln County, Idaho*, about 7 poles east of mile pole 345, 60 feet south of center of tracks, 4 feet south of the line of telegraph poles. (Note 7, p. 420.)

D_4—*Bliss*, *Lincoln County*, *Idaho*, in the west end of the small railroad park west of the water tank, and nearly opposite mile pole 351, 3½ rails east of the station semaphore, and 20 feet north of the center of the main track. (Note 7, p. 420.)

E_4—*Ticeska*, *Lincoln County*, *Idaho*, 4 rails east of the station sign, 45 feet east of the fifth pole east of mile pole 358 and the third pole east of the one marking the boundary line between Lincoln and Elmore counties; in line with the telegraph poles, and about 60 feet south of the center of the tracks. (Note 7, p. 420.)

F_4—*King Hill*, *Elmore County*, *Idaho*, 3½ rails east of the station sign, 10 feet east of the fifth pole east of mile pole 366, in line with the poles, and 40 feet south of the center of the tracks. (Note 7, p. 420.)

G_4—*Glenns Ferry*, *Elmore County*, *Idaho*, in the center of the west end of the Oregon Short Line Railroad park west of the depot, about 8 feet inside of the west fence. (Note 7, p. 420.)

H_4—*Glenns Ferry*, *Elmore County*, *Idaho*, on the Oregon Short Line Railroad water tank, about 2 blocks south of the depot, and about halfway to the river, where the pumping plant is located; on the northwest corner of the sandstone cap of the lava foundation for the northwest pillar supporting the tank. (Note 5, p. 420.)

I_4—About 4.6 miles west of *Glenns Ferry*, *Elmore County*, *Idaho*, about ½ pole east of mile pole 379 and 60 feet north of the center of the tracks. (Note 7, p. 420.)

J_4—*Medbury*, *Elmore County*, *Idaho*, directly opposite the station sign, 135 feet north of the center of the main track and 90 feet north of the line of telegraph poles. (Note 7, p. 420.)

K_4—*Chalk Spur*, *Elmore County*, *Idaho*, directly behind mile pole 391, 120 feet north of the center of the main track and 70 feet north of the center of the line of telegraph poles. (Note 7, p. 420.)

L_4—Six miles east of *Mountain Home*, *Elmore County*, *Idaho*, about 33 feet west of mile pole 398, which also marks the boundary of sections 58 and 59, 150 feet north of the center of the tracks and 54 feet north of the line of telegraph poles. (No. 7, p. 420.)

M_4—*Mountain Home*, *Elmore County*, *Idaho*, on the foundation of the Oregon Short Line Railroad water tank, in the southeast corner of the southeast capstone, 5 inches from the south and 5 inches from the west side. (Note 5, p. 420.) After this bench mark was established it was learned that the tank was likely to be removed within a few years.

N_4—*Mountain Home*, *Elmore County*, *Idaho*, in the east end of the Oregon Short Line Railroad Park, about equidistant from north and south fences and about 6 feet from east fence. (Note 7, p. 420.)

O_4—*Mountain Home*, *Elmore County*, *Idaho*, at the left-hand side of the Canyon street entrance to the office of the Turner Hotel, in the sandstone water table, about 2½ feet above sidewalk and 8 inches from corner of stone. (Note 8, p. 420.)

P_4—About 5½ miles west of *Mountain Home*, *Elmore County*, *Idaho*, about 20 feet west of the first pole east of mile pole 409½, about 60 feet north of the center of the tracks, in line with the telegraph poles. (Note 7, p. 420.)

Q_4—*Cleft*, *Elmore County*, *Idaho*, opposite the station sign, one pole west of mile pole 415, 120 feet south of the tracks. (Note 7, p. 420.)

R_4—About 3 miles east of *Orchard, Ada County, Idaho*, on a concrete culvert, about 3½ poles east of mile pole 422, about 1 foot from the retaining wall and 1 foot from the edge of the abutment. (Note 5, p. 420.)

S_4—About 2½ miles west of *Orchard, Ada County, Idaho*, 5 feet south of mile pole 428, 55 feet north of the center of the tracks, and south of Orchard Farm fence. (Note 7, p. 420.)

T_4—About 1 mile east of *Owyhee, Ada County, Idaho*, 5 feet north of mile pole 436, and about 45 feet south of the center of the tracks. (Note 7, p.420 .)

U_4—Three-fourths of a mile east of *Owyhee, Ada County, Idaho*, in the capstone of the south end of the east abutment of an Oregon Short Line Railroad bridge, about 14 inches from end of stone and equidistant from the sides. (Note 5, p. 420.)

V_4—*Owyhee, Ada County. Idaho*, 3 poles east of the station sign, 10 feet west of mile pole 437, 60 feet south of the center of the tracks, in line with the telegraph poles. (Note 7, p. 420.)

W_4—*Owyhee, Ada County, Idaho*, in the surface of the southwest corner of the capstone for the southwest column supporting the Oregon Short Line Railroad water tank, about 3 inches from the south edge and 4 inches from the west edge of the stone. (Note 5, p. 420.)

APPENDIX 7

REPORT 1904

PRECISE LEVELING

FROM HOLLAND TO NEW BRAUNFELS, TEXAS, 1903

By JOHN F. HAYFORD
Inspector of Geodetic Work; Assistant, Coast and Geodetic Survey

CONTENTS.

PRECISE LEVELING FROM HOLLAND TO NEW BRAUNFELS, TEXAS.

By John F. Hayford,
Inspector of Geodetic Work; Assistant, Coast and Geodetic Survey.

This line, together with the branch line from Elgin to triangulation station Barton, near Austin, Tex., was leveled by Mr. G. C. Baldwin and Mr. F. H. Sewall, Aids, between November 5, 1903, and February 16, 1904. The two observers used the same instrument, alternating in the recording and observing. The main line followed the Missouri, Kansas and Texas Railroad from Holland to San Marcos, via Smithville, and the International and Great Northern Railroad from San Marcos to New Braunfels. From the vicinity of New Braunfels the main line extends over highways (a distance of 9 kilometers) to the Seguin Base of the ninety-eighth meridian triangulation. The branch line follows the Houston and Texas Central Railroad from Elgin to Austin, and thence over highways (13 kilometers) to Barton station of the ninety-eighth meridian triangulation.

The line is connected at Holland with the precise level net shown in Appendix 3 of the Report for 1903, "Precise Leveling in the United States, 1900–1903." The connection with the triangulation station Barton near Austin and with the Seguin Base near New Braunfels serves to control the elevations fixed by the measurement of vertical angles along the ninety-eighth meridian between the Lampasas Base net and the Seguin Base.

INSTRUMENT AND RODS.

Precise level No. 8 was used. It is one of the most recent type and is fully described in Appendix 3 of the Report for 1903, pages 200–211.

The value of a 2-millimeter division on the level vial of this instrument is slightly less than 2″. The telescope has a clear aperture of 4.2 centimeters and a focal length of 41 centimeters.

Rods R_2 and S were used. They are of the type described on pages 418–419 of Appendix 8 of the Report for 1899. They are of the direct reading type and carry a centimeter graduation on which readings are made to millimeters by estimation. The lengths of the 3-meter interval, marked on each of the rods by a fine graduation on metallic plugs in its face, as determined by the Bureau of Standards, before and after the field work, and reduced to 0° Centigrade, are as follows:

	Rod R_2.	Rod S.
Oct. 17, 1903	$3^{m} + 0^{mm}.8$	$3^{m} + 1^{mm}.2$
Mar. 31, 1904	3 +0 .7	3 +1 .2

Each rod was measured with a steel tape at least twice each month while in the field. The reading of the rod thermometer was always noted in connection with these measurements and care was taken that the rods and tape should be at the temperature of the atmosphere, so that reliable comparisons could be made. These measurements were made in order to detect, if possible, any change in the lengths of the rods during the season. They do not give the absolute lengths of the rods at any time, as the error of the tape with which the measurements were made is not known.

The total range in the field measurements of the 3-meter interval on rod R_2 was 0.4 millimeter, and on rod S, 0.5 millimeter. The field measurements agreed with the measurements at the Bureau of Standards in indicating that no change took place in the length of either rod during the season. The computation of the elevations was made with the mean excess of length from the four Bureau of Standards measurements of the two rods, namely, 0.33 millimeter per meter.

The index corrections for the rods as determined at Washington before and after the field work were as follows, in millimeters: for rod R_2, −0.5 and for rod S, −0.7, on October 13, 1903; for rod R_2, −0.5 and for rod S, −0.8, on April 13, 1904.

RESULTS AND THEIR ACCURACY.

The methods of observation were those which are stated in detail on pages 211–222 of Appendix 3 of the Report for 1903.

The direct results of the leveling are shown in the following table, in which all the permanent bench marks are given.

If no distance is given in the fourth column, the bench mark is in the main line of levels. If a distance is given in the fourth as well as the third column, the bench mark is on a spur and the distance given in the fourth column shows the point at which the spur branches from the main line.

Each short section, usually from 1 to 2 kilometers long, into which the line was divided by permanent and temporary bench marks, was leveled at least twice, once in the forward and once in the backward direction. On each section upon which a forward and backward measure differed by more than $4^{mm} \sqrt{K}$ (in which K is the distance leveled between adjacent bench marks in kilometers), both the forward and backward measures were repeated until two such measures fell within the limit stated. The fifth column gives the total discrepancy accumulated at each permanent bench mark between the elevation as computed from the backward lines and from the forward lines separately.

The elevations given in the last column are referred to mean sea level on the Atlantic and Gulf of Mexico and are based upon the adjustment of the precise level net as given in Appendix No. 3 of the Report for 1903.

These are the best values of the elevations for these bench marks which are available at the date of the preparation of this report. They are given to tenths of millimeters. This does not imply that the tenths are free from error. For bench marks not more than 4 kilometers apart the difference of elevation is uncertain in the millimeters and tenths; for bench marks from 4 to 400 kilometers apart the centimeters are also uncertain; and for those at greater distances apart the decimeters are uncertain.

The initial elevation at Holland, Tex., may possibly be in error by 200 millimeters, but it is an even chance that it is within 39 millimeters of the truth.

Expressed in more precise and technical terms these uncertainties are as follows: the probable error of the elevation above mean sea level of bench mark W_4 at Holland is ±39 millimeters, of Barton triangulation station, near Austin, is ±41 millimeters, and of Seguin West Base, near New Braunfels, ±42 millimeters, and for any intermediate bench mark it lies between these values. The probable error of the difference of elevation of any two bench marks in millimeters is $\pm 1.04 \sqrt{K}$, in which K is the distance between the bench marks in kilometers measured along the level line. The value ±1.04 millimeters used above for the probable error for a single completed kilometer of leveling of this class was derived from the adjustment of the level net. See Appendix 3 of the Report for 1903, page 379.

RESULTS OF THE LEVELING.

When commencing the leveling at Holland in November, 1903, it was found that bench mark Y_4, established in April, 1903, had been destroyed. Lines were run connecting W_4 with X_4 and Z_4. The difference of elevation $X_4 - W_4$, as observed in April, 1903, was +6.2580 meters,* and as observed in November, 1903, + 6.2628 meters. This discrepancy of 4.8 millimeters on the distance of 0.8 kilometer was interpreted as indicating that these bench marks were undisturbed. The building on which X_4 is situated had been partially burned between April and November, but the portion of the wall near X_4 had not been disturbed. The difference of elevation $Z_4 - W_4$, as observed in April, 1903, was +5.8932 meters, and as observed in November, 1903, +5.8222 meters. This large discrepancy, 71.0 millimeters on 1.0 kilometer, indicates, in connection with the leveling between X_4 and W_4 cited above, that Z_4 had settled about 7 centimeters between April and November.

The computation of elevations was based upon the elevation of W_4 as determined in April, namely, 154.6978 meters.

Results of leveling from Holland to New Braunfels, Tex., with branch line to Austin, Tex.

	Permanent bench mark	Distance to bench mark †	Distance to base of spur †	Total discrepancy (B-F) at bench mark	Elevation
		km	*km*	*mm*	*m*
Near Holland	W_4		0.00		154.6978
Holland	Z_4	1.0	0.00	− 2.0	‡ 160.5200
Near Bartlett	A_5	7.8	7.8	−10.4	180.2080
Granger	B_5	17.4		−11.4	175.4671
Granger	C_5	17.8	17.4	− 9.4	175.4366
Near Circleville	D_5	26.1		− 5.1	164.5839
Taylor	E_5	35.5	35.1	− 6.0	166.0087
Taylor	F_5	35.8	35.1	− 5.4	168.4433

* For the results of the April leveling at Holland and for description of the bench marks, see Appendix 3 of the Report for 1903, pages 338, 575, 791–792.

† From bench mark W_4 at Holland.

‡ This elevation supersedes the one given for Z_4 on p. 575, Appendix 3 of 1903.

Results of leveling from Holland to New Braunfels, Tex., with branch line to Austin, Tex.—Continued.

	Permanent bench mark	Distance to bench mark	Distance to base of spur	Total discrepancy (B–F) at bench mark	Elevation
		km	*km*	*mm*	*m*
Coupland	526 Coupland	47.6	46.6	+1.7	157.5949
Near Coupland	G_5	48.0		+1.6	160.3633
Elgin	576 S. A.	60.7		−0.1	173.1297
Beginning, branch line to Austin and to Barton triangulation station.					
Elgin	576 S. A.	60.7		−0.1	173.1297
Littig	K_5	69.1		−5.4	140.5457
Manor	L_5	80.8	80.5	+11.7	163.0038
Daffan	M_5	89.1		+11.1	185.4536
Near Austin	N_5	95.8		+9.2	137.1454
Austin	Geol. Austin	103.6	103.0	+11.6	141.8973
Austin	P_5	104.5	104.5	+10.8	146.0929
Austin	O_5	104.9	104.5	+9.7	149.4489
Austin	North Meridian Mark	105.7	104.5	+6.1	166.1009
Austin	508 Austin	105.2	104.5	+8.1	153.0438
Near Austin	476 Austin	105.2		+11.0	143.2432
Near Austin	Barton ◬	117.3		+16.7	315.7015
End, branch line to Austin and to Barton triangulation station.					
Elgin	H_5	60.7	60.7	+0.6	175.2537
Near Elgin	I_5	62.6		+5.3	166.0697
Near Sayers	J_5	73.9		+10.0	120.9687
Near Sayers	Q_5	77.4	77.2	+2.4	130.8091
Near Sayers	449 S. A.	77.6	77.2	+1.8	134.4157
Near Bastrop	460 S. A.	84.5	83.6	−2.3	137.9368
Near Bastrop	R_5	85.3		−1.7	132.2620
Near Bastrop	365 S. A.	89.0	88.5	−4.2	108.9346
Bastrop	372 Bastrop	91.6	91.3	−5.2	111.7252
Bastrop	Geol. Bastrop	92.2	91.3	−5.2	111.9966
Bastrop	377 Bastrop	92.2	91.3	−4.9	113.2446
Bastrop	S_5	92.3	91.3	−4.4	113.3906
Near Bastrop	T_5	94.9		−14.9	109.1584
Hills Prairie	359 Hills Prairie	99.2	98.0	−13.5	107.7452
Near Upton	U_5	101.9		−13.3	101.8172
Upton	349 Upton	105.5		−18.0	104.7076
Near Upton	V_5	107.3		−22.6	109.9573
Smithville	329 Smithville	115.9		−40.7	98.6645
Smithville	W_5	116.4	115.9	−42.5	100.6165
Smithville	X_5	116.4	115.9	−42.9	100.6527
Smithville	Y_5	116.6	115.9	−42.5	99.5198
Near Smithville	433 S. A.	119.8	118.9	*	129.658
Near Smithville	460 S. A.	123.4		−28.3	137.9305
Near Smithville	Z_5	128.2		−29.4	150.5013
Rosanky	512 S. A.	132.7	131.6	−39.5	153.7224
Near Hemkens	451 S. A.	139.1	138.1	−48.9	134.9441
Near Hemkens	117	139.4		−50.9	136.0403
Near Hemkens	A_6	139.7	139.4	−50.5	135.9465
Redrock	491 S. A.	148.5	147.7	−54.0	147.1423
Bateman	B_6	152.8	152.6	−52.8	144.0214
Near Dale	C_6	160.8	160.7	−62.3	152.4206
Near Lockhart	D_6	171.3		−78.3	130.7846
Lockhart	Geol. Lockhart	174.1		−81.6	153.8278
Lockhart	E_6	174.8	174.1	−79.9	160.2476
Lockhart	F_6	175.0	174.1	−80.7	159.7400
Near Lockhart	G_6	175.6		−77.3	162.8245
Near Clear Fork	Geol. Clear Fork	180.6		−88.5	173.6528
Maxwell	Geol. Maxwell	186.2		−88.9	184.0672
Near Maxwell	H_6	188.1		−87.6	177.6737

*The spur is on a single line of levels—that is, run in one direction only.

Results of leveling from Holland to New Braunfels, Tex, with branch line to Austin, Tex.—Continued.

	Permanent bench mark	Distance to bench mark	Distance to base of spur	Total discrepancy (B–F) at bench mark	Elevations
		km.	*km.*	*mm.*	*m.*
Near Reedville	100 S. A.	194.0		− 98.9	177.0844
San Marcos	I_6	200.4		− 92.8	178.3273
San Marcos	J_6	200.8	200.4	− 93.3	188.5889
San Marcos	K_6	200.9	200.4	− 92.5	189.9818
Near San Marcos	585 San Marcos	200.8	200.4	− 90.5	176.0931
Near Hunter	L_6	207.7		− 98.2	205.0700
Near Hunter	627 Yorks	212.4		−105.4	189.4730
Near Hunter	M_6	213.8		−108.5	197.7876
Goodwin	N_6	221.9		−102.3	210.4307
Goodwin	695 S. A.	222.1		−102.6	210.3561
Near New Braunfels	T_6	232.2		− 92.9	187.7330
Near New Braunfels	Seguin W. B. ◬	234.3		− 95.5	189.0932
Near Seguin	Seguin E. B. ◬	241.1	234.3		*181.8735
Near New Braunfels	O_6	227.0	225.3	−101.6	190.2783
Near New Braunfels	638 Comal	229.5	225.3	−103.4	193.0182
New Braunfels	P_6	230.0	225.3	−103.7	194.6696
New Braunfels	Q_6	230.1	225.3	−104.4	193.6122
New Braunfels	R_6	230.2	225.3	−105.7	192.1704
New Braunfels	S_6	230.3	225.3	−105.0	193.1736

Principal maximum values of total discrepancy (B–F) in main line

Distance	B–F	B–F per kilometer
km.	*mm.*	*mm.*
15.9	− 15.4	−0.97
73.9	+ 10.0	+0.14
115.9	− 40.7	−0.35
213.8	−108.5	−0.51
At end 234.3	− 95.5	−0.41

On the branch line to Austin and Barton triangulation station the maximum value of B–F was +20.6 millimeters on a distance of 116.1 kilometers, or −0.18 millimeter per kilometer.

RAIL ELEVATIONS.

The following elevations for the top of the rail in front of the railroad stations named were determined during the progress of the leveling, usually by a single rod reading taken from one of the instrument stations on the main line of levels. They are computed upon the same basis as the elevations in the preceding tables.

	Meters.
Bartlett, Tex	182.48
Granger, Tex	176.29
Circleville, Tex	167.70

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*The line from Seguin West Base to Seguin East Base was run by the base line party, 1900–1901.

	Meters.
Hoxie, Tex	186.29
Taylor, Tex	165.83
Coupland, Tex	159.10
Elgin, Tex	173.56
Elgin, Tex	174.07
Littig, Tex	139.22
Manor, Tex	160.88
Daffan, Tex	187.77
Austin, Tex	141.97
Clopton, Tex	154.42
Sayers, Tex	124.29
Bishop, Tex	151.00
Ransom, Tex	139.24
Bastrop, Tex	112.31
Hills Prairie, Tex	108.18
Upton, Tex	104.38
Fawcett, Tex	101.16
Smithville, Tex	98.94
Rosanky, Tex	154.82
Hemkens, Tex	133.77
Tomlin, Tex	162.71
Redrock, Tex	147.34
Bateman, Tex	144.14
Dale, Tex	158.42
Lockhart, Tex	157.85
Blanks, Tex	171.36
Clear Fork, Tex	173.12
Maxwell, Tex	184.34
Reedville, Tex	172.41
Blanco, Tex	179.91
San Marcos, Tex	176.98
Hunter, Tex	191.39
Goodwin, Tex	210.56
New Braunfels, Tex	194.30

STATISTICS OF THE LINE.

The principal items of information in regard to this line are given in the table below in the same form as the tables on pages 224–225 of Appendix 3 of the Report for 1903, arranged in such a manner as to be conducive to comparison between lines.

The number of permanent bench marks includes all with which the leveling was directly connected, regardless of whether they are new bench marks or bench marks previously established by some other party or organization.

The average distance between bench marks was obtained by dividing the total length of the main line by the number of permanent bench marks.

The speed was obtained by dividing the total length of the line by the interval in months from the date of the first leveling to the date of the last, inclusive. The expression, "total length" refers to the completed line. Each completed section of the line was leveled at least twice, and in some cases four or more times. To obtain the speed in terms of single line one must therefore multiply the speed here given by a factor somewhat greater than two.

The discrepancy in millimeters per kilometer was obtained by dividing the total discrepancy on the main line by the length of the main line.

The probable error of the mean result for a section was computed by the formula

$$r'' = 0.674\sqrt{\frac{\Sigma d^2}{4s}}$$

in which d is the discrepancy between the forward and backward leveling over a section, and s is the number of sections.

The probable error for 1 kilometer, r_1, was derived by assuming that the average length of a section is to 1 kilometer as $(r'')^2$ is to r_1^2.

	Holland to New Braunfels, Tex.*
Observers	G. C. B. & F. H. S.
Instrument	8
Rods	R_2 & S
Date of first leveling	Nov. 5, 1903
Date of last leveling	Feb. 16, 1904
Length of main line, km.	291
Length of side lines, km.	21
Total length, km.	312
Total length, miles	194
Number of permanent bench marks	80
Average distance between permanent bench marks, in km.	3.6
Speed, km. per month	92
Speed, miles per month	57
Percentage run more than twice	22
Discrepancy (B–F) total, mm.	−95.5
Discrepancy (B–F) in mm. per km.	− 0.41
Probable error for 1 km. in mm.	± 0.8
Velocipede cars used	Yes

COMMENTS ON THE LEVELING.

Both observers used the railroad rails as rod supports during the greater part of the time, following the practice of Mr. Libby and Mr. King during the latter part of their leveling in the summer of 1903, as set forth in Appendix 6 of the Report for 1904. The observers were cautious in avoiding the use of the rail when a train was known to be approaching, or after heavy rains, or when the track had been tamped recently by the section men.

Apparently the rather large percentage of re-running (22) was due mainly to the inexperience of the two observers. Neither observer had any experience as observer on precise leveling before the beginning of this work. Mr. Baldwin had had several seasons of experience as rodman and recorder. During the last month of the leveling, over the interval from bench mark 457 S. A. to the end of the line, 95 kilometers, the percentage of re-running was 8, much smaller than the average for the season.

The effect of experience on the part of the observers also shows in the rate of progress. The average rate of progress for the whole season was 92 kilometers of completed line per month. During the last month of work, January 17–February 16, 113 kilometers were completed.

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* Includes the branch line from Elgin to Austin and triangulation station Barton.

The alternation in observing furnished a good opportunity to compare the results of two men under nearly the same conditions. Mr. Baldwin ran four sections of the main line having an aggregate length of 148 kilometers, and Mr. Sewall ran three sections with the same aggregate length, 148 kilometers. Each short section of the line which was run forward by a certain observer was also run backward by the same observer. The percentage of re-running was 24 for Mr. Baldwin and 19 for Mr. Sewall. The average accumulated discrepancy (B–F) was for Mr. Baldwin +0.03 millimeter per kilometer, and for Mr. Sewall −0.60 millimeter per kilometer. The probable error of a single kilometer of completed line was for Mr. Baldwin ±0.84 millimeter, and for Mr. Sewall ±0.83 millimeter.

The conclusion from these figures must be that there was but slight difference in the habits of observing of the two men or in the accuracy of the results. The most marked difference was that Mr. Baldwin was more successful than Mr. Sewall in preventing the accumulation of discrepancy between the forward and backward lines.

The number of rejections on the whole line under the rule that "if any measure over a section gives a result differing by more than 6 millimeters from the mean of all the measures over that section, this measure shall be rejected" was 20, or one rejection for each 15 kilometers of completed line.

DESCRIPTIONS * OF PERMANENT BENCH MARKS BETWEEN HOLLAND AND NEW BRAUNFELS, TEX., 1903–4.

NOTE.—A bench mark referred to this note is the bottom of a hole, 1¼ inches square and ¼ inch deep, cut in the top of a limestone post, 4 feet long and 6 inches square, with 6 inches dressed and projecting above the ground, the top lettered

U S
□
B M

X_4—*Holland, Tex.* (Appendix 3, Report for 1903, p. 791.) See also p. 437.

Z_4—*Holland, Tex.* (Appendix 3, Report for 1903, p. 792.)

W_4—Near *Holland, Tex.* (Appendix 3, Report for 1903, p. 791.)

A_5—About three-fourths mile north of *Bartlett, Williamson County, Tex.*, on the line of the Missouri, Kansas and Texas Railway; about 20 feet south of mile pole 902; on the west side of the track; a stone post, 6 feet east of a telegraph pole and 3 feet east of the barbed wire fence. (Note above.)

B_5—*Granger, Williamson County, Tex.*, in the southwest corner of the yard of the house of Charles Shoemaker, corner of Commerce and Ash streets; a stone post, 2½ feet northeast of the picket fences surrounding the yard and about 140 feet east of the track of the Missouri, Kansas and Texas Railway. (Note above.)

C_5—*Granger, Williamson County, Tex.*, at the northeast corner of the main entrance to the building of the First National Bank of Granger; a copper bolt, unlettered, leaded vertically in the top of the triangular limestone step, about 6 millimeters below the wearing surface.

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* Any person who finds that one of the bench marks here described is disturbed or that the description no longer fits the facts, is requested to send such information to the Superintendent, Coast and Geodetic Survey, Washington, D. C.

D_5—About two-fifths mile north of *Circleville, Williamson County, Tex.*, on the line of the Missouri, Kansas and Texas Railway, about 60 meters south of the south abutment of the Missouri, Kansas and Texas Railway bridge over the San Gabriel Creek; at the railroad water tank, about 2 meters west of the track; the bottom of a square hole, 1 by 1 by ¼ inches deep, in the top of the sandstone base of the southeast column, which is 3 feet square and 2½ feet high above ground.

E_5—*Taylor, Williamson County, Tex.*, in the grass plot or gore park east of the station of the International and Great Northern Railroad; a stone post, 25.5 meters east from the east wall of the station and 17.8 meters north from the center of the track of the International and Great Northern Railroad, nearest the station. (Note, p. 442.)

F_5—*Taylor, Williamson County, Tex.*, in the south wall of the Taylor National Bank, corner of Main and Second streets, a brick building, with first story granite; 20 feet west of the east entrance; a horizontal mark on the face of a copper bolt leaded horizontally in the wall, 2½ feet above the sidewalk, marked $\underset{B\ M}{\overset{U\ S}{\ominus}}$.

526 Coupland—A United States Geological Survey bench mark at *Coupland, Williamson County, Tex.*, opposite the station, 50 feet east of main track of Missouri, Kansas and Texas Railway and 5 feet east of the southwest corner of the fence inclosing the section-house yard; an iron post, marked 526.

G_5—About one-fourth mile south from *Coupland, Williamson County, Tex.*, on the line of the Missouri, Kansas and Texas Railway, 9½ rails north from mile pole 927; a stone post opposite the south end of the first switch west of the main track, about 35 feet west of the main track and 4 feet east of the right-of-way fence. (Note, p. 442.)

576 S. A.—A United States Geological Survey bench mark at *Elgin, Bastrop County, Tex.*, at Union passenger station, 7 feet east of the southeast corner of a small park, 115 feet east of the crossing of Missouri, Kansas and Texas and the Houston and Texas Central railroads, 20 feet north of Houston and Texas Central Railroad main track; an iron post, marked 576 S. A.

K_5—*Littig, Travis County, Tex.*, in the southwest corner of the yard of section house 115, almost opposite the east end of the switch and about 8 meters north of the main track of the Houston and Texas Central Railroad; a stone post, about 1.2 meters north and east, respectively, of the south and west fences bounding the yard. (Note, p. 442.)

L_5—*Manor, Travis County, Tex.*, in the front wall of the brick building facing on the main street of the town, owned by Mr. Harris and occupied by W. H. Richardson, hardware and general merchandise; the center of a cross cut in the face of a copper bolt, unlettered, leaded horizontally into the street facing of the west wall of the building, about 1.4 meters above the sidewalk and about 0.6 meter west of the show window.

M_5—About 445 meters west of the Houston and Texas Railroad depot at *Daffan, Travis County, Tex.*, about 56 meters west of the first cattle guard west of the station; a stone post about 1 meter south of the line of telegraph poles and about 7 meters north of the main track. (Note, p. 442).

N_5—About 5½ miles east of the Houston and Texas Central Railroad passenger depot, at *Austin*, *Travis County*, *Tex.*, on the west stone abutment of that railway's bridge over Walnut Creek; in the top layer of the backing; 1.35 meters north of the main track; the top of a copper bolt leaded vertically into the top of the stone, 0.18 meter west of the east edge, and roughly lettered

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⊙ .
B M

O_5—*Austin*, *Travis County*, *Tex.*, in the Driskill Hotel building, corner of Brazos and Sixth streets; the top of a copper bolt, unlettered, leaded vertically into the top of the limestone step to the first door west of the entrance to the American National Bank; about 1.2 meter from the door and 0.5 meter from the wall.

P_5—*Austin*, *Travis County*, *Tex.*, in the passenger depot of the Houston and Texas Central Railroad, corner of Congress avenue and East Third street; in the south wall, bay projection, just west of the large door of the general truck or baggage room at the east end of the building; a horizontal mark in the face of a copper bolt, unlettered, leaded horizontally into the face of the wall about 1.75 meters from the ground and 0.2 meter from the inside corner.

Geol. Austin.—A United States Geological Survey bench mark at *Austin*, *Travis County*, *Tex.*, in the freight yard of the Houston and Texas Central Railroad, 60 meters west of the office door of the freight depot; an iron post close to a telegraph pole and 5 meters north of the northernmost track.

North Meridian Mark.—*Austin*, *Travis County*, *Tex.*, on Capitol Hill; a cross on the copper bolt in the center of the top of the square stone pillar marking the north end of the meridian line established in 1872.

508 Austin.—A United States Geological Survey bench mark at *Austin*, *Travis County*, *Tex.*, on the southwest corner of the post-office, facing Colorado street; a bronze tablet marked 508.

476 Austin.—A United States Geological Survey bench mark at *Austin*, *Travis County*, *Tex.*, on the highway bridge over Colorado River, in the west end of the south rock pier; a copper bolt, marked 476 feet.

Barton △—About 6 miles W. 19° N. of *Austin*, *Travis County*, *Tex.*, on the north side of the Austin and Bee Caves road, on very rough ground, upon a prominent wooded hill, abreast and north of the 8-milepost from Austin. The station mark is a 2-inch iron pipe embedded in and filled with concrete, with a nail projecting from the concrete. The bench mark is a chisel mark on the rim of the iron pipe.

H_5—*Elgin*, *Bastrop County*, *Tex.*, on the east side of the station of the Missouri, Kansas and Texas Railway and the Houston and Texas Central Railroad; a horizontal mark on the face of a copper bolt, not lettered, leaded horizontally into the brick wall of the bay projection, 4 feet above the ground, 4 inches above the base of the bay window toward the Missouri, Kansas and Texas Railway track, and 2 feet south of the window along the wall.

I_5—About 1¼ miles south of the station at *Elgin*, *Bastrop County*, *Tex.*, on the line of the Missouri, Kansas and Texas Railway, about 15 feet south from mile pole 936; a stone post 3 feet inside of the west right-of-way fence. (Note, p. 442.)

J_5—About one-half mile north of the freight shed or station at *Sayers*, *Bastrop County*, *Tex.*, on the line of the Missouri, Kansas and Texas Railway, about 130 feet north of mile pole 943; a stone post 5 feet inside the east right of way fence. (Note, p. 442)

Q_5—About 1⅜ miles south of *Sayers*, *Bastrop County*, *Tex.*, on the line of the Missouri, Kansas and Texas Railway, on a large concrete culvert, about 140 meters north of a public road crossing; the top of a copper bolt, unlettered, leaded vertically into the concrete of the culvert in the south corner of the east end, about 0.1 meter from each of the two edges of the corner of the culvert.

449 S. A.—A United States Geological Survey bench mark, about 1½ miles south of *Sayers*, *Bastrop County*, *Tex.*, and 8¾ miles north of Bastrop, 4½ telegraph poles south of mile pole 945, 5 feet east of the northwest corner of the right of way fence at the public road crossing; an iron post, marked 449 S. A.

R_5—About 4 miles north of *Bastrop*, *Bastrop County*, *Tex.*, along the line of the Missouri, Kansas and Texas Railway, about 70 meters south of mile pole 950; a stone post in the line of telegraph poles, 8.5 meters east of the track and about 6.5 meters west of barbed wire fence bounding the right of way. (Note, p. 442, except that the post is but 3 feet long and projects 3 inches.)

460 S. A.—A United States Geological Survey bench mark, 4½ miles north of *Bastrop*, *Bastrop County*, *Tex.*, at the crossing of the Bastrop and Elgin public road, 3 feet outside of the southeast corner of the right of way fence; an iron post, marked 460 S. A.

365 S. A.—A United States Geological Survey bench mark, 1.66 miles north of *Bastrop*, *Bastrop County*, *Tex.*, at the northeast end of the east rock pier of the bridge over Piney Creek; a copper bolt, marked 365 S. A., in the top of the coping.

372 Bastrop.—A United States Geological Survey bench mark at *Bastrop*, *Bastrop County*, *Tex.*, 100 feet southwest of the freight depot and 50 feet south of the Bastrop and Lagrange county road; an iron post, marked 372.

Geol. Bastrop.—A United States Geological Survey bench mark at *Bastrop*, *Bastrop County*, *Tex.*, in the northeast part of the court-house grounds, close to the iron fence on the north side of the grounds, and about 15 meters east of the pathway leading to the main entrance to the court-house; a bronze tablet in the top of a square stone post. The post had been pulled up and reset since it was established.

377 Bastrop.—A United States Geological Survey bench mark at *Bastrop*, *Bastrop County*, *Tex.*, at the northwest side of the main entrance to the court-house; a bronze tablet set in the brick wall, marked 377.

S_5—*Bastrop*, *Bastrop County*, *Tex.*, on the east side of the county jail, about 1.6 meters south of the northeast corner, and 1.2 meters above the ground; the center of a cross on the face of a copper bolt, unlettered, leaded horizontally into the plaster-covered brick wall, 0.85 meter north of the window on the east side of the building nearest the northeast corner, and about 0.1 meter below the level of the window sill.

T_5—About 2 miles south of *Bastrop*, *Bastrop County*, *Tex.*, on the north stone abutment of the Missouri, Kansas and Texas Railway bridge over Colorado River, 1.2 meters west of main track and 0.3 meter below the top of the rails; the top of a copper bolt, unlettered, leaded vertically into the top of the rough plaster-covered stone wall which forms the backing for the abutment.

359 Hills Prairie.—A United States Geological Survey bench mark at *Hills Prairie, Bastrop County, Tex.*, 28 feet east of the south head block, near the right of way fence; an iron post, marked 359.

U_5—About 2 miles north of *Upton, Bastrop County, Tex.*, on the south stone abutment of the Missouri, Kansas and Texas Railway bridge over Cedar Creek, on the southwest corner; the bottom of a square hole, 1¼ inches square and ¼ inch deep, cut in the top stone, about 0.11 meter from the north and east edges, lettered $\overset{\text{U S}}{\underset{\text{B M}}{\square}}$.

349 Upton.—A United States Geological Survey bench mark at *Upton, Bastrop County, Tex.*, about 45 feet east of the head block at the south end of the switch, near the right of way fence; an iron post, marked 349.

V_5—About 1⅓ miles south of *Upton, Bastrop County, Tex.*, on the line of the Missouri, Kansas and Texas Railway, about 420 meters north of mile pole 964; a stone post in the line of telegraph poles on the east side of the track, about midway between the track and the right-of-way fence. (Note, p. 442.)

329 Smithville.—A United States Geological Survey bench mark at *Smithville, Bastrop County, Tex.*, 10 feet east of the second telegraph pole south of mile pole 969, also the second telegraph pole north of the station; an iron post, marked 329.

W_5—*Smithville, Bastrop County, Tex.*; in the brick building on Main street owned by Ed. Eagleston and occupied by the American Express Company; a cross cut in the face of a copper bolt, unlettered, leaded horizontally into the partition wall between the express office and a barber shop, in slight recess, 0.22 meter from either edge of the protruding wall and 1.13 meters above the pavement.

X_5—*Smithville, Bastrop County, Tex.*; in the brick building of the Bank of Smithville, corner of Main and Second streets; a cross cut in the face of a copper bolt, unlettered, leaded horizontally in the wall, 1.2 meters above pavement and 0.3 meter from the edge of the wall at the window on Second street.

Y_5—*Smithville, Bastrop County, Tex.*; in the Masonic Building (of brick), corner of Main and Third streets; the bottom of a square hole, unlettered, cut in the concrete ledge to the window on Third street, 0.15 meter from the edge of the corner brick pillar and 0.12 meter from the window.

433 S. A.—A United States Geological Survey bench mark about 3⅓ miles west of *Smithville, Bastrop County, Tex.*, about ¼ mile east of mile pole 972, 25 feet northwest of a road crossing; an iron post, marked 433 S. A. Reported in very poor condition in 1904.

460 S. A.—A United States Geological Survey bench mark about 4½ miles west of *Smithville, Bastrop County, Tex.*, near the second telegraph pole east of mile pole 974, 65 feet northeast of the road crossing; an iron post in a corner of the fence, marked 460 S. A.

Z_5—Near *Rosanky, Bastrop County, Tex.*, in the right of way of the Missouri, Kansas and Texas Railway, 103 meters east of mile pole 977 and 48 meters west of a road crossing; a stone post in the line of telegraph poles on the south side of the track. (Note, p. 442.)

512 S. A.—A United States Geological Survey bench mark, 120 yards west of the railroad station at *Rosanky, Bastrop County, Tex.*, 50 feet south of the crossing of the Rosanky and Jeddo public road; an iron post, marked 512 S. A.

451 S. A.—A United States Geological Survey bench mark, ¼ mile east of the section house at *Hemkens, Bastrop County, Tex.*, 4 miles west of Rosanky and 6 miles east of Redrock, 45 feet southwest of the settlement road crossing and about halfway between mile poles 983 and 984; an iron post, marked 451 S. A.

T. B. M. 117.—Just west of *Hemkens, Bastrop County, Tex.;* the bottom of a square hole cut on the red rock base to the column at the northwest corner of the old water tank.

A_6—About ¾ mile west of *Hemkens, Bastrop County, Tex.*, on the right of way of the Missouri, Kansas and Texas Railway, 282 meters west of a water tank near mile pole 984, in a red sandstone culvert; the top of a copper bolt, lettered $\overset{\text{U S}}{\underset{\text{B M}}{\bigcirc}}$, leaded horizontally in the northwest corner of the side north of the track, 0.37 meter from the north and west edges.

491 S. A.—A United States Geological Survey bench mark at *Redrock, Bastrop County, Tex.*, 1 200 feet southeast of the passenger station on the Lockhart branch of the Missouri, Kansas and Texas Railway, 125 feet south of the track at the intersection of the Waelder and Redrock and the Redrock and Rosanky public roads; an iron post, marked 491 S. A. Reported unstable in 1904.

B_6—*Bateman, Bastrop County, Tex.*, on the San Antonio branch of the Missouri, Kansas and Texas Railway; 18.6 meters northeast of the signboard "Bateman," and about 18 meters south of Redrock–Taylorville road and railroad crossing; 4.87 meters from the middle of the south rail, 3.3 meters from the line of telegraph poles; the top of a copper bolt leaded vertically in an outcrop of red sandstone, 1.5 meters long by 0.4 meter wide, by 0.2 meter high, with the letters U. S. cut in the stone below the bolt.

C_6—Three-fourth mile east of *Dale, Caldwell County, Tex.*, on the right of way of the Missouri, Kansas and Texas Railway, on a red sandstone culvert, 2.3 meters east of mile pole 997; the top of a copper bolt leaded vertically into the center of the top of the upper southwest corner stone, 0.25 meter from the south and west edges of the culvert, roughly lettered $\overset{\text{U S}}{\underset{\text{B M}}{\bigcirc}}$.

D_6—Two and a half miles east of *Lockhart, Caldwell County, Tex.*, on the right of way of the Missouri, Kansas and Texas Railway, in the west limestone pier of the bridge over Plum Creek; the bottom of a square hole, unlettered, cut in the northwest corner of the top of the southernmost topstone, 0.2 meter from the joint, 0.1 meter from the west edge, and 0.9 meter south of the south rail of the track.

Geol. Lockhart.—A United States Geological Survey bench mark at *Lockhart, Caldwell County, Tex.*, 30 feet south of the track of the Missouri, Kansas and Texas Railway, 200 feet west of the transfer track of the San Antonio and Aransas Pass Railway, and 40 feet west of the road; an iron post. Reported slightly loose in 1904.

E_6—*Lockhart, Caldwell County, Tex.*, on the county court-house; in the east wall, about 1.2 meters from the northeast corner and about 1.2 meters above the ground; about 0.52 meter south of the granite corner stone, and 0.14 meter above the layer of red sandstone; a cross cut in the face of a copper bolt, leaded horizontally into a block of limestone dressed ready for lettering, but not lettered.

F_6—*Lockhart, Caldwell County, Tex.*, in the Eugene Clark Library building, about 0.42 meter north of the southeast corner of the front wall of the building, and about 1.2 meters from the ground; a cross in the face of a copper bolt, leaded horizontally into the limestone window ledge, lettered $\overset{\text{U S C.}}{\odot}$

G_6—About ½ mile west of the Missouri, Kansas and Texas Railway depot at *Lockhart, Caldwell County, Tex.*, about 100 meters west of the westernmost switch in the yards; a stone post in the line of telegraph poles on the railway right of way, south of the track. (Note, p. 442.)

Geol. Clear Fork.—A United States Geological Survey bench mark, 400 feet east of the spur at *Clear Fork, Caldwell County, Tex.*, 25 feet north of the center of the track and 50 feet south of the San Marcos and Lockhart road crossing; an iron post. Reported very slightly loose in 1904.

Geol. Maxwell.—A United States Geological Survey bench mark at *Maxwell, Caldwell County, Tex.*, 30 feet south of the center of the main track, directly in front of the station; an iron post.

H_6—About 1¼ miles west of *Maxwell, Caldwell County, Tex.*, 38 meters west of mile pole 1014, on the right of way of the Missouri, Kansas and Texas Railway; a limestone post, 10 meters south of track. (Note, p. 442.)

100 S. A.—A United States Geological Survey bench mark about ⅝ mile west of *Reedville, Caldwell County, Tex.*, 10 feet west of the ninth telegraph pole east of mile pole 1018, 40 feet south of the track and 30 feet east of the wagon road; an iron post marked 100 S. A.

I_6—*San Marcos, Hays County, Tex.*, opposite the freight depot of the International and Great Northern Railroad and just south of the track; in the middle of the southeast face of the octagonal limestone base (3 meters high) of the steel water tank, 1 meter above the ground; a horizontal mark in the face of a copper bolt, unlettered.

J_6—*San Marcos, Hays County, Tex.*, at the east entrance of the court-house, in the face of the corner pillar of dressed limestone; the center of a cross cut in the face of a copper bolt, unlettered, about 1.5 meters north from the entrance and 1.5 meters above the ground.

K_6—*San Marcos, Hays County, Tex.*, in the building of the Glover National Bank, in the top of the limestone ledge step below the window at the left of the entrance; the top of a copper bolt, unlettered, in the center of the step.

585 San Marcos.—A United States Geological Survey bench mark near *San Marcos, Hays County, Tex.*, on the International and Great Northern Railroad bridge over San Marcos River, in the west end of the north rock pier; a copper bolt, marked 585 feet.

L_6—2.8 miles east of *Hunter, Comal County, Tex.*, 25 meters east of milepole 214, on the right of way of the International and Great Northern Railroad, 6 meters south from the track; a stone post. (Note, p. 442.)

627 Yorks.—A United States Geological Survey bench mark near *Hunter, Comal County, Tex.*, on the International and Great Northern Railroad bridge over Yorks Creek, near mile pole 219, in the top of the west end of the north rock pier; a copper bolt, marked 627 feet.

M_6—1 mile west of *Hunter*, *Comal County*, *Tex.*, 210 meters east of milepole 218, opposite post with sign "Hunter, 1 mile," 4.5 meters east of a crossing, on the right of way of the International and Great Northern Railroad; a stone post. (Note, p. 442.)

N_6—200 meters east of *Goodwin*, *Comal County*, *Tex.*, opposite the switch block at the east end of the siding, on the right of way of the International and Great Northern Railroad, 16 meters north of the track; a stone post. (Note, p. 442.)

695 S. A.—A United States Geological Survey bench mark at *Goodwin*, *Comal County*, *Tex.*, opposite the station, in the right of way of the International and Great Northern Railroad, 50 meters north of mile pole 223 and 12 meters east of the track; an iron post, marked 92 S. A. 695 feet.

T_6—In *Guadalupe County*, *Tex.*, about 4 miles southeast of New Braunfels on the New Braunfels–Seguin highway, about 10 meters east from the center of the road, in the northwest corner of the front yard of Gottfried Janer, 1 meter from both the north and west yard fences; a stone post. (Note, p. 442.)

Seguin West Base △—6½ miles from *New Braunfels*, *Comal County*, *Tex.*, 1 100 meters west of the Seguin–New Braunfels road and about 400 meters east of Guadalupe River, on a small hill covered with scattering mesquite brush, on the land of Henry Steinman. The base monument is a limestone block set in concrete and carrying on its top surface a bronze station mark, 80 millimeters in diameter, with an inner circle, countersunk, 37 millimeters in diameter, and the letters U. S. C. & G. S. cast on the space between the inner and outer circles. The center of the inner circle is the bench mark.

Seguin East Base △—Near *Seguin*, *Guadalupe County*, *Tex.*, about 2 miles northwest of Von Beckman's store and gin, 1 050 meters east of the main road between Van Beckman's and New Braunfels, on the land of Henry Soefje, at the western edge of the live oak timber. The monument and mark are similar to those at Seguin West Base △.

O_6—1.35 miles east of *New Braunfels*, *Comal County*, *Tex.*, in the top of the northeast limestone pier of the bridge of the International and Great Northern Railroad, over Guadalupe River; the bottom of a square hole, unlettered, 0.2 meter from the east edge and 0.6 meter from the north edge of the pier.

638 Comal.—A United States Geological Survey bench mark near *New Braunfels*, *Comal County*, *Tex.*, on the International and Great Northern Railroad bridge over Comal Dry Creek, in the top of the north end of the east rock pier; a copper bolt, marked 638 feet.

P_6—*New Braunfels*, *Comal County*, *Tex.*, on the Opera House (of yellow brick) owned by Louis and Otto Seekatz, about 1.4 meters from the sidewalk, at the base of the window just to the left of the entrance on San Antonio street; a horizontal mark in the face of a copper bolt marked $\overset{\text{U S}}{\underset{\text{B M}}{\ominus}}$.

Q_6—*New Braunfels, Comal County, Tex.*, in the Comal County prison, at the left of the entrance to the building (of limestone), in the face of the square corner limestone pillar, about 1.5 meters above the sidewalk; a horizontal mark in the face of a copper bolt marked $\underset{\text{B M}}{\overset{\text{U S}}{\ominus}}$.

R_6—*New Braunfels, Comal County, Tex.*, in the square park at the intersection of San Antonio and Seguin streets, in the northwest part, about 8 meters west of the center line of San Antonio street, and 20 meters north of the center line of Seguin street; a stone post. (Note, p. 442.)

S_6—*New Braunfels, Comal County, Tex.*, in the court-house (of limestone), in the top of the low limestone wall, top-dressed, at the right of the steps leading to the side entrance on San Antonio street; the bottom of a square hole, 3 centimeters square and 0.6 centimeter deep, lettered $\underset{\text{\& G S}}{\overset{\text{U S C}}{\square}}$.

APPENDIX 8

REPORT 1904

A TEST OF A TRANSIT MICROMETER

By JOHN F. HAYFORD

Inspector of Geodetic Work; Assistant, Coast and Geodetic Survey.

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ILLUSTRATIONS.

A TEST OF A TRANSIT MICROMETER.

By John F. Hayford,
Inspector of Geodetic Work; Assistant, Coast and Geodetic Survey.

Theory of the Transit Micrometer.

The transit micrometer* is a form of registering micrometer placed with its movable line in the focal plane of an astronomic transit, and at right angles with the direction of the motion of the image of a star which is being observed as it crosses the meridian. Certain contact points on the micrometer head serve to make or break an electric circuit as they pass a fixed contact spring, and they record upon a chronograph the instant at which the micrometer head, and, therefore, the moving micrometer line, reached each of the positions corresponding to the contact point.

The movement necessary to make the micrometer line follow a star image is given to the micrometer head either by the hand of the observer, by clockwork, or by an electric motor.

The purpose of the transit micrometer is to furnish a means of determining time, that is, clock errors, which shall be sensibly free from any personal equation on the part of the observer.

The process of observing consists simply in bisecting the star image and in keeping it bisected continuously as it moves across the field of vision. The record made upon the chronograph is similar to that which would appear there if a series of fixed lines were in the focal plane of the telescope, and the observer recorded the instant of transit of a star image across each line as seen by him by operating an electric key in the chronograph circuit. The computation is, with a possible exception in some minor details, made exactly as if the chronograph record had been produced by the use of fixed lines and a key.

The mental process of the observer is widely different in the two cases. In the first case he attempts to observe and record the particular instant of the transit of a star image across a certain fixed line. The result as recorded upon the chronograph sheet depends upon the rapidity of perception and action of the observer. In the other case the time element does not enter directly into the mental process of the observer. He is not trying to note the particular instant at which any event occurs. He is intent simply

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* The expression transit micrometer is preferred over the expression registering micrometer for the reason that it is more definite. There is a registering micrometer made by the Repsolds which is used to record repeated pointings made on a star, as it crosses the meridian, to determine its declination.

upon keeping a star image bisected by a movable line which is under his control. In general he sees the star image at a given instant either slightly ahead of or slightly behind the moving line, and determines to make the line move more slowly or more rapidly,* so as to improve the bisection. After an interval which depends upon his rapidity of action, the bisection is improved, perhaps made perfect. He soon observes that the bisection is again imperfect and makes an attempt to improve it. This cycle of events, the noting that the bisection is imperfect, deciding to correct it, attempting to correct it, and again observing that it is imperfect, is repeated at a rate which is dependent upon the rapidity of perception and of action of the observer and upon his temperament. His personal equation of the kind which affects the key method of observation is now effective in determining the amplitude and period of the oscillation of the moving line forward and backward across the star image, but not in fixing the average error in the position of the moving line. The latter is fixed mainly by a personal equation of the same form as if a series of bisections of a fixed star image were being made. The observer may be subject to a personal equation in estimating the position of the image which leads him to habitually place the line slightly to the right or to the left of the image. Such a personal equation in estimating the position of a stationary or slowly moving image has a much smaller effect upon the result of an observation of time with a transit micrometer than the personal equation in observing the instant of transit has upon the result of an observation of time with an electric key.† This is the theory of the transit micrometer. The proof of the correctness of the theory lies in the results which have been secured with the transit micrometer by various observers.

Though it has been claimed that the accidental errors of observation have been reduced by the use of a transit micrometer in the place of a key, the principal claim, and in all cases the important claim, is that it nearly, if not quite, eliminates from the results the effects of all personal equation on the part of the observer, and hence, also, the effects of variation of the personal equation, which would otherwise be present.

SHORT HISTORY OF THE TRANSIT MICROMETER.

The observations of star transits by means of a movable transit line was first suggested in 1865 by Director Carl Braun, of Kalocsa Observatory, in Hungary, in a publication entitled "Das Passagen-Mikrometer," 1865, Leipzig. He believed that it was necessary to have the movable line driven by clockwork. He failed in an attempt to construct a clockwork which would drive the movable line satisfactorily so as to follow the transits of stars of various declinations. Many years then elapsed during which, apparently, no attempt was made to use a transit micrometer.

Repsold, the well-known instrument maker, was the first to suggest in print,‡ in

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*If the observer with a transit micrometer driven by clockwork gives the moving line a sudden forward movement, or backward movement, superposed upon the approximately uniform motion given by clockwork, instead of making the mere change of speed indicated in the text, this does not materially alter the facts as to the mental process.

† These statements as to personal equation made in regard to observers by the key and chronograph method apply with little modification to eye and ear method of observation.

‡ "Neuer Vorschlag zur Vermeidung des persönlichen Zeit-Fehlers bei Durchgangsbeobachtungen," in No. 2940 of the Astronomische Nachrichten.

1889,* that no clockwork was required, and that very good results could be secured with a hand-driven transit micrometer. He then constructed such a micrometer with which excellent results were secured.

The Prussian Geodetic Institute made a series of tests of the Repsold transit micrometer in 1891, which showed that the apparent differences of the personal equation of the four observers who took part in the test were about one-tenth as large with the transit micrometer as with fixed lines and a key. The tests also showed that there are other well-marked advantages of the transit micrometer over other methods of observing star transits.

The Prussian Geodetic Institute acquired two transits of the broken telescope type made by Bamberg, of Berlin, which were equipped with transit micrometers slightly modified from the Repsold design, especially as to the contact mechanism. From 1891 to the present time the Geodetic Institute has had these instruments in use on various occasions on telegraphic longitude determinations. Its experience constitutes a strong proof that the use of the transit micrometer is effective in increasing the accuracy of such determinations. The latest work of this kind of which the results have been published at the date of this writing, is the determination in 1903 of the difference of longitude between Potsdam and Greenwich.

The transit micrometer has been tried at various times in fixed observatories, and various opinions in regard to it have been formed.

The consensus of opinion as published is strongly in favor of the transit micrometer as being effective in eliminating the effects of personal equation.

In the United States the transit micrometer has been used continuously for several years at the Washburn Observatory at Madison, Wis. It has also been used at the observatory at the University of Michigan, Ann Arbor, Mich. Both of these instruments are hand-driven Repsold transit micrometers. At the Philadelphia Central High School experiments have been made by Prof. M. B. Snyder with a transit micrometer driven by an electric motor.

A short summary of the literature which is the basis for the above outline of the history of the transit micrometer is given in the latter part of this Appendix.

When the question of using transit micrometers in making telegraphic longitude observations was under consideration in the Coast and Geodetic Survey, the facts, very briefly outlined above, were available. While these seemed to be sufficient to leave no doubt that on large instruments used in fixed observatories the transit micrometer is a complete success, and that similarly it has proved successful when applied to longitude transits of the Prussian Geodetic Institute, it did not seem safe to predict the degree of accuracy which would be attained with transit micrometers applied to the particular type of transits used for longitude determinations in the Coast and Geodetic Survey. These transits carry a straight telescope, and therefore do not have the eye end of the telescope supported so rigidly as it is in the Geodetic Institute instruments, which have the eyepiece in the end of the horizontal axis of the telescope, and therefore quite near to one of the fixed points of support. The degree of stability of the eye end of the telescope is important with hand-driven micrometers, since the observations must be

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* Mr. F. D. Granger, Assistant, Coast and Geodetic Survey, had made the suggestion verbally in connection with longitude determinations in 1878; but his suggestion was not acted upon and never appeared in print.

made while the observer's fingers are in contact with the micrometer. There were also various minor points on which more information was desired before placing the transit micrometer in regular use in longitude parties. A transit micrometer suitable for use on the Coast and Geodetic Survey transits was therefore designed by Mr. E. G. Fischer, Chief of the Instrument Division of the Coast and Geodetic Survey, constructed under his directions, and the tests discussed in this Appendix were made. The following description was written by Mr. Fischer.

DESCRIPTION OF THE HAND-DRIVEN TRANSIT MICROMETER, MADE FOR COAST AND GEODETIC SURVEY TRANSIT NO. 2.

Before considering the details of this micrometer, three points were determined upon as being essential to insure accurate and decisive action, durability, and convenience in reading the chronograph record made by it.

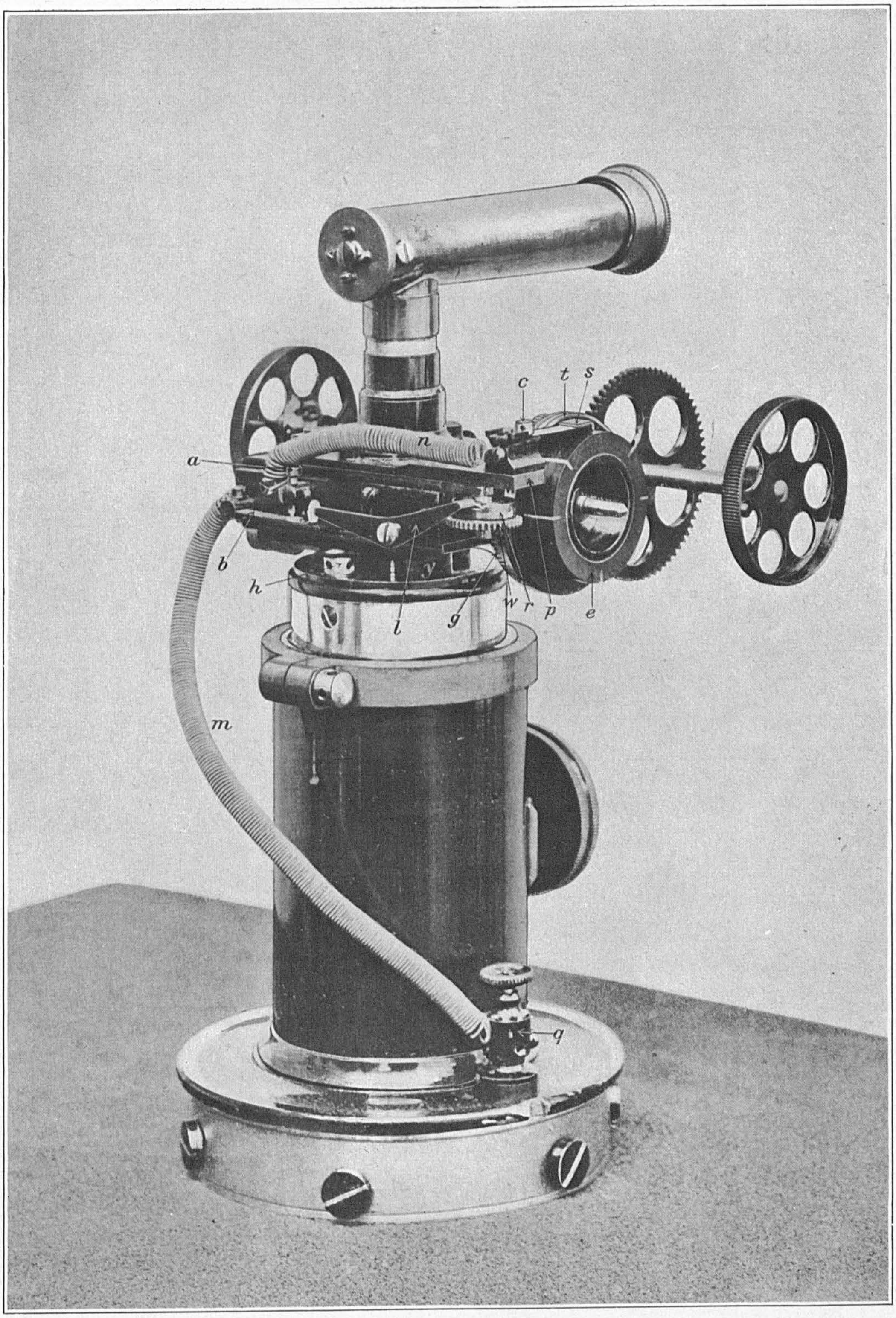
First, it was decided that the mechanism of the slide carrying the wire should be of the form in which the screw is mounted in bearings at the extreme ends of the box or case holding the slide, the micrometer head being fast upon the end of the screw projecting from the box, because this insures greater stability under the side stress of the gears connecting the screw with the hand-wheel shaft than the form usually employed in theodolite and ocular micrometers, in which the screw is fastened to the slide and therefore takes part of whatever play there may be in the latter.

Second, it was decided that the electric recording device of the micrometer should be of the make-circuit form, transmitting its records to the chronograph, which is in the break-circuit of the chronometer, through a relay. This permits the use of a strong current through the contact points of the micrometer head, and therefore a minimum of pressure upon the latter by the contact spring.

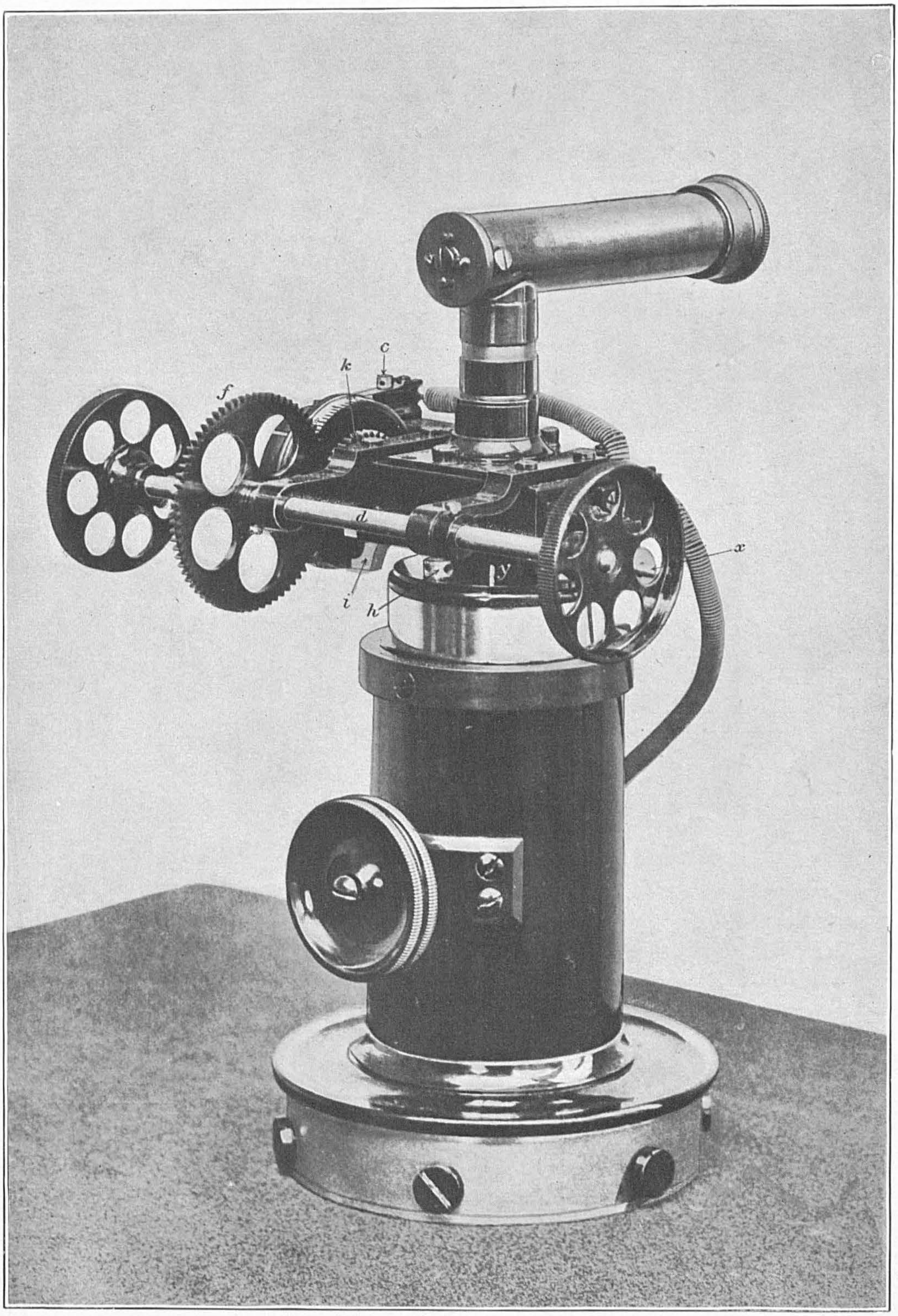
Third, in order that the micrometer transmit no records except those made within an accepted space on either side of the line of collimation and forming the observations of the star transits proper, an automatic cut-out must be provided.

Figures 1 and 2 show the micrometer with draw tube and eye end of the telescope. The telescope has a focal length of 115 centimeters and an aperture of 77 millimeters. It is of the straight type, of the same general form as that shown in illustration No. 1 of Appendix 7 of the Report for 1898.

The micrometer box or case is 46 millimeters in length and 31 millimeters wide. Within it and near to one side is mounted the micrometer screw. Upon the latter fits, by a thread and cylindrical bearing, a rectangular frame forming the slide, which is 31 millimeters long and 23 millimeters wide. All play or lost motion, both of the slide upon the screw and the screw in its bearings, is taken up by means of a helical spring within the box, which, pressing from the inner end of the box against the slide and through it against the screw, holds the latter firmly against the point of an adjustable abutting screw, without impeding its free rotary motion. Upon the slide, at right angles to its line of motion, is mounted the single spider thread, which is used for bisecting the star during its passage across the field. Two threads, parallel to the line of motion, about four time seconds apart, and mounted against the inner surface of the box, define the space within which the observations should be made. A short comb of five teeth, with distances equal to one turn of the screw between them, is also provided



TRANSIT MICROMETER. VIEW 1.



TRANSIT MICROMETER. VIEW 2.

and indicates the four whole turns of the screw within which the observations are to be made. The diameter of the field of view through the Airy diagonal eyepiece, which has an equivalent focus of 12 millimeters, is something over 24 turns of the screw; thus giving a space of fully 10 turns of the screw on each side of the four turns in the center of the field.

That portion of the micrometer screw which projects through the box has the micrometer head fitted upon it, and secured in position by a clamp nut. The edge of this head, graduated at the corner nearest the box to 100 parts (*g*, Fig. 1), also carries at its opposite corner a screw thread of three turns with a pitch of 1 millimeter and a diameter of 32 millimeters (*t*, Fig. 1). Sunk into the outer side of the head and fitted concentrically with it is a thin metallic shell, which has fitted upon it a hollow cylinder made of ebonite, 6 millimeters long and 26 millimeters diameter (*e*, Fig. 1). Five strips of platinum, $0^{\mathrm{mm}}.4$ thick, and corresponding to the 12.5, 25.0, 50.0, 75.0, and 87.5 division points[*] of the graduation, *g*, are slotted into the edge of the ebonite cylinder (see Figs. 1 and 2) and secured in such manner as to make metallic contact with the micrometer head proper, and, through it, with the screw, micrometer box, telescope and telescope pivots and the iron uprights of the transit. By releasing the clamp nut within the the ebonite ring the graduated head, with its thread, *t*, can be adjusted, in a rotary sense, in relation to the thread of the screw, and therefore also of the spider thread upon the slide. At the same time the position of the platinum contact strips can be set to correspond to the zero of the graduation, *g*, which latter is read by the index, *i*, Fig. 2.

A small ebonite plate, *p*, Fig. 1, secured to the micrometer box, carries upon its outer end, mounted in a suitable metal block, the contact spring, *s*, Fig. 1. It ends in a piece of platinum turned over so as to rest radially upon the ebonite cylinder. Its width is 4 millimeters, and its thickness that of the contact strips, i. e., $0^{\mathrm{mm}}.4$. A small screw, *c*, Figs. 1 and 2, serves to adjust the pressure of the spring upon the cylinder. Against one end of the micrometer box is fastened a small bracket, upon which is centered a small worm wheel, *w*, Fig. 1, gearing into the screw thread, *t*, of the micrometer head. It has 40 teeth, and moves one tooth for each turn of the micrometer head. The rim of a cup-shaped cylinder, *r*, Fig. 1, which is secured to this worm wheel so that it can be turned and clamped in any position relative to the zero point of the micrometer head, has cut into it a notch with sloping ends and of a length corresponding to four teeth of the worm wheel, *w*, or four turns of the micrometer screw. From the end of a lever, *l*, Fig. 1, mounted against the side of the micrometer box, projects a small steel pin reaching over the rim of the cylinder, *r*. The other end of this lever carries a small ivory tip, which rests upon the end of a spring, *b*, Fig. 1, mounted on an ebonite plate and pressing at its middle point against a platinum-tipped screw, *a*. Whenever the small steel pin of the lever, *l*, rests in the notch of the cylinder, *r*, the spring, *b*, is in contact with the screw, *a*, and allows the flow of an electric current through the coiled wires, *m* and *n*, to the contact spring, *s*. But when the micrometer has been turned two revolutions to either side of its middle or zero position, and its motion is continued, the sloped ends of the notch in the cylinder, *r*, will engage the lever, *l*, and through it force the spring, *b*, away from the screw, *a*, thus breaking the current. It will be seen,

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[*] On the instrument as originally made and tested there were 10 contact strips, corresponding to the 10, 20, 30, 40, 50, 60, 70, and 80 division points of the graduation.

therefore, that this arrangement permits of the motion of the spider thread across the entire field without transmitting records to the chronograph, except during the four revolutions symmetrically disposed about the line of collimation.

Against the inner side of the micrometer head is fastened a spur wheel, *k*, Fig. 2, with 36 teeth of 48 dimetral (inch) pitch, into which gears the wheel, *f*, with 72 teeth, mounted on the hand-wheel shaft, *d*. This shaft is supported by arms from the micrometer box, as can readily be seen from Fig. 2. The hand wheels have a diameter of 33 millimeters, are 116 millimeters apart, and equidistant from the middle of the telescope, allowing ample space for manipulating in either position of the eyepiece.

The pitch of the micrometer screw is about 48.4 threads per centimeter, or 123 per inch. In the telescope of Transit No. 2 the angular value of one revolution of the screw is 2.4 equatorial time seconds, nearly. As the gearing of the hand-wheel shaft to the micrometer screw is as 2 to 1, it follows that the hands must produce rotary motion of one revolution in $4^s.8$ for an equatorial star.*

The adjustment for collimation is made by means of two nuts upon a small screw, *x*, Fig. 2, fastened to the micrometer box, which in turn is mounted by dovetail slides upon a short flanged cylinder, *y*. The latter is fixed in position by the screws, *h*, which, when loosened, also permit of a rotary motion for adjusting the transit wire into the vertical. Neither of these adjustments will disturb the rather delicate relations between the zero of the transit wire, the contact breaks upon the micrometer head, and the worm wheel with its electric cut-out attachment.

As indicated in the description of the ebonite head, with its five platinum contact strips, the instrument itself is used as part of the electric conductor forming the relay circuit. The relay of 20 ohms resistance converts the make records into break records in the chronometer and chronograph circuit. From the binding post, *q*, Fig. 1, the current is carried by means of a rubber-covered wire along the telescope to and into the telescope axis, within the latter to an insulated metal cylinder projecting from the transit pivot. Each of the wye bearings of the transit has fastened to it an insulated contact spring, which, being connected with an insulated binding post at the foot of the instrument, establishes the circuit whether the telescope lies in an east or west position. Another binding post, screwed directly into the iron foot of the transit, affords a ready means for making the necessary connection to begin observations.

THE TEST OF THE FIRST COAST AND GEODETIC SURVEY TRANSIT MICROMETER.

The test of the transit micrometer described above was made in March, April, and May, 1904. The principal objects of the test were:

(1) To determine whether any difference of personal equation between different observers, or relative personal equation, exists in observations taken with the transit micrometer; and if so, its magnitude as compared with that ordinarily found with the key and chronograph.

(2) To determine what changes, if any, should be made in this transit micrometer to adapt it to use by Coast and Geodetic Survey field parties in telegraphic longitude observations.

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* During the first half of the tests reported in this Appendix the gears were such that the driving heads made one revolution in $2^s.4$ for an equatorial star.

(3) To determine how many nights of observation will be necessary to secure a given degree of accuracy if the transit mirometer is used.

In a test with these objects in view it was considered desirable to make the conditions no more favorable to the success of the micrometer than would be encountered in the field. The test was made for the purpose of discovering possible defects in the instrument and method rather than to show what could be done under ideal conditions.

The conditions during the test were, in the following respects, more unfavorable than would ordinarily be encountered in field work. With one exception each observer concerned in the test stopped observing before securing sufficient practice to be an expert with the apparatus; not one of the observers practiced at all with the instrument before taking part in the test; few of the observers had done any astronomic observing recently and were therefore out of practice, and some of them had never had any experience in making astronomic observations. Each time set extended over twice the interval it would take in regular work, and hence the errors due to changes in the instrument, pier, and rate of the chronometer should be greater than in the regular work. The weather conditions were no better than the average in the field, the nights on which there was no interruption by clouds being exceptional.

The observations were all made at the observatory on the grounds of the Coast and Geodetic Survey Office. They were made on 18 nights, commencing on March 15 and ending on May 3. The total number of time sets observed was 75, some of them being incomplete sets. A complete set consisted of 10 to 12 stars and included one reversal of the horizontal axis of the instrument at about the middle of the set.

The 16 observers who took part in the work are indicated below in five classes. They will be referred to hereafter in this report by initials only.

Class 1. Observers having experience in astronomic observations and sufficient practice within a year in handling some instrument of precision to be in good training: E. G. Fischer, Chief of Instrument Division, O. B. French and C. H. Sinclair, Assistants.

Class 2. Observers having no experience in astronomic observations, but having sufficient practice in handling some instrument of precision within a year to be in good training: W. H. Burger and O. W. Ferguson, Assistants, and F. H. Sewall, Aid.

Class 3. Observers having experience in astronomic observations, but not having had sufficient practice with any instrument of precision within a year to be in good training: F. D. Granger and William Eimbeck, Assistants, C. E. Morford, Aid, and A. L. Baldwin, Computer.

Class 4. Observers with little experience at any time in handling instruments of precision of such a nature as to be in training for this class of observations: C. R. Duvall, R. M. Packard, Lelia J. Harvie, Sarah Beall, and Lilian Pike, Computers.

Class 5. An observer with experience in astronomic observations, but with little practice in observing with any instrument of precision within a year. This observer, J. F. Hayford, had the advantage over all others in that he did about half of all the observing with the transit micrometer from March 15 to May 3, and had, therefore, an opportunity which the others did not have to become thoroughly familiar with and expert in the use of the transit micrometer.

The stars observed were all selected from the Berliner Jahrbuch. In the finder list prepared at the beginning of the test the stars were designated by consecutive numbers.

On each night the observations were commenced as early as possible. Two observers, J. F. H. and one other, took alternate stars in the list, J. F. H. taking the odd numbers on about half of the nights and on the remaining nights the even numbers. The observers were forced to depart from the rule of observing alternate stars on some occasions on account of missed stars, or for the purpose of balancing the azimuth factors in a half set. When each observer had secured observations on five or six stars, the horizontal axis was reversed and another half set taken and thus a complete time set secured for each observer. The stride level was read four times during the double set of stars. Each observer thus secured a time set of ten to twelve stars, from which the the errors of azimuth, collimation, and level could be eliminated with considerable accuracy by computation. The mean epochs of the two time sets were nearly the same and they were affected in nearly the same manner by any irregularity in the running of the chronometer. The difference between the two derived chronometer errors from such a pair of time sets was evidently due almost entirely to errors of observation and to relative personal equation.

Each of such a pair of complete time sets was computed independently of the other, except that the stride level readings were common to the two. In a few cases in which incomplete sets were secured, the collimation constant (and sometimes, also, the azimuth constant) was adopted from some complete set.

The computations were made by a modified form of the field method of reduction stated in Appendix 9 of the Report for 1896.

PRINCIPAL DIRECT RESULTS OF OBSERVATION.

In the following tables, *c* is the error of collimation of the telescope as derived from the observations and expressed in equatorial seconds of time. The quantities a_w and a_e are the azimuth errors of the instrument with band west and east, respectively, expressed in seconds of time. The time sets are grouped in pairs in the table to indicate which ones were taken simultaneously.

TABLE 1.

Date	Observers	Number of stars	Chronometer error	c	a_w	a_e
1904			s.			
Mar. 15	E. G. F.	11	+0.957	+0.016	+0.288	+0.483
	J. F. H.	5	+1.053	*		+0.034
Mar. 15	†E. G. F.	11	+0.957	+0.016	+0.288	+0.483
	O. B. F.	10	+1.070	*	+0.046	
Mar. 16	E. G. F.	10	+1.192	+0.075	+0.286	−0.060
	J. F. H.	12	+1.233	+0.093	+0.223	−0.008
Mar. 16	E. G. F.	10	+1.356	+0.118	+0.041	--0.040
	J. F. H.	11	+1.341	+0.113	+0.022	+0.232
Mar. 16	O. B. F.	12	+1.445	+0.070	+0.158	+0.003
	J. F. H.	11	+1.532	+0.097	+0.084	−0.104

* *c* adopted from simultaneous set by E. G. F. No reversal of telescope.

† This line of table repeated from above.

TABLE 1—Continued.

Date.	Observers	Number of stars	Chronometer error	c	a_w	a_e
1904			s.			
Mar. 18	E. G. F.	11	+1.427	+0.144	+0.088	+0.191
	J. F. H.	10	+1.430	+0.168	+0.049	−0.024
Mar. 18	E. G. F.	11	+1.338	+0.187	+0.035	+0.137
	J. F. H.	10	+1.360	+0.159	+0.142	+0.193
Mar. 18	O. B. F.	2	+1.355	*		
	J. F. H.	2	+1.310	*		
Mar. 19	W. H. B.	8	+1.160	+0.235	† −0.309	
	J. F. H.	9	+1.167	+0.223	† +0.197	
Mar. 22	O. W. F.	11	+0.409	+0.219	+0.424	+0.311
	J. F. H.	12	+0.485	+0.218	+0.370	+0.303
Mar. 22	W. H. B.	10	+0.491	+0.210	+0.202	+0.317
	J. F. H.	9	+0.509	+0.224	−0.042	+0.338
Mar. 23	O. W. F.	10	+0.729	+0.288	+0.293	−0.386
	J. F. H.	12	+0.751	+0.239	+0.197	+0.063
Mar. 25	C. R. D.	11	−0.419	+0.250	+0.171	+0.117
	J. F. H.	12	−0.392	+0.285	+0.159	+0.227
Mar. 25	F. H. S.	13	−0.487	+0.258	+0.368	+0.000
	J. F. H.	13	−0.486	+0.275	+0.111	+0.112
Mar. 29	C. E. M.	11	−2.384	+0.192	−0.230	+0.320
	J. F. H.	11	−2.342	+0.282	+0.120	+0.368
Mar. 29	C. E. M.	11	−2.281	+0.316	+0.367	+0.136
	J. F. H.	11	−2.366	+0.315	+0.062	+0.411
The speed of the driving heads was reduced from 2.4 seconds to 4.8 seconds per turn for equatorial stars between March 29 and April 1						
Apr. 1	C. H. S.	11	−3.453	+0.353	+0.129	+0.393
	J. F. H.	11	−3.357	+0.307	+0.131	+0.145
Apr. 1	C. H. S.	11	−3.449	+0.410	−0.011	+0.053
	J. F. H.	11	−3.411	+0.490	+0.216	+0.058
Apr. 2	A. L. B.	11	−3.737	+0.418	+0.200	+0.125
	J. F. H.	10	−3.748	+0.388	+0.198	+0.137
Apr. 2	A. L. B.	12	−3.742	+0.473	+0.073	+0.012
	J. F. H.	12	−3.702	+0.472	+0.074	+0.098
Apr. 5	C. H. S.	11	−4.451	+0.459	+0.207	+0.081
	J. F. H.	11	−4.435	+0.511	+0.176	+0.224
Apr. 5	C. H. S.	11	−4.443	+0.478	−0.036	−0.074
	J. F. H.	11	−4.391	+0.426	+0.021	+0.008
Apr. 5	C. H. S.	11	−4.516	+0.500	+0.000	−0.006
	J. F. H.	11	−4.485	+0.480	+0.129	+0.127

* c assumed +0.173 and a_w assumed +0.088, being the mean of values from preceding sets by E. G. F. and J. F. H. No reversal of telescope.

† No distinction made between a_w and a_e. Incomplete sets.

TABLE I—Continued.

Date	Observers	Number of stars	Chronometer error	c	a_w	a_e
1904			s			
Apr. 7	C. H. S.	10	−4.790	+0.450	−0.022	+0.179
	J. F. H.	11	−4.887	+0.426	+0.144	+0.265
Apr. 7	C. H. S.	10	−4.854	+0.399	+0.071	+0.185
	J. F. H.	10	−4.900	+0.375	+0.193	+0.008
Apr. 9	W. H. B.	10	−3.902	+0.409	+0.298	+0.007
	J. F. H.	10	−4.009	+0.472	+0.344	+0.435
Apr. 9	R. M. P.	10	−3.839	+0.338	+0.374	−0.302
	J. F. H.	10	−4.000	+0.418	+0.299	+0.237
Apr. 11	F. D. G.	11	−3.628	+0.371	+0.532	+0.160
	J. F. H.	12	−3.510	+0.467	+0.267	+0.171
Apr. 11	W. E.	12	−3.491	+0.468	+0.278	+0.420
	J. F. H.	11	−3.525	+0.470	+0.321	+0.300
Apr. 12	E. G. F.	12	−3.496	+0.410	+0.227	+0.060
	J. F. H.	11	−3.463	+0.394	+0.191	+0.125
Apr. 12	E. G. F.	11	−3.515	+0.432	+0.165	+0.146
	J. F. H.	12	−3.471	+0.488	+0.068	+0.122
Apr. 13	W. E.	12	−3.563	+0.497	+0.265	+0.336
	J. F. H.	11	−3.602	+0.456	+0.160	+0.195
Apr. 13	F. D. G.	6	−3.399	*	+0.316	
	J. F. H.	6	−3.553	*	+0.110	
Apr. 15	L. J. H.	5	−4.500	†	+1.960	
	J. F. H.	10	−3.894	+0.502	−0.022	+0.099
Apr. 15	S. B.	4	−3.741	‡		+0.405
	§J. F. H.	10	−3.894	+0.502	−0.022	+0.099
Apr. 15	L. P.	5	−3.808	‖	+0.227	
	J. F. H.	10	−3.983	+0.441	+0.349	+0.238
Apr. 15	L. J. H.	3	−3.392	‖		+0.119
	**J. F. H.	10	−3.983	+0.441	+0.349	+0.238
May 3	W. H. B.	11	−1.474	+0.468	+0.154	+0.125
	J. F. H.	11	−1.540	+0.506	+0.229	+0.340
May 3	L. P.	10	−1.564	+0.496	+0.081	+0.166
	J. F. H.	11	−1.546	+0.484	+0.062	+0.225

*c assumed +0.456 as derived from preceding set by J. F. H. No distinction made between a_w and a_e.

† c assumed +0.502 as derived in the following set by J. F. H. No reversal of telescope.

‡ c assumed +0.502 as in simultaneous set by J. F. H. No reversal of telescope.

§ Values repeated from second line above.

‖ c assumed +0.441 as derived from simultaneous set by J. F. H. No reversal of telescope.

** Values repeated from two lines above.

RELATIVE PERSONAL EQUATION.

The relative personal equation of two observers as derived from each pair of simultaneous time sets by taking the difference of the two computed chronometer errors is shown below. A plus sign indicates that the observer first named observes later (slower) than the other.

The probable errors of the personal equations as given in the fourth column of the table were derived from the residuals from the separate stars in the two time sets concerned. The weights as given in the last column are made inversely proportional to the squares of the probable errors given in the preceding column.

TABLE II.

Observers	Date	Relative personal equation	Probable error	Weight
		s.	*s.*	
E. G. F.—J. F. H.	Mar. 15	−0.096	±0.029	1.9
E. G. F.—J. F. H.	Mar. 16	−0.041	0.047	0.7
E. G. F.—J. F. H.	Mar. 16	+0.015	0.043	0.9
E. G. F.—J. F. H.	Mar. 18	−0.003	0.053	0.6
E. G. F.—J. F. H.	Mar. 18	−0.022	0.037	1.2
E. G. F.—O. B. F.	Mar. 15	−0.113	0.035	1.3
O. B. F.—J. F. H.	Mar. 16	−0.087	0.042	0.9
O. B. F.—J. F. H.	Mar. 18	+0.045	0.066	0.4
W. H. B.—J. F. H.	Mar. 19	−0.007	0.092	0.2
W. H. B.—J. F. H.	Mar. 22	−0.018	0.034	1.4
O. W. F.—J. F. H.	Mar. 22	−9.076	0.026	2.3
O. W. F.—J. F. H.	Mar. 23	−0.022	0.037	1.2
C. R. D.—J. F. H.	Mar. 25	−0.027	0.031	1.7
F. H. S.—J. F. H.	Mar. 25	−0.001	0.036	1.2
C. E. M.—J. F. H.	Mar. 29	−0.042	0.048	0.7
C. E. M.—J. F. H.	Mar. 29	+0.085	±0.042	0.9
The speed of the driving heads was reduced from 2.4 seconds to 4.8 seconds per turn for equatorial stars between Mar. 29 and Apr. 1				
C. H. S. —J. F. H.	Apr. 1	−0.096	±0.044	0.8
C. H. S. —J. F. H.	Apr. 1	−0.038	0.026	2.3
C. H. S. —J. F. H.	Apr. 5	−0.016	0.034	1.4
C. H. S. —J. F. H.	Apr. 5	−0.052	0.042	0.9
C. H. S. —J. F. H.	Apr. 5	−0.031	0.033	1.5
C. H. S. —J. F. H.	Apr. 7	+0.097	0.051	0.6
C. H. S. —J. F. H.	Apr. 7	+0.046	0.046	0.8
A. L. B. —J. F. H.	Apr. 2	+0.011	0.040	1.0
A. L. B. —J. F. H.	Apr. 2	−0.040	0.017	5.5
W. H. B.—J. F. H.	Apr. 9	+0.107	0.046	0.8
W. H. B.—J. F. H.	May 3	+0.066	0.031	1.6
R. M. P.—J. F. H.	Apr. 9	+0.161	0.068	0.3
W. E. —J. F. H.	Apr. 11	+0.034	0.049	0.7
W. E. —J. F. H.	Apr. 13	+0.039	±0.032	1.6

TABLE II—Continued.

Observers	Date	Relative personal equation	Probable error	Weight
		s.	*s.*	
F. D. G.—J. F. H.	Apr. 11	−0.118	±0.036	1.2
F. D. G.—J. F. H.	Apr. 13	+0.154	0.074	0.3
E. G. F.—J. F. H.	Apr. 12	−0.036	0.039	1.1
E. G. F.—J. F. H.	Apr. 12	−0.044	0.036	1.2
L. J. H.—J. F. H.	Apr. 15	−0.506	0.200	0.04
L. J. H.—J. F. H.	Apr. 15	+0.591	0.172	0.05
S. B. —J. F. H.	Apr. 15	+0.153	0.196	0.04
L. P. —J. F. H.	Apr. 15	+0.175	0.022	3.3
L. P. —J. F. H.	May 3	−0.018	±0.030	1.8

There are 39 determinations in all of the relative personal equation.

In 22 cases out of 39 the derived value of the relative personal equation from a pair of time sets is less than $0^s.05$ and there are but 9 cases in which it is greater than $0^s.10$.

It is evident that the derived values of the relative personal equation are so small that it is necessary to examine the evidence carefully to determine whether they are real values or simply the result of accidental errors of observation. If they are the latter, that is, merely residuals, it should be expected from the theory of errors that in about 19 cases out of 39 the derived value of the relative personal equation should be less than its computed probable error. The table shows 18 such cases. Similarly in not more than one case out of 39 should the derived value be greater than 3½ times its computed probable error, if the values are residuals only. The table shows but one such case. Apparently, therefore, the relative personal equation of each pair of observers was so small as to be almost, if not entirely, concealed by the accidental errors.

The different values of the relative personal equation for each pair of observers being combined according to the relative weights shown in Table II, the values in Table III are found. The probable errors here given correspond to these weights and therefore depend upon the residuals of the separate stars in the time sets.

TABLE III.

Observers	Number of determinations	Relative personal equation	Probable error
		s.	s.
E. G. F. —J. F. H.	7	—0. 041	±0. 015
E. G. F. —O. B. F.	1	—0. 113	0. 035
O. B. F. —J. F. H.	2	—0. 046	0. 035
W. H. B. —J. F. H.	4	+0. 041	0. 020
O. W. F. —J. F. H.	2	—0. 058	0. 021
C. R. D. —J. F. H.	1	—0. 027	0. 031
F. H. S. —J. F. H.	1	—0. 001	0. 036
C. E. M. —J. F. H.	2	+0. 029	0. 032
C. H. S. —J. F. H.	7	—0. 022	0. 014
A. L. B. —J. F. H.	2	—0. 032	0. 016
R. M. P. —J. F. H.	1	+0. 161	0. 068
W. E. —J. F. H.	2	+0. 037	0. 026
F. D. G. —J. F. H.	2	—0. 064	0. 032
L. J. H. —J. F. H.	2	+0. 103	0. 133
S. B. —J. F. H.	1	—0. 153	0. 196
L. P. —J. F. H.	2	+0. 107	±0. 018

It may seem that in combining different determinations of the relative personal equation for a given pair of observers the weights should be made equal, upon the supposition that the variation in relative personal equation from set to set of time observations is greaterthan the uneliminated effects of accidental errors in each set. Accordingly, Table IV has been made upon this basis. The probable errors as given in this table are computed from the residuals of the different determinations from the mean for that pair of observers, with the exception of the values, given in parentheses, corresponding to single determinations, which are merely repeated from Table III.

TABLE IV.

Observers	Number of determinations	Relative personal equation	Probable error
		s.	s.
E. G. F. —J. F. H.	7	—0. 032	±0. 009
E. G. F. —O. B. F.	1	—0. 113	(0. 035)
O. B. F. —J. H. F.	2	—0. 021	0. 045
W. H. B.—J. F. H.	4	+0. 037	0. 020
O. W. F.—J. F. H.	2	—0. 049	0. 018
C. R. D. —J. F. H.	1	—0. 027	(0. 031)
F. H. S. —J. F. H.	1	—0. 001	(0. 036)
C. E. M. —J. F. H.	2	+0. 021	0. 043
C. H. S. —J. F. H.	7	—0. 013	0. 016
A. L. B. —J. F. H.	2	—0. 014	0. 017
R. M. P.—J. F. H.	1	+0. 161	(0. 068)
W. E. —J. F. H.	2	+0. 036	0. 002
F. D. G. —J. F. H,	2	+0. 018	0. 092
L. J. H. —J. F. H.	2	+0. 042	0. 370
S. B. —J. F. H.	1	+0. 153	(0. 196)
L. P. —J. F. H.	2	+0. 080	±0. 065

The same tests as were applied to Table II may be applied to Tables III and IV to determine whether the values in the third column represent relative personal equations, or are merely residuals resulting from accidental errors. In Table III there are 5, and in Table IV, 9, out of 16 cases in which the value in the third column is less than its computed probable error. This corresponds fairly well with the number, 8 in each case, which should be expected if these values were entirely due to accidental errors. There is but one case in Table III and two in Table IV in which the value in the third column exceeds 3½ times its probable error, as shown in the fourth column. This is a slight indication that the values in the third column are relative personal equations rather than residuals.

It is a curious fact, for which no explanation is apparent, that there is no value in the third column of Table IV which is larger than the corresponding value in Table III.

The relative personal equation of J. F. H., as compared with the mean of the 15 other observers involved in the test, has been computed in three different ways: First, by taking the weighted mean of the 15 values involving J. F. H. in Table III, with weights depending upon the probable errors there shown; second, by taking the weighted mean of the values in Table IV, with weights proportional to the number of determinations as shown in column 2; third, by taking the indiscriminate mean of the values in Table IV. The three values thus obtained are respectively:

Mean observer—J. F. H. $= -0^s.004 \pm 0^s.006$
" " —J. F. H. $= + .009 \pm .009$
" " —J. F. H. $= + .026 \pm .011$

It is therefore uncertain whether there is a relative personal equation between the mean observer and J. F. H.

The conclusion from Tables II, III, and IV must be that the relative personal equation between two observers with a transit micrometer is so small as to be masked by the accidental errors of observation, and that it is probably less in every case than $0^s.050$.

Two interesting contrasts may be shown between the values of the relative personal equation here derived from observations with the transit micrometer and those which have resulted from longitude observations with a key and chronograph.

On pages 212–245 of Appendix 2 of the Coast and Geodetic Survey Report for 1897, "Telegraphic Longitude Net of the United States," there are shown 59 values of the relative personal equation derived from observations in the field, excluding European connections and certain cases in which the relative personal equation was determined in some unusual way. These 59 values involved 10 different observers. Each value is, in general, derived from ten nights of observation, and a total of twenty time sets by each observer, and is subject to a probable error of only from $\pm 0^s.003$ to $\pm 0^s.020$. There are but 16 out of these 59 values less than $0^s.050$; whereas, Table III shows 9 out of 16 values smaller than this limit.* Similarly there are 41 out of these 59 values greater than $0^s.100$; whereas Table III shows but 4 values out of 16 greater than this limit. Moreover, of these four values, three involved observers having no previous experience in this class of observations, and not one of the four is based on as much as two complete time sets by each observer.

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* The contrast is still greater if Table IV is used.

In June, 1896, the relative personal equation C. H. S.—J. F. H. was determined at Washington with a key, using the half-transit method on two nights and on the remaining night by simultaneous time sets with two instruments. It was found to be

$$\text{C. H. S.—J. F. H.} = + 0^{s}.238 \quad \pm 0^{s}.007.$$

In this test with the transit micrometer the relative personal equation of the same observers (see Table III) is found to be

$$\text{C. H. S.—J. F. H.} = - 0^{s}.022 \quad \pm 0^{s}.014.$$

ACCURACY AS SHOWN BY THE RESIDUALS IN EACH TIME SET.

To secure a standard with which to compare the transit micrometer observations, 19 primary longitudes observed by Coast and Geodetic Survey parties in the interval 1895–1899 were examined. Nine observers, nearly all having long experience in this class of work, were concerned in these 19 determinations. They represent, therefore, average work with the key by expert observers.

The probable error of a single observation of an equatorial star (weight unity)* was computed in each of these longitude determinations from the residuals of each star from the mean for the time set. Its minimum value for any group of ten nights was $\pm 0^{s}.022$, its maximum value $\pm 0^{s}.072$, and its mean value $\pm 0^{s}.036$. If these values be reduced in accordance with the scale of weights to correspond to the average probable error of a single observation of a star, for stars of such declinations as were used in the test of the transit micrometer, thus making a direct comparison possible with the values given below in Table V, they become $\pm 0^{s}.025$ for the minimum, $\pm 0^{s}.082$ for the maximum, and $\pm 0^{s}.041$ for the mean.

In the transit micrometer test all stars were given equal weight regardless of their declination. The average value of the probable error of a single observation of a star for each observer with the transit micrometer, is given below in Table V for comparison with the average $\pm 0^{s}.041$, shown above for key observations.

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* For the scale of weights used, see p. 291 of Appendix 7 of the C. & G. S. Report for 1898, "Determination of Time, Longitude, Latitude, and Azimuth."

TABLE V.—*Average values of ε_1=probable error of a single observation of a star.*

With rapid speed of driving heads			With slow speed of driving heads		
Observer	Number of time sets	Average ϵ_1	Observer	Number of time sets	Average ϵ_1
		s.			s.
J. F. H.	15	±0.066	J. F. H.	21	±0.063
E. G. F.	5	0.078	C. H. S.	7	0.083
O. B. F.	3	0.075	A. L. B.	2	0.064
W. H. B.	2	0.138	W. H. B.	2	0.082
O. W. F.	2	0.069	R. M. P.	1	0.162
C. R. D.	1	0.057	W. E.	2	0.089
F. H. S.	1	0.065	F. D. G.	2	0.108
C. E. M.	2	±0.104	E. G. F.	2	0.070
			L. J. H.	1	0.306
			S. B.	1	0.321
			L. P.	2	±0.046
Average for all except J. F. H., $=\pm 0^{s}.085$			Average for all except J. F. H., $=0^{s}.113$. Average for all except J. F. H., after rejecting L. J. H. and S. B., $=0^{s}.083$		

For the one observer, J. F. H., who had sufficient continuous practice with the transit micrometer to become somewhat expert with it, the probable error of a single observation is about 50 per cent greater than for experts with the key. For the remaining observers, without any previous practice with the transit micrometer, and, as a rule, observing not more than two sets, it is about 100 per cent greater than for experts with the key. These comparisons refer to accidental errors only.

Table V indicates that the change in the speed of the driving heads had almost no effect on the accuracy of the observations.

With a key and with portable transits of the size used in the primary longitude determinations in the Coast and Geodetic Survey, the slow moving stars of large declination are observed with much less accuracy than the equatorial stars. (See weight table, p. 291, Report for 1898, already referred to.) The errors for stars of declination 60° are supposed to be about 41 per cent larger, and for stars of declination 70° about 85 per cent larger than for equatorial stars. To determine whether such a relation holds for the transit micrometer Table VI was compiled, using all the observations made during the test. The computations were made in such a way that the residuals represent the relative accuracy correctly, with the exception of a few stars of very large declination, all stars having been given equal weight and, in general, all having been used as time stars.

TABLE VI.

Declination for group	Mean value of $\sec\delta$ (=collimation factor)	Mean residuals, without regard to sign			
		J. F. H. with rapid speed of driving heads	J. F. H. with slow speed of driving heads	Other observers with rapid speed of driving heads	Other observers with slow speed of driving heads
° °		s	s	s	s
2 to —22	1.0	0.03	0.04	0.09	0.07
3 to 16	1.0	0.03	0.04	0.08	0.08
17 to 29	1.1	0.04	0.04	0.08	0.09
30 to 38	1.2	0.05	0.06	0.07	0.08
39 to 46	1.3	0.07	0.07	0.09	0.11
47 to 52	1.5	0.10	0.07	0.08	0.10
53 to 57	1.7	*0.17	0.08	0.12	0.06
58 to 64	2.1	0.08	0.09	0.11	0.09
65 or more	3.4	0.11	0.08	0.12	0.08

Table VI indicates that the residuals of J. F. H. with the transit micrometer for slow-moving stars are much larger in proportion to those for equatorial stars than for key observations. Thus, for stars of declination about 60° the residuals are fully double those for equatorial stars, whereas for key observations they would be but 50 per cent greater. On the other hand, for all other observers than J. F. H. with the transit micrometer, the accuracy is much more nearly the same for stars of different declinations than for key observations.

Each observer who was just beginning to use the transit micrometer usually showed by his remarks, and by the character of the record on the chronograph sheet, that he had some difficulty in keeping up a steady motion of the driving heads when observing an equatorial star, even after the change to the slower speed of the driving heads had been made. On the other hand, little difficulty of this kind was encountered after one became expert in the manipulation of the driving heads. This is the apparent explanation of the relatively large errors for equatorial stars of the other observers as compared with J. F. H.

For J. F. H. and with the slower speed of the driving heads the relative magnitudes of the residuals for different declinations correspond closely to a constant angular error, as shown in Table VII.

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* There was but one residual in this group; hence this value is uncertain.

TABLE VII.

Declination for group	Mean value of sec δ=collimation factor	Mean residual without regard to sign, for J. F. H. with slow speed of driving head (See Table VI)	The same expressed as an angular error
° °		s	″
2 to —22	1.0	0.04	0.6
3 to 16	1.0	0.04	0.6
17 to 29	1.1	0.04	0.5
30 to 38	1.2	0.06	0.8
39 to 46	1.3	0.07	0.8
47 to 52	1.5	0.07	0.7
53 to 57	1.7	0.08	0.7
58 to 64	2.1	0.09	0.6
65 or more	3.4	*0.08	*0.4

The fourth column was computed from the third by multiplying each value by the quantity $\frac{15}{\sec \delta}$, in which sec δ was taken from the second column.

The residuals were also carefully examined to see whether there was any tendency for stars near to and on opposite sides of the zenith to have opposite signs upon the average for a given observer. No such tendency could be found. Such a tendency would be produced by the habit on the part of an observer of placing the line slightly to the right or to the left of the star image as seen by him.

ACCURACY OF BISECTION OF STAR WITH MOVING LINE.

In making the computation of the time of transit of each star, the first step was to add together the times of the first and thirty-sixth, second and thirty-fifth, third and thirty-third, etc., records made on the chronograph sheets for that star. As each of these pairs of lines are symmetrically placed with reference to the mean of all, the eighteen sums will differ from each other by amounts depending upon the accidental errors in keeping the star bisected. The theoretically best method of measuring these accidental errors is to compute the probable error of a single such sum by taking out the residuals of each of the eighteen sums from the mean, squaring them, etc. This would involve more computation than is necessary for the present purpose. Accordingly the following much simpler method of reaching the same result was used:

On each star the number of sums of pairs that agreed within $0^s.1$ with the mean was counted. Call this number N. The separate records on the chronograph sheet were read to the nearest one-tenth of a second. The mean of the eighteen sums, or mean time of transit for each star, was taken to the nearest one-hundredth of a second. If this mean were $18^s.17$, $N=13$ would mean that 13 out of the 18 sums were either 18.1 or 18.2. Evidently the greater the value of N the greater the accuracy.

Table VIII serves to indicate the relative accuracy of bisections by different observers and for the two speeds of the driving heads. Table IX serves to make the comparison for the two speeds used and also for different declinations.

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* The method of computation was such as to tend to make this computed mean residual too small.

TABLE VIII.

With rapid speed of driving heads			With slow speed of driving heads		
Observer	Number stars	Mean value of *N*	Observer	Number stars	Mean value of *N*
J. F. H.	150	11.2	J. F. H.	223	11.7
E. G. F.	53	10.6	C. H. S.	75	8.8
O. B. F.	24	9.0	A. L. B.	23	9.1
W. H. B.	18	7.2	W. H. B.	21	6.9
O. W. F.	21	10.0	R. M. P.	10	7.2
C. R. D.	11	8.2	W. E.	24	7.4
F. H. S.	13	7.8	F. D. G.	17	9.0
C. E. M.	22	8.3	E. G. F.	23	10.5
			L. J. H.	8	5.5
Mean for all except J. F. H.		9.2	S. B.	4	5.0
Mean for all, including J. F. H.		10.2	L. P.	15	6.3
			Mean for all except J. F. H.		8.1
			Mean for all except J. F. H. and after rejecting L. J. H. and S. B.		8.3
			Mean for all, including J. F. H.		9.9

For the observer with much practice, J. F. H., the accuracy is slightly greater with the slow speed for the driving heads, but for the remaining observers the reverse is true. The means for all, including J. F. H., indicate that the change of speed had practically no effect on the accuracy.

The table shows clearly the advantage of practice with the instrument.

TABLE IX.

Declination for group	Mean collimation factor (sec δ) for group	Mean values of *N*			
		J. F. H. with rapid speed of driving heads	J. F. H. with slow speed of driving heads	Other observers with rapid speed of driving heads	Other observers with slow speed of driving heads
° °					
2 to —22	1.0	12.9	13.4	10.3	8.5
3 to 16	1.0	13.1	13.0	8.5	9.9
17 to 29	1.1	11.7	12.8	10.6	9.2
30 to 38	1.2	12.3	12.2	9.2	8.7
39 to 46	1.3	10.2	11.6	9.7	8.3
47 to 52	1.5	10.6	12.0	8.2	6.7
53 to 57	1.7	9.0	8.1	10.0	6.6
58 to 64	2.1	9.3	10.9	8.2	7.7
65 or more	3.4	6.4	6.7	5.7	5.4

Table IX indicates that for J. F. H. the slight apparent gain in accuracy when the speed of the driving heads was decreased was not confined to equatorial stars. The gain is so slight, however, that it may be due simply to the effect of practice. Similarly, the apparent loss in accuracy for other observers is not confined either to slow-moving stars or to equatorial stars. It may be due simply to a difference in observers.

The mean values for *N* may be converted into probable errors by the use of the table on page 435 of Wright's Adjustment of Observations. The fourth column of Table IX has been so converted and is shown in Table X below. There is placed beside it in the fourth column of Table X the probable error reduced to angular measure by multiplying it by the factor $\frac{15}{\sec \delta}$. The fourth column indicates that for all stars of declination less than 58° the bisections were about equally accurate, expressed in angular measure, but that for the extremely slow stars of greater declination included in the last two groups the bisections are considerably more accurate. By inspection of Table IX, it may be seen that this statement also holds good for J. F. H. with the rapid speed of the driving heads.

TABLE X.

For J. F. H. with slow speed of driving heads			
Declination for group	Mean collimation factor for group	Probable error of the sum of two records	The same expressed as an angular error
° °		s	″
2 to —22	1.0	±.06	±0.9
3 to 16	1.0	.06	0.9
17 to 29	1.1	.06	0.8
30 to 38	1.2	.07	0.9
39 to 46	1.3	.07	0.8
47 to 52	1.5	.07	0.7
53 to 57	1.7	.11	1.0
58 to 64	2.1	.08	0.6
65 or more	3.4	±.14	±0.6

The mean value of *N* for J. F. H. with the slow speed of the driving heads is 11.7. This corresponds to the probable error of $\pm 0^s.071$ for the sum of two records. For comparison with key observations the computation was made in precisely the same manner for the forty time sets involved in the determination of the difference of longitude of Charleston and Key West in 1896 by Assistants Sinclair and Putnam, two observers of long experience. The probable error of the sum of two records was for that work found to be $\pm 0^s.077$. This is in substantial agreement with the value shown above, $\pm 0^s.071$ for the transit micrometer.

MOST FAVORABLE SPEED OF DRIVING HEADS.

If the speed of the driving heads is made very great, the observer will have difficulty in making the moving line keep up with the moving star image, and this difficulty will be greater for the fast-moving equatorial stars than for others. The errors of bisection expressed in angular measure should be considerably greater for equatorial stars than for slow-moving stars under these conditions.

If the speed of the driving heads is made very small, there will be no difficulty in keeping up with any star. A given error in the position of the driving heads at any instant will produce, however, a much larger displacement of the movable line in the field of view than when the driving heads are geared to move much more rapidly. The consequent difficulty in placing the movable line in a desired position will tend to produce errors of bisection of about the same magnitude expressed in angular measure for all declinations,* and the size of the errors will tend to increase as the speed of the driving heads is made slower.

In selecting the speed of the driving heads to be used the problem is, then, to avoid difficulty in keeping up with equatorial stars on the one hand and to avoid losing accurate control of the moving line for stars of any declination on the other hand.

Tables V, VI, and VIII indicate clearly that the change from the relatively rapid speed of 2.4 seconds per revolution to the much slower speed of 4.8 seconds per revolution has produced a change in the average accuracy which is almost too small to be appreciable. This indicates that the slower speed is not too slow.

It is somewhat surprising that so large a change in speed of the driving heads has so little effect on the accuracy.

Table VII indicates that the errors expressed in angular measure are no larger for the fast than for the slow stars with the slower of the two speeds for the driving heads, and that therefore this speed of the driving heads is not too fast. Table X confirms this conclusion if the last two groups be ignored. If these be considered, Table X furnishes a slight indication that the speed of the driving heads should be still further decreased.

The proper conclusion from this test, taken as a whole, seems to be that the speed of the driving heads most favorable to accuracy is slightly slower than one revolution in 4.8 seconds for equatorial stars, and that a considerable departure on either side from this speed would have very little effect on the accuracy.

Number of Records Needed for Each Star.

If one secures a large number of records on the chronograph for a star, the process of taking the mean eliminates to a considerable extent the effect of the accidental errors in the separate records, but has no effect on the errors which are common to all the records. The decision as to the number of records necessary per star depends, therefore, primarily on the relative magnitude of these two classes of errors.

The probable error of the sum of two records for J. F. H. for the slower speed is $\pm 0^{s}.071$. (See p. 474.) The probable error of the mean of the thirty-six records for any star as computed from this is $\pm 0^{s}.008$. The probable error of this mean as computed from the residuals of each star from the mean of the set, and thus including angular errors which are common to all the records for the given star, is $\pm 0^{s}.063$. Evidently the number of records may be reduced far below thirty-six with but little decrease in the accuracy of the work. If twenty records are used the probable error of the mean as computed by the first of the above methods will be $\pm 0^{s}.011$, and if ten are used, $\pm 0^{s}.016$. This indicates that ten lines only might be used with little decrease in average accuracy. Under very unfavorable conditions, with faint or blurred star images, or very irregular refraction, with ten lines, the uneliminated errors of bisection might contribute the major portion of the errors in the mean, although under average conditions they would not. The writer believes that for this reason, and for others which can not be briefly explained, it is best to use twenty records per star.

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*The effect of variable refraction and of instability of instrument will also tend to produce errors of the same angular magnitude regardless of the declination.

INFLUENCE OF ERRORS OF RIGHT ASCENSION ON THE RESULTS OF THE TEST.

The right ascensions of the stars used in the test were all taken from the Berliner Jahrbuch, and are therefore all well determined. The total number of different stars used was large, about one hundred.

Moreover, the effect of the errors of right ascension upon the computed relative personal equation was eliminated, in part at least, by the practice of having the observer, J. F. H., who observed every night, take, as a rule, stars of even numbers on the list on about half of the nights and stars of odd numbers on the remaining nights. The effect of errors of right ascension upon the results is therefore almost entirely eliminated from the mean values of the relative personal equation for those pairs of observers who observed on several nights. In general, the errors of right ascension have increased the range of the results, but have had little effect upon the means.

For every star for which the residual on any night was as great as $0^s.15$, the residuals for all the nights were tabulated. There were fifty-one such stars. The mean residual for each star, which is the best value which can be derived from these observations for the error of right ascension for that star, was less than $0^s.10$ in all but nine cases out of fifty-one. There was but one case in which it was greater than $0^s.13$. In this case it was $0^s.16$. A careful examination indicates that, except for these nine stars out of about one hundred, the errors in right ascension were too small to be detected with certainty by the observations. The greatest error in the relative personal equation derived from a pair of time sets due to errors of right ascension is probably not greater than $0^s.02$, and in most cases is probably much less than this.

It is a curious fact, of which no explanation is apparent, that eight of the nine stars for which a small error in right ascension was detected were stars which culminate north of the zenith.

NUMBER OF NIGHTS NECESSARY TO SECURE THE REQUIRED DEGREE OF ACCURACY.

Let it be assumed that the required degree of accuracy is that which was obtained in the primary longitude net of the United States. In other words, let it be assumed that the future work is to be done with such accuracy that, if a longitude net were developed and adjusted, the corrections to the separate lines found to be necessary would be of the same magnitude as those in the present primary longitude net.

The results of the test indicate that the possible relative personal equation between two observers which is liable to be encountered is so small that its possible variation may be left out of consideration. The test also indicates that there is no appreciable systematic error of any kind involved in transit micrometer observations. The problem in hand is, then, to determine how many nights of observation are necessary to reduce the effects of accidental errors to the required limit.

From the fact set forth on pages 469 and 470, that the probable error of observation of a single star is from 50 per cent to 100 per cent greater with the transit micrometer than with the key, it might appear that from twenty to forty nights of observation would be necessary with the transit micrometer to secure the same degree of accuracy as was obtained from ten nights of observation with a key in the telegraphic longitude net.

Such a conclusion is deceptive for the reason that in observations with the key, though the accidental errors are quickly reduced to within very narrow limits, there remains in the mean result for a night, and even in the mean result for a pair of stations, constant errors, which are apparently independent of the accidental errors and are much larger than the accidental errors. These constant errors are supposed to be mainly due to variations in the relative personal equation of the two observers.

Thus* in observations with a key the probable error in the result for a night arising from accidental errors of observation, and therefore capable of further elimination by increased observation, is upon the average $\pm 0^{s}.013$; while the error peculiar to each night, and therefore not capable of elimination by increasing the number of observations per night, is $\pm 0^{s}.022$; and the constant error peculiar to each longitude determination, and not capable of elimination by increasing the number of nights per station, is $\pm 0^{s}.022$. These are values derived from the adjustment of the telegraphic longitude net of the United States. It thus appears that the principal errors in the mean of ten nights of observation with a key are of the constant kind. The accidental errors are relatively insignificant. The probable error of the difference of longitude of two stations connected by a land line and determined by ten nights of observation, including all three of the above classes of errors, is for the primary longitude net $\pm 0^{s}.025$.

If it be assumed that the errors in a transit micrometer determination of difference of longitude are all of the accidental class, the result from a single night's observations of 20 to 24 stars at each station will have a probable error of from $\pm 0^{s}.020$ to $\pm 0^{s}.027$. The value of $\pm 0^{s}.020$ is based upon the probable error of $\pm 0^{s}.063$, derived from observations by J. F. H. with the slow speed of the driving heads; and the probable error $\pm^{s}.027$ is based upon the probable error $\pm 0^{s}.084$ for a single observation for other observers than J. F. H. and with both speeds of the driving heads. On this basis it then appears that a pair of observers, either experienced or inexperienced, would secure as accurate a determination of a difference of longitude from a single night of observation with a transit micrometer as has been obtained, as a rule, from ten nights of observation with a key.

It is to be expected, however, that in regular longitude work the difference in atmospheric conditions at the two stations, the possible unknown interposition of repeaters in the telegraph line between stations, the irregular running of chronometers, and perhaps other conditions which have not operated to influence this test of the micrometer, may introduce additional errors of both the accidental and the constant class. It is the opinion of the writer that such additional errors will be so small that it is safe to predict that three nights of observation without exchange of observers will give as great accuracy as has been secured from ten nights of observation with the key, including an exchange of observers. This is a prediction of which the truth or falsity can only be proved conclusively by field experience. The writer relies upon such experience to be gained within the next ten years to verify the prediction.

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*See pp. 331-332 of Appendix 7 of the Report for 1898, "Determination of Time, Longitude, Latitude, and Azimuth."

SUMMARY OF CONCLUSIONS.

The principal conclusions from this test of the transit micrometer are:

(1) That the relative personal equation between any two observers with the transit micrometer is so small as to be masked by the accidental errors of observation. This is equivalent to saying that it is probably less in every case than $0^s.050$, and is as a rule much smaller than this. The relative personal equation with a transit micrometer is certainly not more than one-tenth as large upon the average as with a key. This conclusion as to the relative personal equation applies to inexperienced as well as experienced observers.

(2) The speed of 4.8 seconds per revolution for the driving heads of the transit micrometer, for an equatorial star, is the most favorable for accuracy, or possibly a slightly slower speed.

(3) Very little loss in accuracy will result from reducing the number of records per star from 36, as in the present instrument, to 20. Such a reduction should be made to save time in reading the chronograph sheets.

(4) It is predicted that three nights of observation with a transit micrometer and without exchange of observers will probably secure the same grade of accuracy as has been obtained from ten nights of observation with a key, and including an exchange of observers. Each night of observation is supposed to include two time sets, or 20 stars for each observer.

Aside from these conclusions the following items of information secured during the test are interesting and important:

1. For a practiced observer with a transit micrometer, the total error for a star, including errors which are constant for all the records as well as the accidental errors of bisection, is for the slower speed of the driving heads nearly the same for stars of all declinations, if expressed in angular measure. This is what should be expected if the errors concerned are of the same nature as if the object pointed upon were stationary instead of being a moving star.

2. For both the speeds used and for a practiced observer, the accidental errors of bisection are nearly the same, expressed in angular measure, for stars of all declinations up to 58°, and are probably somewhat less for stars of greater declination. This is an indication that the accidental errors of bisection are of the same nature as if the image pointed upon were stationary, the conclusion being partially contradicted by the smaller errors for stars of declination greater than 58°.

3. Good observations can be secured at once with the transit micrometer without previous practice. More practice simply reduces the accidental errors by about 25 per cent.

4. One incidental advantage of a transit micrometer not commented upon heretofore in this report is that the observations may be made much more rapidly with it than with a key. With a key about ten stars per hour may be observed conveniently. With a transit micrometer sixteen stars per hour can with equal convenience be observed. The list used during this test contains sixteen stars per hour. This advantage results from taking all the observations for an equatorial star in less than ten seconds instead of scattering them over an interval, for instance, 30 seconds or more, when observing with a key.

5. Each record on the chronograph is made too soon by the interval required for the micrometer head to turn, for that particular star, through an angle corresponding to one-half the effective width of the contact strips on the micrometer head. The effective contact width was directly determined at the close of the test. The half contact width was found to be, expressed in time, $0^s.010 \sec\delta$. Any lost motion in the micrometer also tends to make the record on the chronograph occur too soon. An unsuccessful attempt was made to determine the lost motion. The attempt showed that the lost motion is so small that it would require special devices to measure it.

In conclusion the writer wishes to bear testimony to the excellence of the design of the instrument. During the test no defects of any kind have been found, even in this experimental instrument. Not a single record has ever been lost from the chronograph sheet during the whole of the test because of failure of action of the transit micrometer part of the apparatus. On account of the perfect action of the cut-out switch, which insures that none but the required records shall appear on the chronograph sheet, the identification of the record on the sheets is no more difficult than for a key record.

Literature of the Transit Micrometer.

In the following paragraphs is shown the literature which was used in reaching the conclusions stated in this Appendix. These are not intended to constitute a complete bibliography of the subject. They are printed here simply as an indication of the history of the development of the transit micrometer as an instrument for use in the telegraphic determination of differences of longitude. The short abstract made of each article shows simply the more important points in the article considered from this point of view.

Das Passagen-Mikrometer, Leipzig, 1865, von Carl Braun, S. J.—This is the publication referred to on page 456 as being the first suggestion of the observation of transits with a movable micrometer line. Carl Braun was the Director of the Kalocsa Observatory in Hungary.

Neuer Vorschlag zur Vermeidung des persönlichen Zeit-Fehlers bei Durchgangs-Beobachtungen, von Dr. J. Repsold, September, 1889. Published in Astronomische Nachrichten No. 2940, Band 123.—In this paper Doctor Repsold describes a hand-driven transit micrometer constructed by him, and gives the results of certain tests. The tests were made by the laboratory method—that is, by pointing upon a near moving mark instead of a star, the mark being made to record automatically its true position, and the whole constituting a special form of personal-equation apparatus. Two driving heads were used, one for each hand. The driving heads made one revolution in 3.85 seconds. The test demonstrated that no clockwork was necessary to enable an observer to keep a mark bisected continuously with a transit micrometer with the high degree of accuracy necessary to make the instrument valuable in observations of star transits. The largest personal equation developed on any of the tests is $0^s.021$ and the mean of the six tests gives for the personal equation of the observer $0^s.002$.

Verhandlungen der vom 15. bis 21. September 1890 zu Freiburg I/B. abgehaltenen Conferenz der Permanenten Commission der Internationalen Erdmessung, 1890, pages 21, 71.—At the meeting of the International Geodetic Association Prof. Dr. Th. Albrecht referred to the above paper by Doctor Repsold. He also referred to certain tests upon stars, in which, with six combinations of observers, the largest relative personal equation discovered with the hand-driving transit micrometer was only some hundredths of a second (höchtens einige hundertstel Secunden), whereas the maximum relative personal equation between the same observers with the key method of observation was $0^{s}.32$. The driving heads of this transit micrometer made one revolution in 5.8 seconds for an equatorial star. As to accidental errors, he stated that the probable error of a single registration was about the same with the transit micrometer as with the key.

Ueber einige Versuche von Durchgangsbeobachtungen nach dem neuen Repsold'schen Verfahren. Von Prof. E. Becker, März, 1891. Published in Astronomische Nachrichten, No. 3036, Band 127.—This paper gives the results of certain tests made with a Repsold hand-driven transit micrometer mounted on a transit of 2½ inches aperture of the broken telescope type. The transit was furnished with a group of five fixed lines on each side of the center of the field of view, the middle 36 seconds of the field being left clear for the use of the transit micrometer. Ten of the contacts observed with the transit micrometer on each star were used in the computation. Four observers took part in the tests, which extended over four nights. On each night the relative personal equations of the four observers were determined by the half-transit method with a key in each of the 6 possible combinations of observers, using from 6 to 9 stars for each determination. By the "half-transit method" is meant that one person observed the transit of the star across one-half of the fixed lines in the field of view, and immediately afterwards another person observed the transit of the same star across the remaining fixed lines, or across the same lines in the reverse order, after reversing the telescope. On the same night each person observed from 5 to 15 other stars (usually 6) by both the key and the transit micrometer method, and thus determined the difference of his personal equations by the two methods. From these observations the relative personal equations of the observers corresponding to the transit micrometer observations as well as the key observations were derived. The observed relative personal equations for the six combinations of observers were as follows:

	B.-H.	B.-K.	B.-Z.	H.-K.	H.-Z.	K.-Z.
	s.	*s.*	*s.*	*s.*	*s.*	*s.*
With a key	+0.155	+0.255	+0.159	+0.100	+0.004	−0.096
With the transit micrometer, all four nights	+0.060	+0.046	−0.002	−0.014	−0.062	−0.048
With the transit micrometer, last two nights only	−0.009	−0.016	−0.026	−0.007	−0.017	−0.010

The values in either the second or the third line of the table are so small as to be possibly simple errors of observation. Increased experience apparently reduced the relative personal equations with the transit micrometer as the values in the third line are each, with one exception, smaller than the corresponding values in the second line.

As to accidental errors, it was shown that the mean error of a single registration with the transit micrometer for each of the observers, B., H., K., and Z., respectively, was $\pm 0^{s}.107$, $\pm 0^{s}.104$, $\pm 0^{s}.117$, and $\pm 0^{s}.122$; and the mean error of observation of a single line with the key method was, for the four observers, respectively $\pm 0^{s}.084$,

$\pm0^{s}.086$, $\pm0^{s}.085$, and $\pm0^{s}.092$. With both the key and the transit micrometer the accuracy increased from night to night with accumulated practice, but the increase was greater with the transit micrometer than with the key. Professor Becker concluded that with the transit micrometer the relative personal equation was either eliminated entirely or reduced to a small quantity. In connection with the slightly larger accidental errors with the transit micrometer he called attention to the facts that the observers were unskilled in the use of the transit micrometer, that there was an appreciable increased resistance to the motion of the micrometer head at the contact points, and that the micrometer screw had but a single driving head. He states that the transit micrometer is not well adapted to observations on faint stars.

Die Anwendung des Repsold'schen Mikrometers bei Beobachtungen im I. Vertical nach der Struve'schen Methode. Von C. Mönnichmeyer, März, 1894. Published in Astronomische Nachrichten No. 3228, Band 135.—This is an account of the use of a Repsold transit micrometer upon a transit mounted in the prime vertical. The author's conclusions are in favor of the transit micrometer.

Verhandlungen der vom 12. bis 18. September 1893 in Genf abgehaltenen Conferenz der Permanenten Commission der Internationalen Erdmessung, 1894, Page 177.—In the report of the Prussian Geodetic Institute, Helmert referred to the use of the transit micrometer in the determination of the differences of longitude between Ubagsberg, Bonn, and Göttingen, stating the fact that the personal equation was reduced to a much smaller quantity than with a key, and gave figures showing that the accidental errors in a single record were as small as or smaller than with a key.

Veröffentlichung des Königl. Preussischen Geodätischen Institutes. 1895. Telegraphische Längenbestimmungen in den Jahren 1890, 1891 und 1893.—Of the determinations of differences of longitude reported upon in this volume five were made with transits equipped with transit micrometers, namely, two independent determinations of the difference Berlin-Potsdam in 1891 by slightly different methods, and determinations of the three differences between Ubagsberg, Bonn, and Göttingen in 1891. The two transits were of the broken-telescope type, made by Bamberg, of Berlin, and equipped with hand-driven transit micrometers, slightly modified from the Repsold design. Transit II had an aperture of 68 millimeters and a focal length of 87 centimeters. The corresponding values for Transit III were 81 millimeters and 92 centimeters, respectively. The driving heads made one revolution in eight seconds for an equatorial star.

Four observers determined their relative personal equations with a key on three nights in August and September, 1890. The determinations were made in all six possible combinations, by twos, of the four observers. Six determinations were made on each night, or 18 in all. These same observers similarly determined their relative personal equations, using the transit micrometer, in March, 1891, on three nights, making 8 determinations on each night. The resulting mean values of the relative personal equations were:

	A.-B.	A.-G.	A.-S.	B.-G.	B.-S.	G.-S.
	s.	*s.*	*s.*	*s.*	*s.*	*s.*
With the key	—0.108	—0.314	—0.184	—0.225	—0.086	+0.109
With the transit micrometer	—0.004	—0.035	—0.027	+0.013	—0.023	—0.006

In the first determination of the difference of longitude between Berlin and Potsdam two observers worked at each end of the line, so that each night's results depended upon four observers. Observations were taken on 12 nights. Three sets of 12 stars each were observed on each night. On each polar star one observer took one good revolution, or 10 contacts, on the first half of the transit, and then, after reversing the instrument, the other observer took 10 contacts. On the remaining stars in the set—time stars—each observer took 20 contacts, or two complete revolutions, one observing before the star reached the middle of the field and the other afterwards, without any reversal of the instrument between their observations. The maximum residual of any one of the 12 determinations of the difference of longitude from the mean was 0.072 second. The probable error of the mean of the 12 values is ±0.009 second. The relative personal equations of the four observers, as derived from the longitude observations and used in their reduction, were A.-B. = $-0^{s}.016$, A.-G. = $-0^{s}.027$, A.-S. = $-0^{s}.033$, B.-G. = $-0^{s}.011$, B.-S. = $-0^{s}.017$, G.-S. = $-0^{s}.006$. These values are comparable with those shown a few lines above.

The results showed systematic differences in the clock errors as derived separately from the two positions of the instrument, amounting to as much as 0.115 second. This was attributed to a difference in the collimation error for zenith stars and for polar stars.

In the second determination of the difference of longitude between Berlin and Potsdam in 1891, there was but one observer at each station. The instrument was reversed during the transit of each star. On time stars 20 contacts (two revolutions) were observed before reversal and 20 more after reversal on the same part of the screw. On polar stars 20 contacts in all were observed, 10 before and 10 after reversal. The regular programme consisted of three sets of 6 stars each at each station on each night. Observations were made on nine nights. The maximum residual of any one of the longitude determinations from the mean of the nine was $0^{s}.033$. The probable error of the mean was $\pm 0^{s}.005$.

The relative personal equation of the two observers, as derived from the longitude observations, was B.-S. = $-0^{s}.013$.

The difference between the mean values of the difference Berlin–Potsdam from this source and from the observations earlier in the year was $0^{s}.020$, a quantity within the allowable limit as deduced from the computed probable errors of the two results.

On the three determinations of differences of longitude between the stations Ubagsberg, Bonn, and Göttingen, 1893, the methods of observations were practically the same as in the Berlin–Potsdam determination, except that more care was taken to use the same part of the screw before and after reversing on each polar star, and that on time stars 10 contacts only, both before and after reversal—that is, the alternate contacts on two revolutions—were used in the computation, or 20 contacts in all. The regular programme at each station on a night consisted of two sets of 12 or 13 stars each. The observations were made on 10 or 11 nights at each pair of stations. For the three determinations the three maximum residuals of any night from the mean were $0^{s}.044$ and $0^{s}.056$ and $0^{s}.031$. The probable errors of the mean results were $\pm 0^{s}.007$, $\pm 0^{s}.006$, and $\pm 0^{s}.004$. The closing error of the longitude triangle formed by the three determinations was $0^{s}.038$, almost too large to be accounted for by the computed probable errors. The closure was attributed mainly to various unfavorable conditions encountered on two of the lines.

The values of the combined personal and instrumental equation from these three determinations were 0^s.009, 0^s.019, and 0^s.034. In the earlier longitude determinations the exchange of instruments between stations was made in such a way that each observer used each instrument a part of the time and the computation was so made as to separate the personal and instrumental equations. On the three determinations here dealt with each observer took his own instrument with him whenever he moved, and a separation of the personal and instrumental equations by computation was not possible.

The following comparison was given of the mean error of observation of a single star in the 1893 longitude determination made with the transit micrometer and the corresponding value by the key method:

Declination	Key method	With transit micrometer, Albrecht	With transit micrometer, Borrass
°	*s.*	*s.*	*s.*
+30	±0.065	±0.049	±0.051
+83	±0.278	±0.217	±0.263

It was also shown that the instrumental errors, azimuth and inclination, were determined more accurately with the transit micrometer than with the key method.

The introduction of the transit micrometer was characterized as an important forward step in longitude determinations.

Neue Mikrometer, von A. Repsold und Söhne. Von J. Repsold. 8 Juli, 1896. Published in Astronomische Nachrichten, No. 3377, Band 141.—This is a complete description of a new transit micrometer constructed by A. Repsold and Sons and furnished to the Washburn Observatory at Madison, Wis.

The Repsold transit-micrometer of the Washburn Observatory, and slat-screen apparatus, by Albert S. Flint. Published in the Astronomical Journal, No. 470, pages 110–111, October, 1899.—This is an account of the performance of the transit micrometer described in the article referred to in the preceding paragraph. It was applied to the meridian circle of the Washburn Observatory and used in the observations for stellar parallax by the method of meridian transits. The aperture of the telescope of this instrument is 12.2 centimeters. The driving heads made one revolution in 18.9 seconds for an equatorial star. The probable error of a single contact for an equatorial star was ±0.030 seconds, the same as for observations with the same instrument with a key. For bisections both a single line and parallel lines, 0^s.70 apart, were tried, and gave equally good results. The double lines were adopted for regular use.

Veröffentlichung des Königl. Preussischen Geodätischen Institutes, Neue Folge No. 3, 1900. Bestimmung der Längendifferenzen Knivsberg–Kopenhagen und Knivsberg-Kiel, im Jahre 1898.—The same instruments and methods of observation were used in this work as in the longitude determinations in 1893 between Ubagsberg, Bonn, and Göttingen. As in that work the accidental errors in observing transits and in determining the inclination and azimuth errors of the instrument were found to be smaller than with the key method of observation. The regular programme on each night was to observe three sets of from 8 to 10 stars each at each station. Between Knivsberg and Kopenhagen the observations were made on 14 nights; between Knivsberg and Kiel on

13 nights. The maximum residual of any night from the mean in the former determination was $0^s.050$, and in the latter determination $0^s.062$. The probable errors of the mean results were $\pm 0^s.006$ and $\pm 0^s.005$, respectively.

The values of the combined personal and instrumental equation were $0^s.034$ and $0^s.033$ from the two determinations.

Veröffentlichung des Königl. Preussischen Geodätischen Institutes, Neue Folge No. 5, 1901. Bestimmung der Längendifferenz Potsdam–Bukarest, im Jahre 1900.—The same instruments, method, and observing programme were again used. The accuracy attained was slightly greater than in the 1898 determinations cited in the preceding reference. The observations were made on 22 nights. The maximum residual of any night from the mean was $0^s.043$ and the probable error of the mean $\pm 0^s.003$.

The combined personal and instrumental equation was $0^s.017$.

In connection with the report upon this determination Albrecht remarks that the superiority of the method employing the Repsold transit micrometer over the older methods is so complete, according to all the experience of the Geodetic Institute, that it should be used in all primary longitude work.

Die Beobachtungsmethode mittelst des Repsold'schen Registrirmikrometer in ihrer Anwendung auf Längenbestimmungen. Von Prof. Th. Albrecht, März, 1901. Published in Astronomische Nachrichten, No. 3699, Band 155.—This is a general critical account of the results secured with transit micrometers in the determinations of longitude by the Prussian Geodetic Institute treated in the foregoing references. Among the facts set forth in regard to the transit micrometer are: that the relative personal equations are reduced to a tenth of their former values and presumably a corresponding reduction has been made in their variations; that variability of personal equation must be regarded as the principal source of error in longitude work with a key; that with the transit micrometer the observations of separate stars may follow each other at much shorter intervals than with a key; that the accuracy of a single contact with the transit micrometer is greater at any declination than that of a single line with a key; that the instrumental errors are determined more accurately when a transit micrometer is used than when fixed lines and a key are used; and that, whereas the mean error of the result for a night as computed from the residuals of the various nights from the mean was from $\pm 0^s.043$ to $\pm 0^s.064$ during 1883–1889 with the key method of observation, it was from $\pm 0^s.020$ to $\pm 0^s.026$ with the transit micrometer method of observation in 1893, 1898, and 1900.

Ueber die Verbindung eines Uhrwerks mit dem „unpersönlichen“ Mikrometer von Repsold. Von H. Struve, Königsberg, 1, März 1901. Published in Astronomische Nachrichten, No. 3719, Band 155.—This is a description of a clockwork driving apparatus connected with a transit micrometer attached to one of the instruments at the Königsberg Observatory. The weight of the clockwork, which is mounted upon the telescope, is 1⅔ kilograms (3⅔ pounds). It serves to drive the movable line at approximately the required speed to follow any star of declination between 0 and 88°. The observer corrects the bisection from time to time as necessary by increasing or decreasing the speed at which the micrometer is driven. The relative personal equation of two observers, as determined with the transit micrometer driven by hand, was $+0^s.020$ and by the transit micrometer driven by clockwork was from two different series of observations $+0^s.012$ and $+0^s.027$. Each of these are values reduced to the equator, and each was determined from a series of observations extending over several nights. The accidental errors were smaller with the clockwork than with the micrometer driven by hand. The author did not consider the series of observations long enough to furnish trustworthy conclusions.

Veröffentlichung des Königl. Preussischen Geodätischen Institutes, Neue Folge, No. 7, 1902. Bestimmung der Längendifferenz Potsdam-Pulkowa, im Jahre 1901.—The same instruments and method were used as in 1900 between Potsdam and Bukarest. The regular programme on each night consisted of 4 sets of 6 or 7 stars each. The accuracy of the observed transits and of the determination of inclination and azimuth was greater than in the 1900 longitude work. The observations were made on twenty nights. The maximum residual of any night from the mean was $0^{s}.043$ and the probable error of the mean result was $\pm 0^{s}.003$. The mean error of the longitude difference from a single complete night as computed from the residuals of the separate nights from the mean was $\pm 0^{s}.018$.

The combined personal and instrumental equation was $0^{s}.025$.

Veröffentlichung des Königl. Preussischen Geodätischen Institutes, Neue Folge, No. 15, 1904. Bestimmung der Längendifferenz Potsdam-Greenwich, im Jahre 1903; and, Sitzungsberichte der Königl. Preussischen Akademie der Wissenschaften, 1904, VIII. Sitzungs der physikalisch-mathematischen Classe vom 11. Februar. Neue Bestimmung des geographischen Längenunterschiedes Potsdam-Greenwich. Von Prof. Dr. Th. Albrecht.—The same instruments and method were employed as before. The accuracy of the observations was about the same as in 1901. The regular programme on each night consisted of 3 sets of 6 to 8 stars each. The observations were made on twenty-four nights. The maximum residual of any night from the mean was $0^{s}.059$ and the probable error of the mean result $\pm 0^{s}.003$. The mean error of a longitude difference from a single complete night as computed from the residuals of the separate nights from the mean was $\pm 0^{s}.021$.

The combined personal and instrumental equation was $0^{s}.000$.

Ueber das Repsold'sche unpersönliche Registrirmikrometer, nebst den mit demselben am Meridiankreis der Münchener Sternwarte beobachteten Rektaszensionen von 208 Fundamentalsternen. Von Prof. Dr. K. Oertel, München, Anfang Dezember 1903. Published in Astronomische Nachrichten, No. 3942-3, Band 165.—This article contains a full statement of the data in regard to a hand-driven transit micrometer attached to the Repsold Meridian Circle at the Munich Observatory, obtained during its use for five nights in determining the right ascension of fundamental stars. A detailed description of the instrument in volume 4 of "Neuen Annalen der Münchener Sternwarte" is referred to. All observations were made with a magnifying power of 270.

The 3 089 observations, 430 by Professor Bauschinger and the remainder by Professor Oertel, failed to show the existence of a relative personal equation as large as $0^{s}.001$.

A thorough investigation failed to discover any systematic errors depending upon the magnitude of the star or the position of the instrument.

Professor Oertel states in regard to advantages of the transit micrometer that, in contrast to the almost unavoidable nervous strain with the key, after suitable practice the screw of the micrometer is turned with absolute calmness; that more stars per hour may be observed with a transit micrometer than with a key, and that the accuracy of observation is greater than with a key.

He states that in the winter months he has often, on several nights in succession and for six or seven hours uninterruptedly on each night, observed with the hand-driven transit micrometer without experiencing any other weariness than that due to the work in general.

An investigation of 224 stars by the use of a reversing prism in the eyepiece indicated a very small error, less than $0^{s}.005$, which is systematic with respect to the direction of motion.

The mean error of a single contact, reduced to the equator, was found to be $\pm 0^{s}.042$.

The mean error of a single contact increased gradually with decreasing brightness of stars from $\pm 0^{s}.034$ for third magnitude stars to $\pm 0^{s}.052$ for stars of the seventh to eighth magnitude. These particular computed values depend upon an investigation of 70 stars.

The mean error of a single contact reduced to the equator (that is, multiplied by the cosine of the declination) decreased slightly as the declinations increased, as shown by the following table, which is condensed from the more extensive table given in the article.

Average declination	Number stars	$m \cos \delta$	Remarks
°		s.	
37.4	22	±0.046	
49.6	24	0.048	
55.7	24	0.041	
81.7	14	0.039	Upper culmination
86.1	9	0.034	Upper culmination
88.5	5	0.029	Upper culmination
88.3	6	0.027	Lower culmination
86.2	12	0.041	Lower culmination
82.7	20	±0.044	Lower culmination

In other words, the mean error of a contact expressed in angular measures varies from about $\pm 0''.70$ for stars of about declination 45° to less than $\pm 0''.45$ for close circumpolar stars.

Ergebnisse von Beobachtungen am Repsold'schen Registrirmikrometer bei Anwendung eines Uhrwerks. Von Dr. Fritz Cohn, 12. November, 1901. Published in Astronomische Nachrichten, No. 3766–3767, Band 157.—This is an account of an investigation made with the clock-driven Repsold transit micrometer mounted on a meridian circle telescope at Königsburg, having a 4-inch objective. The observations were made on 14 nights in July, 1901, from 28 to 94 stars being observed each night, or about 1000 observations in all. Two observers took part in each night's work and the programme was such as to give a strong determination of their relative personal equation.

The clockwork and its counterweight weighed 3 kilograms. No evidence, although it was very thoroughly searched for, could be found that the relative personal equation of the two observers varied during the observations on any night, or from night to night, during the period July 1–22, over which the observations extended. The mean value of the relative personal equation derived from all the observations was C.–P. = $-0^{s}.022$ $\pm 0^{s}.002$. The values from the separate nights all fell within the range $-0^{s}.010$ to $-0^{s}.033$, which is fully accounted for by the computed probable errors.

A special investigation was made to determine a possible relation between the relative personal equation and the magnitude of the stars observed. The relative personal equation was apparently independent of the magnitude.

For all stars down to magnitude 8.3 the accuracy of the observations seemed to be independent of the magnitude. For stars fainter than this the accuracy was somewhat decreased. The author suggests that the inability to observe very faint stars is a slight defect in the transit micrometer method of observation.

All these stars were confined to a comparatively narrow zone in declination and hence no investigation of the relation between the accuracy of the observations and the declinations was feasible.

The mean error of the observed transit of a star, from the whole series of observation, reduced to the equator, was $\pm 0^{s}.019$. In commenting upon this value in comparison with other observations with this and similar instruments without the transit micrometer, it is stated that the transit micrometer observations must be credited with twice the weight of the best observations by other methods.

The observations are remarkable for their nearly complete freedom from systematic error of any kind as well as for their extremely small accidental errors.

Doctor Cohn states that the clockwork driving apparatus makes the observing much easier than it otherwise would be.

The following table shows, for the longitudes determined with transit micrometers by the Prussian Geodetic Institute during the period 1891–1903, the mean error of a single contact, or signal, and the manner in which said mean error varies with the declination. The table shows the values of a and b in the formula $m=\sqrt{a^2+b^2\sec^2\delta}$ in which m is the mean error of a single contact and a and b are constants determined from the observations.

Observer	Date	a	b
All	1891	0.052	0.027
Albrecht	1893	0.039	0.0260
Borrass	1893	0.036	0.0317
Albrecht	1898	0.037	0.0133
Schumann	1898	0.048	0.0250
Albrecht	1900	0.039	0.0174
Borrass	1900	0.048	0.0261
Albrecht	1901	0.044	0.0194
Borrass	1901	0.052	0.0262
Albrecht	1903	0.039	0.0146
Wanach	1903	0.045	0.0174

APPENDIX 9

REPORT 1904

TRIANGULATION IN CALIFORNIA

PART I

By A. L. BALDWIN
Computer, Coast and Geodetic Survey

CONTENTS.

ILLUSTRATIONS.

TRIANGULATION IN CALIFORNIA.

By A. L. BALDWIN,
Computer, Coast and Geodetic Survey.

GENERAL STATEMENT.

The purpose of this Appendix is twofold: first, to set forth fully in convenient form the results of the primary triangulation near the western coast of the United States from Point Arena, California, to the Mexican boundary; second, to produce for the use of the engineer, and on United States Standard Datum, the geographic positions, not only of the primary stations, but also of all stations of the minor triangulations controlled by this primary scheme and lying south of Monterey Bay. The descriptions and elevations are also printed for all stations whose positions are here published, whether primary or tertiary, wherever available.

The accomplishment of the first purpose was comparatively easy, because, at the time of his death in 1901, Assistant C. A. Schott had in progress a complete report on this triangulation. In addition to the assistance of Mr. Schott's notes, the Chief of the Computing Division and several of its members have taken part in the preparation of this Appendix. Miss Lilian Pike, assisted by Mr. C. R. Duvall, made the least square adjustments of the primary work; and Miss Pike also directed the preparation of the descriptions.

The engineer, intent only upon securing the necessary information to enable him to extend this triangulation or base other surveys upon it, will find the information he desires in the latter part of the Appendix, commencing with the explanation of positions, lengths, and azimuths. The index of positions, descriptions, and elevations used in connection with the sketches at the end of the Appendix will enable him to find quickly the data he desires for any given locality.

THE PRIMARY TRIANGULATION.

The earlier field work of the Survey along the western coast of the United States was carried on under peculiar circumstances. The great and sudden influx of miners and adventurers into California from about 1849 onward made it the first duty of the Survey for many years to provide for the safety of navigation, as far as its means allowed, by means of coast and harbor surveys, the mapping of rocks, shoals, reefs, and other dangers to navigation, and the prompt publication of such intelligence in the form of charts. Much of this work necessarily had to be done hurriedly, and was consequently largely of a temporary character. Astronomic expeditions were organized and the positions of many prominent points were roughly determined, particularly during the years from 1850 to 1853; besides, small or local triangulations were made at a number of places; but it was not until a much later date that systematic surveys were attempted. The latitudes were determined by means of zenith telescopes and the longitudes by means of transits and of transportation of chronometers. The various expeditions to the northward and southward of San Francisco were ultimately connected with that central station. The longitudes of a number of stations were determined from observations of moon culminations, collected and referred to San Francisco for the purpose of fixing upon a standard geodetic longitude to be employed for all the surveys in California. From the beginning much difficulty was experienced in getting acceptable standard geodetic values for latitude and longitude, owing to the diversity in the directions and magnitudes of the local deflection of the vertical. This difficulty was eliminated by the adoption of a standard datum for the whole United States.* The treatment of the astronomic determinations will be left for some future date.

At the present time the results of primary triangulation are available on nearly one-half of the western coast of the United States exclusive of Alaska. This triangulation, at the northern end directly connected with the transcontinental arc in latitude 39°, binds together the positions in this latitude and those along the line of the Mexican boundary. A primary triangulation is now in progress which will connect the positions along Juan de Fuca Strait, Washington, with this triangulation at its junction with the transcontinental arc.

The primary triangulation spreads over the crest lines of the coast ranges, which form the western rim of the great California basin. At the Santa Barbara Channel the triangulation takes an abrupt bend, and follows the coast to the Mexican boundary. The distance along a great circle from Point Arena Light-house to the Initial Monument on the Pacific of the Mexican boundary is 8°21′.85, or 501.85 nautical miles (577.9 statute miles); the azimuth of the light-house from the monument is 141° 59′.3, and the reverse azimuth at the light-house is 318° 06′.8.

The triangulation includes two primary base lines, namely, the Yolo Base, measured in 1881, and the Los Angeles Base, measured in 1888 and 1889; both are long bases, each nearly 17½ kilometers in length, and they were found to be in excellent accord.

THE UNIT OF LENGTH OF THE TRIANGULATION.

This triangulation depends for its distances on the length of the Committee Meter, an iron bar standardized at Paris in 1799, one of the original French meters, and which was brought to America in 1805 by Superintendent Hassler. It fell into disuse after the receipt by the Survey of the new national prototype meters in 1890.† Its history, and results of many comparisons for defining its length in terms of the International Prototype Meter, are given at length in Part I of "The Transcontinental Triangulation and the American Arc of the Parallel, Special Publication No. 4. Washington, D. C., 1900." The length of this Committee Meter, from the comparisons of 1799, 1867, 1889, 1894–95, and 1896, is found to be equal to the International Prototype Meter, with a probable error of about three-fourths of a micron.

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*See "Explanation of positions, lengths, and azimuths, and of the United States Standard Datum," later in this Appendix.

†Appendix No. 18, Report for 1890, pp. 735–758: "Historical Account of United States Standards of Weights and Measures," etc., by O. H. Tittmann, Assistant.

LOCATION, MEASUREMENT, AND LENGTH OF THE LOS ANGELES BASE LINE, CALIFORNIA, 1888-89.

Location of the base line.—The line is on the so-called Los Angeles plains, partly in Los Angeles County and partly in Orange County, about 10 miles (or 16 kilometers) from the shore of San Pedro Bay and roughly parallel with it. The necessary reconnaissance was made in 1886 by Assistants J. S. Lawton and E. F. Dickins and Sub-Assistant F. Morse. The final selection of the terminal points was made by Assistant G. Davidson in 1888. Southeast Base is about 1⅔ miles (or 2.7 kilometers) south of the southwestern part of the town of Anaheim, in latitude 33° 47′.5 and in longitude 117° 56′.6. Northwest Base is about 1 mile east of the town of Norwalk, on a slight ridge, in latitude 33° 55′.0 and longitude 118° 03′.5. The base is very nearly 17.5 kilometers (or 10.9 statute miles) in length and the observed azimuths at Southeast Base and at Northwest Base are respectively 142° 37′.0 and 322° 33′.2, making the inclination of the base with the meridian at its middle point about 37° 25′.1. No attempt was made to grade the line, except in six cases where sand and clay hammocks were cut through and by the removal of tussocks and coarse grass. The ground over which the base passes is a broad plain with occasional slight ridges of only a few feet elevation, rising gradually toward both ends from the crossing of the Southern Pacific Railroad at Coyote Creek. The elevation of Northwest Base above the mean tidal level of the Pacific was determined by a double line of spirit levels (forward and backward), from the United States Engineer's bench mark at San Pedro, executed by Assistant I. Winston in May, 1890. No record of leveling along the base could be found, so the height of the bars at every 100 meters was determined by means of the sector readings during the second and third measurements of the base line. These operations gave the following heights above mean tidal level, viz, of the Northwest Base (copper bolt), 127.961 feet or 39.003 meters; of Southeast Base (upper bolt), 107.271 feet or 32.696 meters; of base bars, average for whole line, 88.778 feet ±0.475 feet or 27.060 meters ±0.145 meters.

Marking of the base ends.—A brick and cement foundation, extending 60 inches below the surface, 72 inches square at the bottom and 54 inches square at the top, supported a granite block, 26 inches cube, the top surface of which was flush with the top of the foundation and with the surface of the ground. A copper bolt in the center of the top surface of this block had a piece of silver wire driven into its head, and a hole made in the end of this wire with a fine needle marked the end of the base. A granite block, 3 feet long and 1 foot square, similarly marked, was set with its top surface several inches below the bottom of the foundation as a subsurface mark. Suitable witness marks were placed, two in the line of the base and two at right angles thereto at distances of 10 and 100 feet. A stone with a copper bolt was set in line at the end of each half kilometer from Southeast Base except in three cases where the nature of the ground prevented, in which cases it was set at the end of a succeeding even bar where the conditions were favorable. When the ends of the base were occupied as triangulation stations in 1890 brick towers were erected, 35 feet high at Southeast Base and 15 feet high at Northeast Base.

Measurement of the base line.—The work was in charge of Assistant G. Davidson. His party arrived at Camp Colonna, near the middle of the base, October 16, 1888. A preliminary measurement of the base line was made December 1 and 3 by Messrs. Nelson and Westdahl with a 100-meter steel wire, with the resulting length 17 494.53 meters. The measurement with the bars began December 13 and was completed February 15, 1889. The base was measured three times (with a fourth measure of the last half kilometer) with the 5-meter compensating base bars, first used in the measurement of the Yolo Base in November, 1881. A full description of this apparatus is given in Appendix 7 of the Report for 1882. Each bar is composed of two metals, steel and zinc, joined in such a way as to nearly compensate for changes of temperature. Contact is made by means of contact-slide pieces. The first measurement of the base was delayed by rains and the consequent accumulation of water in low places along the line, but was completed in 22 working days. The second measurement, made in the opposite direction to that of the others, required 15 and the third 13 working days. The party consisted of Assistant George Davidson, chief of party; J. S. Lawson, Assistant; F. Morse, Sub-Assistant; John Nelson, Aid; F. Westdahl, Draftsman; F. W. Edmonds, Recorder, and 17 men, of whom 11 took part in the actual work of measurement. Appendix 10 of the Report for 1889 gives a detailed account of the various operations of the measurement of the Los Angeles Base Line and the duties assigned to the various members of the party.

Computation of the length of the base.—The field computation was made by Sub-Assistant F. Morse; the office computation by D. L. Hazard. In the computation and discussion of the Yolo Base Line, Appendix 11 of the Report for 1883, the conclusion was reached that the lengths of base bars change slightly with the temperature and can not even be assumed as constant at the same temperature at different times. Accordingly observations were made both before and after the measurement of the Los Angeles Base to determine the effect of temperature on the length of the base bars, and the bars were compared twice each morning, before beginning work on the line, with the standard 5-meter bar No. II (Field Standard). The resulting length was used for the work of the day after being corrected for the difference between the temperatures of comparisons and of the base measuring.

The length of the 5-meter Field Standard No. II and its coefficient of expansion were determined in 1881–82–83 with the result:

$$\text{Length of No. II} = 5m + \underset{\pm\ \ 2.1}{1\,163.0\mu} + \underset{\pm\ .21}{57.47\mu}\,(t-17^\circ.07C).$$

For particulars see Appendix 7, Report for 1882. From that appendix are taken also the following values of one revolution of the micrometer of Fauth & Co. comparators:

$$\text{Comparator No. III} = \underset{\pm\ \ .010}{254.528\mu} + 0.002\mu\,(t-20^\circ C).$$

$$\text{Comparator No. IV} = \underset{\pm\ \ .009}{254.535\mu} + 0.002\mu\,(t-20^\circ C).$$

Corrections were applied for irregularity of screw.

Corrections to thermometers.

Temperature, Centigrade.	Base bar 2.		Field standard.		Base bar.		Average bar.
	No. 4524.	No. 4525.	No. 4526.	No. 4518.	No. 4522.	No. 4523.	
°	°	°	°	°	°	°	°
43	—0.34	—0.34	—0.32	—0.33	—0.36	—0.40	—0.36
38	.26	.29	.26	.26	.28	.26	.27
32.5	.24	.32	.28	.30	.33	.24	.28
27	.20	.30	.26	.28	.30	.24	.26
21.5	.13	.20	.17	.18	.19	.18	.18
16	.13	.12	.16	.16	.23	.16	.16
10	.06	.12	.14	.16	.15	.16	.12
4.5	—0.07	—0.10	—0.12	—0.06	—0.08	—0.11	—0.09

The quantities in the last column are to be applied to the mean of the readings of the four (Green) thermometers, Nos. 4524, 4525, 4522, and 4523. In measuring the fractional part of a bar length at Northwest Base, the second meter of a 3-meter steel rod was used. The length is given in Appendix 11, Report for 1883, as 1 meter $+11.2\mu$ $(t+13°.78\ C)$.

To ascertain the effect of temperature on the base bars, hourly comparisons were made for three days (of twenty-four hours) at Lafayette Park, San Francisco, parts of two days at Middle Base (Camp Colonna) and parts of two days at Southeast Base before measuring the base, and for parts of three days at Camp Colonna after the base measure. Owing to the small range of temperature, and conditions differing in other respects from those during the base measure, no use has been made of the San Francisco comparisons. From the daylight observations at the base on six days, three before and three after the measurement of the base, are deduced six values for the outstanding coefficient of expansion of each bar, of which the mean, 3 microns for 1° C. for each bar, is used to correct the length of the bars deduced from the morning comparisons for changes of temperature during the day. All comparisons between the field standard and the base bars were made by means of the Fauth & Co. level-contact comparators No. III and IV. The results of those comparisons used in the computation are appended.

Results from comparisons of the base bars Nos. 1 and 2 with field standard between the hours of 7 a. m. and 5 p. m.

(1) BEFORE THE MEASUREMENT OF THE BASE (1888).

[Length = 5 meters + tabular quantity.]

Hour	Camp Colonna, Dec. 18				Southeast Base, Dec. 11				Southeast Base, Dec. 12			
	No. 2		No. 1		No. 2		No. 1		No. 2		No. 1	
	Length	Temperature	Length	Temperature	Length	Temperature	Length	Temperature	Length	Temperature	Length	Temperature
	μ	°	μ	°	μ	°	μ	°	μ	°	μ	°
7 a. m.	329.9	9.77	−27.0	10.24	......	......	......	......	339.7	6.99	−39.5	7.35
8	332.7	9.43	−25.4	9.99	314.7	6.69	−42.4	7.31	324.0	6.69	−33.9	7.09
9	332.7	9.59	−21.1	10.20	334.6	7.37	−29.6	7.80	341.1	6.95	−26.4	7.46
10	324.5	10.51	−36.7	11.22	331.9	8.40	− 1.3	8.94	343.9	8.29	−12.4	8.92
11	329.1	11.92	−20.4	12.73	348.7	10.13	− 7.1	10.83	335.1	9.97	− 7.0	10.72
12 noon	332.1	13.15	−15.4	14.07	......	......	......	......	335.6	11.69	+ 4.4	12.60
1 p. m.	330.5	14.64	− 4.2	15.57	333.4	13.59	+ 9.2	14.39	347.9	13.58	+15.0	14.55
2	......	......	......	......	355.4	14.93	+33.9	15.98	342.1	15.16	+ 1.0	16.23
3	350.5	16.76	−14.7	17.77	338.6	16.03	+ 3.9	16.92	355.6	16.10	+ 3.3	17.21
4	359.5	17.40	−18.8	18.32	331.9	16.51	− 8.7	17.62	355.9	16.45	+ 3.4	17.59
5	348.0	17.57	−29.2	18.51	361.5	16.49	−15.3	17.50	369.7	16.55	−14.9	17.56
Mean	337.0	13.07	−21.3	13.86	339.0	12.24	− 6.4	18.03	344.6	11.67	− 9.7	12.48
	μ		μ		μ		μ		μ		μ	
Expansion coefficient	2.83		0.97		1.97		2.95		2.32		3.00	

(2) AFTER THE MEASUREMENTS OF THE BASE.

[Length = 5 meters + tabular quantity.]

Hour	Feb. 18, 1889				Feb. 19, 1889				Feb. 20, 1889			
	No. 2		No. 1		No. 2		No. 1		No. 2		No. 1	
	Length	Temperature	Length	Temperature	Length	Temperature	Length	Temperature	Length	Temperature	Length	Temperature
	μ	°	μ	°	μ	°	μ	°	μ	°	μ	°
7 a. m.	304.9	2.46	−24.4	2.80	315.3	3.01	− 9.5	3.08	321.5	4.31	−13.2	4.45
8	307.8	2.43	−21.3	2.92	294.8	2.77	−22.6	3.10	322.1	4.26	− 8.3	4.60
9	312.7	3.09	− 9.3	3.72	295.9	3.54	− 2.1	4.21	312.0	5.12	− 7.1	5.64
10	331.1	4.43	− 1.3	5.15	313.2	5.02	+ 6.3	5.97	328.2	6.92	+ 2.7	7.63
11	337.8	6.13	+ 4.6	6.91	319.4	7.13	+12.9	8.13	338.6	9.20	+17.4	10.04
12 noon	340.1	7.83	+ 8.0	8.55	334.5	9.25	+28.9	10.19	329.3	11.30	+14.9	12.13
1 p. m.	344.8	9.43	+12.6	10.02	327.0	11.03	+13.7	11.97	332.2	13.20	+16.1	13.83
2	364.8	11.03	+33.7	11.40	360.7	12.79	+21.4	13.38	329.9	14.86	+15.3	15.54
3	365.5	12.48	+40.8	12.60	355.6	13.83	+29.0	14.31	341.1	16.50	+29.1	16.91
4	361.5	13.83	+37.4	13.64	360.8	14.91	+21.5	14.97	337.4	17.60	+25.6	17.80
5	360.1	14.79	+35.3	14.32	362.7	15.60	+16.1	15.45	327.0	18.28	+26.6	18.24
Mean	339.2	7.99	+10.6	8.37	330.9	8.99	+10.5	9.52	329.0	11.05	+10.8	11.53
	μ		μ		μ		μ		μ		μ	
Expansion coefficient	4.69		5.31		4.96		2.83		1.03		2.66	

Summary of results for differential coefficient of expansion.

Date	Bar No. 2	Bar No. 1
1888	μ	μ
Dec. 8	2.83	0.97
" 11	1.97	2.95
" 12	2.32	3.00
1889		
Feb. 18	4.69	5.31
" 19	4.96	2.83
" 20	1.03	2.66
Mean	2.97 ±0.43	2.95 ±0.38

Mean of two values 3.0μ
±0.4

That is, each bar becomes 3 microns longer when its temperature is raised 1°C.

As bars 1 and 2 are laid alternately throughout the measurement of the base, the computation may be simplified by using the average length of the two bars except for the last bar at Northwest Base, which is odd numbered.

Length and temperature of average bar from comparisons made during the base measure.

[Length=5 meters + tabular quantity.]

Date	Length	Temperature	Date	Length	Temperature	Date	Length	Temperature	Date	Length	Temperature
1888	μ	°	1889	μ	°	1889	μ	°	1889	μ	°
Dec. 13	153.6	10.72	Jan. 4	155.6	8.14	Jan. 19	140.5	4.82	Feb. 2	163.8	10.76
15	163.9	12.57	5	150.7	9.71	21	156.2	2.62	4	172.3	9.93
17	162.6	13.90	7	159.6	5.33	22	160.5	2.92	5	158.0	8.50
18	157.6	14.04	8	149.2	5.02	23	166.0	3.45	6	165.3	12.58
19	163.5	9.12	9	164.9	13.56	24	140.3	4.66	7	168.4	12.50
20	146.7	12.67	10	167.2	12.06	24	217.1	15.97	8	155.9	7.79
21	157.0	14.34	11	157.2	10.51	25	1145.4	5.14	9	147.9	6.22
28	151.1	7.11	12	162.9	12.03	26	147.1	5.22	11	154.7	6.00
29	145.9	7.87	14	154.9	8.38	28	155.5	4.50	12	169.6	10.68
31	144.2	5.90	15	159.8	4.97	29	146.0	4.84	13	164.5	9.35
1889											
Jan. 1	139.6	7.97	16	165.6	9.04	30	147.1	6.09	14	171.4	14.51
2	145.4	4.16	17	160.4	7.92	31	168.4	9.27	15	167.6	6.06
3	141.7	5.06	18	168.2	7.86	Feb. 1	146.0	6.00	15	191.3	11.57

Recapitulation by sections of the three measures of the Los Angeles base line.

Bar numbers		First measure	Second measure	Third measure	Mean	Δ₁	Δ₂	Δ₃
		m.	*m.*	*m.*	*m.*	*mm.*	*mm.*	*mm.*
1 to	100	499.96399	499.96406	499.96282	499.96362	+ 0.37	+0.44	− 0.80
101	200	499.94893	499.95037	499.94449	499.94793	+ 1.00	+2.44	− 3.44
201	300	499.94680	499.94894	499.94689	499.94754	− 0.74	+1.20	− 0.65
301	400	499.97102	499.96833	499.96966	499.96967	+ 1.35	−1.33	− 0.01
401	500	499.98071	499.98125	499.97952	499.98049	+ 0.22	+0.76	− 0.97
501	600	499.83576	499.83575	499.83866	499 83672	− 0.96	−0.97	+ 1.94
601	700	499.93950	499.93908	499.93929	499.93929	+ 0.21	−0.21	0.00
701	800	499.95670	499.95158	499.95120	499.95316	+ 3.54	−1.58	− 1.96
801	900	499.93575	499.93354	499.93822	499.93584	− 0.09	−2.30	+ 2.38
901	1000	499.95615	499.95549	499.95823	499.95662	− 0.47	−1.13	+ 1.61
1001	1120	599.86518	599.86561	599.86928	599.86669	− 1.51	−1.08	+ 2.59
1121	1200	399.96531	399.96496	399.96876	399.96634	− 1.03	−1.38	+ 2.42
1201	1300	499.92656	499.92753	499.92950	499.92786	− 1.30	−0.33	+ 1.64
1301	1400	499.93750	499.94042	499.94058	499.93950	− 2.00	+0.92	+ 1.08
1401	1500	499.96469	499.96536	499.96612	499.96539	− 0.70	−0.03	+ 0.73
1501	1600	499.93705	499.94056	499.94230	499.93997	− 2.92	+0.59	+ 2.33
1601	1700	499.94014	499.94110	499.94203	499.94109	− 0.95	+0.01	+ 0.94
1701	1800	499.97309	499.97575	499.97763	499.97549	− 2.40	+0.26	+ 2.14
1801	1902	509.96798	509.96956	509.97045	509.96933	− 1.35	+0.23	+ 1.12
1903	2000	489.98273	489.98118	489.98080	489.98157	+ 1.16	−0.39	− 0.77
2001	2100	499.98274	499.98275	499.97923	499.98157	+ 1.17	+1.18	− 2.34
2101	2200	499.96031	499.96480	499.96512	499.96341	− 3.10	+1.39	+ 1.71
2201	2300	499.90034	499.90235	499.90197	499.90155	− 1.21	+0.80	+ 0.42
2301	2408	539.94096	539.94326	539.93925	539.94116	− 0.20	+2.10	− 1.91
2409	2500	459.98346	459.98057	459.98307	459.98237	+ 1.09	−1.80	+ 0.70
2501	2600	499.99333	499.99676	499.99375	499.99461	− 1.28	+2.15	− 0.86
2601	2700	499.99364	499.99161	499.99128	499.99218	+ 1.46	−0.57	− 0.90
2701	2800	499.99283	499.98909	499.99315	499.99169	+ 1.14	−2.60	+ 1.46
2801	2900	499.98718	499.98660	499.98734	499.98704	+ 0.14	−0.44	+ 0.30
2901	3000	499.98631	499.98595	499.98562	499.98596	+ 0.35	−0.01	− 0.34
3001	3100	499.90660	499.90790	499.91031	499.90827	− 1.67	−0.37	+ 2.04
3101	3200	500.00379	500.00442	500.00498	500.00440	− 0.61	+0.02	+ 0.58
3201	3300	499.97832	499.97918	499.97835	499.97862	− 0.30	+0.56	− 0.27
3301	3400	499.98803	499.98922	499.99103	499.98943	− 1.40	−0.21	+ 1.60
3401	N.W.Base	495.80465	495.{80440 80705	495.80983	495.80673	− 2.08	−1.01	+ 3.10
Sum		17494.29803	17494.31060	17494.33071	17494.31311	−15.08	−2.51	+17.60

Length of Los Angeles Base Line as measured	17494^{m}.3131
Reduction to sea level (average elevation 27^{m}.06)	−0 .0744
Length of base reduced to sea level	17494 .2387

PROBABLE ERROR OF THE LENGTH OF THE BASE LINE.

The probable error of measurement of the three sections or measures reduces to the simple formula $r_1 = 0.6745\sqrt{\frac{[\Delta\Delta]}{6}}$ in which the Δ's are the differences of the individual measures of a section from their mean. Hence $r_1 = \pm 4^{mm}.05$, which is about 1/4320000 part of the length of the base. This includes the uncertainty due to the comparisons of the bars with the standard, since each of the three measures of a section depends on a different set of comparisons. The probable error due to the uncertainty of $\pm 0.4\mu$ in the expansion coefficient of the base bars, r_2, is $\pm 7^{mm}.00$. The uncertainty of the length and expansion coefficient of the field standard produces the probable errors, $r_3 = \pm 7^{mm}.35$ and $r_4 = \pm 6^{mm}.30$, respectively. The principal part of the probable error of the base is due to the uncertainty in the length of the Committee Meter taken as ± ¾ micron. This gives $r_5 = \pm 13^{mm}.12$. Finally, there is the uncertainty in the reduction to sea level, $r_6 = \pm 0^{mm}.40$. The square root of the sum of the squares of these six quantities gives finally for the probable error of the length of the base line $r = \pm 18^{mm}.2$, which is about 1/960000 part of the length.

Adopted length of Los Angeles Base Line:
$17494^{m}.2387 \pm 0^{m}.0182$ and its logarithm $4.242895048 \pm 0.000000452$

STATEMENTS OF ADJUSTMENTS.

Local adjustments of directions were made in every case according to the methods usually employed and fully described in previous publications of the Survey.*

The length of the Los Angeles Base with which this triangulation connects has already been given in preceding pages with the description of its measurement and reduction. The other base which completes the control of this triangulation is the Yolo, and has already been completely described.† The length of the Yolo base is $17486^{m}.5119$, with a probable error of $\pm 16^{mm}.3$, or about one part in 1073000 of its length.

The lengths and relative directions of the lines of the triangle Mount Tamalpais–Mount Diablo–Mocho, before the adjustments herein set forth were commenced, had been fixed by the adjustment published in Special Publication No. 4, "The Transcontinental Triangulation and the American Arc of the Parallel."

The figure adjustment was made in four sections.

The first section extends from the lines of the fixed triangle Mount Tamalpais–Mount Diablo–Mocho to the Los Angeles base net. (See illustrations 2 and 3.) The adjustment of this triangulation from the fixed triangle to the line San Pedro–Wilson Peak of the base net, which had been previously adjusted, involves 128 observed directions connected by 56 rigid conditions. Forty of these related to the closure of the triangles, fifteen to the ratio of sides, and the last condition was that the length of the line San Pedro–Wilson Peak carried through from the line Mount Diablo–Mocho of the Yolo base net must agree with the length computed in the Los Angeles base net.

The second section comprises the Los Angeles base net. (See subsketch, illustration 4.) The only fixed line in the figure was the base, and the number of observed directions involved was 20. There were 9 rigid conditions to be satisfied, 6 relating to the closures of the triangles and 3 to the ratios of the sides.

The third section (shown in illustration 4) extends from the triangle San Juan–San Pedro–Wilson Peak, fixed in the base net adjustment, to the line Soledad–Cuyamaca. There were 32 observed directions involved, and these were connected by 17 rigid conditions. Eleven of these conditions related to the closure of triangles and 6 to the ratios of the sides.

The fourth section (shown also in illustration 4) comprises the simple quadrilateral Boundary Monument 258–Point Loma Light-house–Soledad–Cuyamaca with the fixed line Soledad–Cuyamaca. This figure involves 10 observed directions requiring 4 rigid conditions.

These four sections do not comprise all of the triangulation now completed in this State considered of a primary character. It, however, combined with that already published in connection with the transcontinental triangulation, will serve to control the whole triangulation. The additional primary triangulation which is shown in illustrations 1 to 4, in heavy lines without numbers, has been fully adjusted to be consistent with this control. The old San Pedro Base, which was measured in 1853

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* See pp. 36–46, Special Publication No. 4.

† Ibid., pp. 116–121.

with 4-meter iron rods, was found defective. Efforts to remedy the defect by a remeasurement in 1881 were unsatisfactory. Measurement was made with a 60-meter wire and the northwest terminus was not certainly recovered. The base, therefore, appears only as a line of the triangulation.

ABSTRACTS OF HORIZONTAL DIRECTIONS AT THE MAIN STATIONS OF THE COAST TRIANGULATION BETWEEN THE GOLDEN GATE AND THE MEXICAN BOUNDARY.

The abstracts of the first three stations, Mount Tamalpais, Mount Diablo, and Mocho, are abbreviated from the preceding adjustment of these stations as forming part of the transcontinental triangulation.*

The methods and notation used in the local or station adjustment and in the net or figure adjustment are the same as explained in the account of the arc of the parallel across the country. All observed directions in the triangulation have been given equal or unit weight. The probable error of a single observation, telescope direct and telescope reversed, of a direction is found from

$$e_1^2=\frac{0.455\ \Sigma v^2}{n-s_1-d+1}$$

where n= number of observations, s= the number of series, d= the number of directions at the station, and v= the residuals. The resulting horizontal directions are reduced to the sea level, which, expressed in seconds, is given by

$$e^2h \sin 2\alpha \cos^2 \varphi/2\rho \sin 1''$$

where $e^2=(a^2-b^2)/a^2$, h= height of station sighted, ρ= the radius or curvature in a plane normal to the meridian, φ= the latitude and α= the azimuth counted from the south, westward.

The spherical excess of a triangle is computed by the usual formula,

$$\varepsilon=\frac{a_1b_1 \sin C_1}{2a^2\,(1-e^2)\sin 1''}\,[1-e^2\sin^2\varphi]^2$$

which gives ε in seconds. Hence $\varepsilon=a_1b_1 \sin C_1m$, the value of m being tabulated with the argument φ.

ABSTRACT OF RESULTING HORIZONTAL DIRECTIONS AT EACH STATION FROM LOCAL AND FROM FIGURE ADJUSTMENT.

Mount Tamalpais, Marin County, Cal. August 24 to October 9, 1882, G. Davidson, observer. 50-centimeter direction theodolite No. 115.

Number of direction	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction from previous figure adjustment	Correction from present adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″	″
	Mount Diablo	0	00	00.000	−0.011	$\overline{59.989}$	+0.277	.....	00.266
	Mocho	23	47	56.302	−0.071	56.231	+0.422	.....	56.653
3	Sierra Morena	61	37	29.923	−0.037	29.886	+0.026	+0.328	30.240

Circle used in 23 positions. Probable error of a single observation of a direction (D. & R.) = ±0″.54.

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* See pp. 575, 598, and 599 of Special Publication No. 4.

Mount Diablo, Contra Costa County, Cal. June 25 to September 8, 1876, G. Davidson and W. Eimbeck, observers. 50-centimeter theodolite No. 5. November 14 to December 29, 1884, R. A. Marr, observer. 50-centimeter theodolite No. 115. June 28 to July 19, 1892, G. Davidson, observer. 50-centimeter theodolite No. 115.

Number of direction	Object observed.	Resulting direction from station adjustment.			Reduction to sea level	Resulting seconds	Correction from previous figure adjustment	Correction from present adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″	″
	Mount Helena	0	00	00.000	−0.082	59.918	−0.645	.....	59.273
	Mocho	180	16	12.207	−0.080	12.127	+0.004	.....	12.131
1	Loma Prieta	211	22	06.404	−0.011	06.393	+0.091	+0.011	06.495
2	Sierra Morena	249	16	39.858	+0.046	39.904	+0.091	−0.234	39.761
	Mount Tamalpais	310	12	09.226	−0.008	09.218	−0.047	.....	09.171

In 1884 circle used in 23 positions. In 1892 circle used in 51 positions. Probable error of a single observation of a direction (D. & R.) = ±0″.72.

Mocho, Santa Clara County, Cal. August 19 to October 30, 1887. J. S. Lawson, F. Morse, and P. A. Welker, observers. 50-centimeter theodolite No. 115.

		°	′	″	″	″	″	″	″
	Azimuth Mark	0	00	00.000	.....	00.000	.....	.....	......
8	Santa Ana	176	18	45.389	−0.057	45.332	+0.002	−0.157	45.177
9	Mount Toro	203	17	21.473	+0.007	21.480	+0.002	+0.190	21.672
10	Loma Prieta	232	55	15.468	+0.072	15.540	+0.002	+0.215	15.757
11	Sierra Morena	284	31	49.647	+0.011	49.658	+0.002	+0.065	49.725
	Mount Tamalpais	319	22	10.160	−0.046	10.114	−0.010	.....	10.104
	Mount Diablo	345	38	23.364	−0.076	23.288	−0.176	.....	23.112

Circle used in 23 positions. Probable error of a single observation of a direction (D. & R.) = ±0″.70.

Sierra Morena, San Mateo County, Cal. E. F. Dickins, observer. November 28, 1883 to January 15, 1884. 50-centimeter direction theodolite No. 115.

Number of direction	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction from present adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″
4	Mount Tamalpais	0	00	00.000	−0.040	59.960	+0.326	00.286
	Rocky Mound	30	15	57.947	.....	......	.....	......
5	Mount Diablo	57	27	09.550	+0.074	09.624	−0.325	09.299
	Red Hill	74	14	10.754	.....	......	.....	......
6	Mocho	107	20	16.128	+0.020	16.148	+0.313	16.461
	Lick Observatory Dome	121	05	37.148	−0.023	37.125	.....	......
7	Loma Prieta	152	40	58.866	−0.079	58.787	−0.314	58.473
	Southeast Farrallon Lighthouse	321	46	58.74	.....	......	.....	......

Circle used in 23 positions. Probable error of a single observation of a direction (D. & R.) = ±0″.56.

Loma Prieta, Santa Clara and Santa Cruz counties, Cal. E. F. Dickins, observer. February 24 to March 17, 1884. 50-centimeter direction theodolite No. 115.

Number of direction	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction from present adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″
14	Mocho	0	00	00.000	+0.079	00.079	−0.013	00.066
	Lick Observatory Dome	2	46	35.868	+0.084	35.952	.....	......
15	Santa Ana	80	33	22.047	−0.055	21.992	+0.006	21.998
16	Mount Toro	130	00	01.638	−0.045	01.593	−0.045	01.548
12	Sierra Morena	276	57	09.135	−0.050	09.085	+0.555	09.640
13	Mount Diablo	323	48	56.126	−0.012	56.144	−0.504	55.610

Circle used in 23 positions. Probable error of a single observation of a direction (D. & R.) =±0″.56.

Santa Ana, San Benito County, Cal. E. F. Dickins, observer. November 30 to December 9, 1885. 50-centimeter direction theodolite No. 115.

		°	′	″	″	″	″	″
19	Mount Toro	0	00	00.000	+0.075	00.075	+0.015	00.090
20	Loma Prieta	74	14	55.541	−0.057	55.484	+0.042	55.526
	Lick Observatory Dome	104	28	55.30	−0.087	55.213	.....	......
21	Mocho	117	05	10.157	−0.064	10.093	+0.016	10.109
17	Hepsedam	291	58	17.793	−0.079	17.714	−0.055	17.659
18	Santa Lucia	332	28	17.630	+0.049	17.679	−0.019	17.660

Circle used in 23 positions. Probable error of a single observation of a direction (D. & R.) =±0″.57.

Mount Toro, Monterey County, Cal. R. A. Marr, observer. January 20 to February 15, 1885. 50-centimeter direction theodolite No. 115.

		°	′	″	″	″	″	″
22	Loma Prieta	0	00	00.000	−0.047	$\overline{59.953}$	+0.074	00.027
	Lick Observatory Dome	15	55	53.525	−0.006	53.519	.....	......
23	Mocho	20	22	10.895	+0.008	10.903	−0.071	10.832
	Gavilan	35	08	50.621	+0.034	50.655	.....	......
24	Santa Ana	56	18	32.742	+0.075	32.817	−0.014	32.803
25	Hepsedam	125	59	16.573	−0.056	16.517	+0.045	16.562
26	Santa Lucia	175	39	38.445	−0.088	38.357	−0.034	38.323
	Santa Cruz Light-house	339	41	17.195	.....	......	.....	......

Circle used in 23 positions. Probable error of a single observation of a direction (D. & R.) =±0″.56.

Hepsedam, San Benito County, Cal. J. S. Lawson, observer. December 16, 1885, to January 6, 1886. 30-centimeter direction theodolite No. 131.

		°	′	″	″	″	″	″
27	Castle Mount	0	00	00.000	−0.095	$\overline{59.905}$	−0.093	$\overline{59.812}$
28	Rocky Butte	62	53	06.470	+0.041	06.511	−0.314	06.197
29	Santa Lucia	117	16	16.232	+0.079	16.311	+0.489	16.800
30	Mount Toro	155	05	36.893	−0.045	36.848	−0.095	36.753
31	Santa Ana	197	23	20.132	−0.066	20.066	+0.014	20.080

Circle used in 23 positions. Probable error of a single observation of a direction (D. & R.) =±1″.00.

Santa Lucia, Monterey County, Cal. E. F. Dickins, observer. October 10 to 24, 1885. 50-centimeter direction theodolite No. 115.

Number of direction	Object observed	Resulting direction from station adjustment.			Reduction to sea level	Resulting seconds	Correction from present adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″
32	Mount Toro	0	00	00.000	−0.053	59.947	+0.120	00.067
33	Santa Ana	33	07	17.591	+0.029	17.620	−0.073	17.547
34	Hepsedam	92	30	25.445	+0.061	25.506	−0.608	24.898
35	Castle Mount	124	58	25.575	−0.041	25.534	+0.317	25.851
36	Rocky Butte	170	34	53.115	−0.066	53.049	+0.245	53.294

Circle used in 23 positions. Probable error of a single observation of a direction (D. & R.) =±0″.56.

Rocky Butte, San Luis Obispo County, Cal. J. S. Lawson, observer. November 27, 1884, to January 31, 1885. 30-centimeter direction theodolite No. 131.

		°	′	″	″	″	″	″
44	Castle Mount	0	00	00.000	+0.074	00.074	+0.492	00.566
45	San Jose	53	28	15.597	−0.069	15.528	+0.173	15.701
46	San Luis	68	40	53.141	−0.063	53.078	−1.158	51.920
	Saddle Peak	88	57	26.097	−0.032	26.065	.....	......
47	Lospe	89	23	21.415	−0.029	21.386	+0.314	21.700
42	Santa Lucia	264	01	23.627	−0.114	23.513	−0.302	23.211
43	Hepsedam	311	33	52.460	+0.051	52.511	+0.482	52.993

Circle used in 23 positions. Probable error of a single observation of a direction (D. & R.)=±1.″20.

Castle Mount, Monterey and Fresno counties, Cal. J. S. Lawson, observer. October 6 to 30, 1885. 30-centimeter direction theodolite No. 131.

		°	′	″	″	″	″	″
41	Hepsedam	0	00	00.000	−0.097	59.903	−0.096	59.807
37	San Jose	220	50	04.090	−0.015	04.075	−0.370	03.705
38	San Luis	241	30	24.392	+0.032	24.424	+1.341	25.765
39	Rocky Butte	291	19	04.369	+0.059	04.428	−0.905	03.523
40	Santa Lucia	329	44	10.067	−0.059	10.008	+0.029	10.037

Circle used in 23 positions. Probable error of a single observation of a direction (D. & R.)=±1.″09.

San Luis, San Luis Obispo County, Cal. J. S. Lawson, observer. November 9 to December 6, 1883. 30-centimeter direction theodolite No. 131.

		°	′	″	″	″	″	″
57	Lospe	0	00	00.000	+0.007	00.007	−0.273	59.734
	Saddle Peak	68	20	51.216	+0.022	51.238	.....	......
53	Rocky Butte	128	16	44.748	−0.076	44.672	+1.179	45.851
54	Castle Mount	189	47	27.721	+0.049	27.770	−0.440	27.330
55	San Jose	255	36	21.318	+0.025	21.343	−0.077	21.266
56	Tepusquet	314	28	06.035	−0.072	05.963	−0.389	05.574

Circle used in 23 positions. Probable error of a single observation of a direction (D. & R.)=±1.″76.

San Jose, San Luis Obispo County, Cal. J. S. Lawson, observer. January 1 to 19, 1884. 30-centimeter direction theodolite No. 131.

Number of direction	Object observed	Resulting direction from station adjustment.			Reduction to sea level	Resulting seconds	Correction from present adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″
48	Tepusquet	0	00	00.000	−0.024	59.976	+0.654	00.630
49	Lospe	42	57	06.086	+0.034	06.120	−0.803	05.317
	Saddle Peak	87	31	55.099	+0.017	55.116	.....	......
50	San Luis	90	47	29.355	+0.020	29.375	+0.114	29.489
51	Rocky Butte	128	15	20.918	−0.064	20.854	+0.390	21.244
52	Castle Mount	184	18	18.605	−0.018	18.587	−0.353	18.234

Circle used in 23 positions. Probable error of a single observation of a direction (D. & R.) = ±1.″28.

Lospe, Santa Barbara County, Cal. J. S. Lawson, observer. February 6 to May 15, 1883. 30-centimeter direction theodolite No. 131.

		°	′	″	″	″	″	″
61	Tepusquet	0	00	00.000	+0.007	00.007	+0.029	00.036
62	Gaviota	52	04	21.897	−0.055	21.842	−0.085	21.757
63	Arguello	86	03	08.412	−0.012	08.400	−0.253	08.147
58	Rocky Butte	247	14	08.253	−0.060	08.193	−0.797	07.396
	Saddle Peak	247	49	23.012	−0.031	22.981	.....	......
59	San Luis	278	14	55.884	+0.012	55.896	+0.927	56.823
60	San Jose	306	00	56.759	+0.077	56.836	+0.181	57.017

Circle used in 20 positions. Probable error of a single observation of a direction (D. & R.) ± = 1.″20.

Tepusquet, Santa Barbara County, Cal. J. S. Lawson, observer. October 6 to November 26, 1882. 30-centimeter direction theodolite No. 131.

		°	′	″	″	″	″	″
61	Lospe	0	00	00.000	+0.004	00.004	+0.059	00.063
	Saddle Peak	34	49	28.854	−0.037	28.817	.....	......
67	San Luis	52	43	06.727	−0.063	06.664	+0.157	06.821
68	San Jose	83	03	57.355	−0.028	57.327	−0.559	56.768
64	Gaviota	274	00	17.696	+0.003	17.699	+0.028	17.727
65	Arguello	316	05	04.272	+0.049	04.321	+0.315	04.636

Circle used in 17 positions. Probable error of a single observation of a direction (D. & R.) = ±1.″33.

Arguello, Santa Barbara County, Cal. O. H. Tittmann, observer. December 30, 1875, to February 18, 1876. 45-centimeter direction theodolite No. 4.

		°	′	″	″	″	″	″
	Azimuth Mark	0	00	00.000	.....	00.000	.....	......
72	Santa Cruz West	24	22	55.866	−0.016	55.850	+0.151	56.001
73	New San Miguel	55	52	42.260	−0.009	42.251	+0.249	42.500
69	Lospe	254	07	55.341	−0.009	55.332	+0.302	55.634
70	Tepusquet	294	09	55.703	+0.073	55.776	−0.299	55.477
71	Gaviota	355	53	02.801	−0.028	02.773	−0.402	02.371

Circle used in 7 positions. Probable error of a single observation of a direction (D. & R.) = ±1.″24.

Gaviota, Santa Barbara County, Cal. O. H. Tittmann, observer. May 10 to 18, and October 5 to December 6, 1875. 45-centimeter direction theodolite No. 4.

Number of direction	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction from present adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″
	Azimuth Mark	0	00	00.000	.....	00.000	.....	......
74	Santa Barbara	33	44	50.627	−0.005	50.622	−0.313	50.309
75	Santa Cruz East	60	24	38.908	−0.007	38.901	−0.216	38.685
76	Santa Cruz West	81	38	20.201	−0.014	20.187	+0.202	20.389
77	New San Miguel	128	56	22.731	+0.011	22.742	+0.019	22.761
78	Arguello	215	26	47.323	−0.025	47.298	+0.324	47.622
79	Lospe	249	42	57.272	−0.037	57.235	+0.087	57.322
80	Tepusquet	291	38	57.772	+0.004	57.776	−0.102	57.674

Circle used in 8 positions. Probable error of a single observation of a direction (D. & R.) = ± 1.″04.

New San Miguel, Santa Barbara County, Cal. O. H. Tittmann, observer, November 8 to December 18, 1873. 45-centimeter direction theodolite No. 4.

Number of direction	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction from present adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″
	Azimuth Mark	0	00	00.000	.....	00.000	.....	......
83	Santa Cruz West	42	58	26.595	+0.003	26.598	+0.267	26.865
81	Arguello	303	05	29.463	−0.025	29.438	−0.235	29.203
82	Gaviota	336	35	28.945	+0.034	28.979	−0.033	28.946

Circle used in 7 positions. Probable error of a single observation of a direction (D. & R.) = ± 0.″82.

Santa Cruz West, Santa Barbara County, Cal. O. H. Tittmann, observer, January 23 to March 10, 1874. 45-centimeter direction theodolite No. 4.

Number of direction	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction from present adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″
84	New San Miguel	0	00	00.000	+0.003	00.003	−0.261	59.742
85	Arguello	48	37	22.322	−0.049	22.273	+0.086	22.359
86	Gaviota	66	19	05.313	−0.047	05.266	−0.347	04.919
87	Santa Barbara	121	37	35.989	+0.008	35.997	+0.485	36.482
88	Santa Cruz East	188	14	27.208	.000	27.208	+0.036	27.244
	Azimuth Mark	205	27	28.120	.....	......	.....	......

Circle used in 7 positions. Probable error of a single observation of a direction (D. & R.) = ± 1.″20.

Santa Barbara, Santa Barbara County, Cal. J. Kincheloe, observer in 1862, 1863. 20-centimeter repeating theodolite No. 44. G. Davidson, observer in 1869. 45-centimeter direction theodolite No. 4. W. E. Greenwell, observer in 1870. 20-centimeter repeating theodolite No. 44. O. H. Tittmann and W. Eimbeck, observers in 1874. 45-centimeter direction theodolite No. 4. A. T. Mosman, observer, July 8 to August 5, 1898. 50-centimeter direction theodolite No. 115.

Number of direction	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction from present adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″
	Pelican	0	00	00.00	.....	00.00	.....	......
93	Gaviota	13	31	19.29	−0.025	19.265	+0.223	19.488
	Azimuth mark	88	29	51.44	.....	51.44	.....	......
89	Chaffee	197	42	39.03	−0.015	39.015	−0.330	38.69
	San Buenaventura	200	10	45.41	.....	......	.....	......
90	Laguna	208	17	46.81	−0.03	46.78	+0.657	47.44
	Anacapa	234	56	13.36	.....	......	.....	......
91	Santa Cruz East	250	01	46.020	−0.005	46.015	−0.083	45.932
92	Santa Cruz West	296	43	16.92	+0.013	16.933	−0.467	16.466

Circle used in 7 positions in 1874. Probable error of a single observation of a direction (D. & R.) = ±1″.30.

Circle used in 12 positions in 1898. Probable error of a single observation of a direction (D. & R.) = ±0″.75.

Santa Cruz East, Santa Barbara County, Cal. W. E. Greenwell, observer in 1857. 20-centimeter repeating theodolite No. 44. J. Kincheloe, observer in 1863. Same instrument. O. H. Tittmann, observer in 1876. 45-centimeter direction theodolite No. 4. W. B. Fairfield, observer, July 19 to August 7, 1898. 50-centimeter direction theodolite No 114.

		°	′	″	″	″	″	″
94	Santa Cruz West	0	00	00.00	−0.002	$\overline{59.998}$	−0.012	$\overline{59.986}$
95	Gaviota	36	50	59.513	−0.055	59.458	+0.313	59.771
96	Santa Barbara	66	41	41.763	−0.006	41.757	+0.076	41.833
97	Chaffee	124	34	39.14	+0.02	39.16	−0.188	38.97
	San Buenaventura	135	56	42.126	....	.....	.....	.....
98	Santa Clara	144	21	52.53	+0.05	52.58	+0.280	52.86
99	Laguna	168	48	39.77	+0.01	39.78	−0.469	39.31
	Anacapa	193	30	17.709	....	.....	.....	.....

Circle used in 7 positions in 1876. Probable error of a single observation of a direction (D. & R.) = ±1″.47.

Circle used in 12 positions in 1898. Probable error of a single observation of a direction (D. & R.) = ±0″.40.

Chaffee, Ventura County, Cal. A. T. Mosman, observer. August 19 to 28, 1898. 50-centimeter direction theodolite No. 115.

		°	′	″	″	″	″	″
101	Laguna	0	00	00.00	−0.03	$\overline{59.97}$	+0.46	00.43
102	Santa Cruz East	87	28	04.93	+0.01	04.94	−0.27	04.67
103	Santa Barbara	157	16	03.08	−0.01	03.07	+0.29	03.36
100	Santa Clara	313	05	41.42	+0.01	41.43	−0.48	40.95

Circle used in 12 positions. Probable error of a single observation of a direction (D. & R.) = ±0″.97.

Laguna, Ventura County, Cal. O. H. Tittmann, observer. January 15 to February 7, 1877. 45-centimeter direction theodolite No. 4. W. B. Fairfield, observer. September 6 to 11, 1898. 50-centimeter direction theodolite No. 114.

Number of direction	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction from present adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″
108	Castro	0	00	00.00	−0.01	$\overline{59.99}$	−0.54	$\overline{59.45}$
109	San Pedro	25	03	49.80	−0.03	49.77	+0.77	50.54
	Santa Barbara Island	82	40	33.503	....	.....	....	.....
	Anacapa	153	53	57.147	....	.....	....	.....
104	Santa Cruz East	167	12	53.61	0.00	53.61	+0.13	53.74
	Hueneme Light-house	191	32	54.70 56.35	....	55.52	....	.....
105	Santa Barbara	203	22	03.25	−0.01	03.24	−0.71	02.53
106	Chaffee	215	30	52.12	−0.03	52.09	−0.05	52.04
	San Buenaventura	217	33	22.316	....	.....	....	.....
107	Santa Clara	270	04	24.76	+0.01	24.77	+0.41	25.18

Circle used in 7 positions in 1877. Probable error of a single observation of a direction (D. & R.) =±1″.14.

Circle used in 12 positions in 1898. Probable error of a single observation of a direction (D. & R.) =±0″.82.

Santa Clara, Ventura County, Cal. A. T. Mosman, observer. September 9 to 17, 1898. 50-centimeter direction theodolite No. 115.

		°	′	″	″	″	″	″
112	Laguna	0	00	00.00	+0.01	00.01	−0.55	$\overline{59.46}$
113	Santa Cruz East	52	41	43.48	+0.01	43.49	+0.87	44.36
114	Chaffee	78	32	08.47	+0.01	08.48	−0.02	08.46
110	San Fernando	263	35	32.54	0.00	32.54	−0.27	32.27
111	Castro	313	01	15.33	−0.06	15.27	−0.02	15.25

Circle used in 12 positions. Probable error of a single observation of a direction (D.& R.)=±0″.73.

Castro, Los Angeles County, Cal. F. Morse, observer. October 15 to 20, 1898. 50-centimeter direction theodolite No. 114.

		°	′	″	″	″	″	″
116	Santa Clara	0	00	00.00	−0.05	$\overline{59.95}$	−0.10	$\overline{59.85}$
117	San Fernando	73	18	20.83	+0.08	20.91	−0.56	20.35
118	Wilson Peak	118	04	42.43	+0.06	42.49	+0.42	42.91
119	San Pedro	173	14	30.71	−0.03	30.68	−0.22	30.46
115	Laguna	316	54	16.28	−0.01	16.27	+0.47	16.74

Circle used in 12 positions. Probable error of a single observation of a direction (D.& R.)=±0″.69.

San Fernando, Los Angeles County, Cal. A. T. Mosman, observer. October 6 to 11, 1898. 50-centimeter direction theodolite No. 115.

		°	′	″	″	″	″	″
122	Castro	0	00	00.00	+0.06	00.06	+0.28	00.34
123	Santa Clara	57	15	59.33	0.00	59.33	+0.28	59.61
120	Wilson Peak	250	57	44.88	−0.06	44.82	−0.87	43.95
121	San Pedro	307	00	32.34	−0.02	32.32	+0.31	32.63

Circle used in 12 positions. Probable error of a single observation of a direction (D.& R.)=±0″.89.

San Pedro, Los Angeles County, Cal. October 22 to November 10, 1878. 45-centimeter direction theodolite No. 4. D. B. Wainwright, observer. September 23 to 29, 1896. 25-centimeter repeating theodolite No. 54. E. F. Dickins, observer. October 27 to November 18, 1898. 50-centimeter direction theodolite No. 115. A. T. Mosman, observer.

Number of direction	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction from base net adjustment	Correction from adjustment, first section	Correction from adjustment, third section	Final seconds in triangulation
		°	′	″	″	″	″	″	″	″
125	Castro	0	00	00.00	−0.06	59.94	....	−0.47	....	59.47
126	San Fernando	27	04	25.84	−0.06	25.78	....	+0.37	....	26.15
13	Wilson Peak	73	11	40.87	+0.10	40.97	+0.13	....	....	41.10
14	Los Angeles N.W.B.	101	09	36.49	0.00	36.49	+0.38	....	....	36.87
	Los Cerritos	117	12	57.14	+0.01	57.15	....	....	....	.....
15	San Juan	118	57	57.48	+0.03	57.51	−1.22	....	....	56.29
16	Los Angeles S. E. B.	129	30	50.42	0.00	50.42	+0.70	....	....	51.12
1	Santiago	140	31	21.19	−0.01	21.18	....	....	−0.21	20.97
	Las Bolsas	150	33	42.85	0.00	42.85	....	....	....	.....
2	Niguel	162	26	10.45	−0.02	10.43	....	....	−0.91	09.52
	Catalina Peak	236	20	29.74	....	.....	....	....	....	.....
	West Peak	261	59	51.62	....	.....	....	....	....	.....
	Santa Barbara Island	293	00	19.71	....	.....	....	....	....	.....
124	Laguna	348	43	35.01	0.03	34.98	....	−0.33	....	34.65

Circle used in 5 positions in 1878, and in 12 positions in 1898. In 1896 each angle was measured in 16 sets or more of 6 repetitions (3D. & 3R.) each. Probable error of an observation of an angle (3D. & 3R.) = ±0″.94. Probable error of a single observation of a direction (mean of D. & R.) in 1898 = ±0″.96.

San Juan, Orange County, Cal. October 15 to 23, 1896. 50-centimeter direction theodolite No. 115. E. F. Dickins, observer. June 16 to 26, 1899. 50-centimeter direction theodolite No. 115. A. T. Mosman, observer.

Number of direction	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction from base net adjustment	Correction from adjustment third section	Final seconds in triangulation
		°	′	″	″	″	″	″	″
9	Los Angeles S. E. Base	0	00	00.00	0.00	00.00	−0.24	....	59.76
10	San Pedro	16	54	50.27	+0.02	50.29	+0.10	....	50.39
11	Los Angeles N. W. Base	36	20	16.82	0.00	16.82	−0.12	....	16.70
12	Wilson Peak	84	26	21.16	−0.13	21.03	+0.25	....	21.28
12	San Jacinto	221	25	35.38	−0.05	35.33	....	+0.82	36.15
13	Santiago	265	18	53.45	−0.13	53.32	....	+1.08	54.40
14	Niguel	304	51	03.34	0.00	03.34	....	+0.46	03.80

Circle used in 17 positions in 1896, and in 12 positions in 1899. Probable error of a single observation of a direction (mean D. & R.) in 1896 = ±0″.70; in 1899 = ±0″.92.

Wilson Peak, Los Angeles County, Cal. November 11 to 15, 1896. 50-centimeter direction theodolite No. 115. E. F. Dickins, observer. November 13 to December 3, 1898. 50-centimeter direction theodolite No. 115. A. T. Mosman, observer.

Number of direction	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction from base net adjustment	Correction from adjustment first section	Correction from adjustment third section	Final seconds in triangulation
		°	′	″	″	″	″	″	″	″
127	Castro	0	00	00.00	−0.03	00.03	....	+0.18	....	00.21
128	San Fernando	26	11	24.76	−0.04	24.72	....	+0.46	....	25.18
3	San Jacinto	211	53	36.91	−0.15	36.76	....	....	−0.87	35.89
17	San Juan	241	39	01.33	−0.04	01.29	−0.08	....	....	01.21
4	Santiago	241	59	38.85	−0.02	38.83	....	....	−0.59	38.24
5	Niguel	261	36	53.30	−0.01	53.29	....	....	−1.15	52.14
18	Los Angeles S. E. Base	269	41	42.83	0.00	42.83	−0.46	....	....	42.37
19	Los Angeles N.W. Base	282	00	47.14	0.00	47.14	+0.68	....	....	47.82
20	San Pedro	308	21	21.48	+0.03	21.51	−0.14	....	....	21.37

Circle used in 17 positions in 1896 and in 12 positions in 1898. Probable error of a single observation of a direction (mean D. & R.) in 1896 = ± 0″.63; in 1898 = ± 1″.09.

Los Angeles Northwest Base, Los Angeles County, Cal. June 2 to 8, 1890. 50-centimeter direction theodolite No. 115. J. J. Gilbert, observer. (G. Davidson, chief of party.)

Number of direction.	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction for figure adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″
4	Los Angeles S. E. Base	0	00	00.00	0.00	00.00	+0.31	00.31
	Las Bolsas	27	02	37.86	0.00	37.86	....	37.86
	Los Cerritos	74	21	10.18	+0.01	10.19	....	10.19
1	San Pedro	91	03	14.97	+0.03	15.00	−0.14	14.86
2	Wilson Peak	216	44	48.16	0.00	48.16	−0.38	47.78
3	San Juan	308	16	58.93	0.00	58.93	+0.21	59.14

Circle used in 47 positions. Probable error of a single observation of a direction (mean D. & R.) = ±0″.61.

Los Angeles Southeast Base, Orange County, Cal. May 6 to 30, 1890. 50-centimeter direction theodolite No. 115. J. J. Gilbert, observer. (G. Davidson, chief of party.)

		°	′	″	″	″	″	″
6	Los Angeles N. W. Base	0	00	00.00	0.00	00.00	−0.22	59.78
7	Wilson Peak	24	25	42.91	−0.06	42.85	−0.13	42.72
8	San Juan	91	56	42.07	+0.04	42.11	+0.60	42.71
	Las Bolsas	242	59	18.91	0.00	18.91	....	18.91
5	San Pedro	299	24	27.39	+0.01	27.40	−0.25	27.15
	Los Cerritos	309	36	24.94	0.00	24.94	....	24.94

Circle used in 47 positions. Probable error of a single observation of a direction (mean D. & R.) = ±0″.80.

Niguel, Orange County, Cal. December 10 to 22, 1898. 50-centimeter direction theodolite No. 115. A. T. Mosman, observer.

Number of direction	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction for figure adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″
9	Santiago	0	00	00.00	+0.13	00.13	-0.05	00.08
10	Cuyamaca	80	23	42.64	-0.13	42.51	-0.08	42.43
11	Soledad	108	40	32.94	-0.02	32.92	-0.90	32.02
6	San Pedro	254	55	35.74	-0.03	35.71	+0.64	36.35
7	Wilson Peak	298	56	47.33	-0.09	47.24	+0.65	47.89
8	San Juan	319	23	45.09	0.00	43.09	-0.27	42.82

Circle used in 12 positions. Probable error of a single observation of a direction (mean D. & R.) = ± 0″.69.

Santiago, Orange County, Cal. August 28 to September 2, 1899. 50-centimeter direction theodolite No. 114. W. B. Fairfield, observer. (A. T. Mosman, chief of party.)

		°	′	″	″	″	″	″
20	Wilson Peak	0	00	00.00	-0.02	-00.02	-0.75	59.23
21	San Juan	0	31	55.77	-0.04	55.73	-0.36	55.37
15	San Jacinto	121	53	13.46	+0.07	13.53	-0.20	13.33
16	Cuyamaca	174	37	20.76	-0.15	20.61	+0.10	20.71
17	Soledad	205	08	41.76	-0.01	41.75	+0.76	42.51
18	Niguel	260	40	19.94	+0.02	19.96	-0.05	19.91
19	San Pedro	313	41	11.48	0.00	11.48	+0.50	11.98

Circle used in 12 positions. Probable error of a single observation of a direction (mean D. & R.) = ±0″.63.

Cuyamaca, San Diego County, Cal. July 26 to August 27, 1899. 50-centimeter direction theodolite No. 115. A. T. Mosman, observer.

Number of direction	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction from previous figure adjustments	Correction from present adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″	″
	San Miguel	0	00	00.00	+0.06	00.06	....	....	.....
2	Point Loma L. H. (old)	14	53	21.21	+0.01	21.22	....	-0.17	21.05
25	Soledad	30	57	04.87	+0.01	04.88	+0.08	....	04.96
26	Niguel	73	01	23.02	-0.02	23.00	-0.02	....	22.98
27	Santiago	86	34	50.04	-0.13	49.91	+0.34	....	50.25
28	San Jacinto	127	52	28.08	-0.04	28.04	-0.39	....	27.65
	Tecate	322	35	10.7	....	10.7	....	....	.....
1	Boundary Mon. 258	358	37	27.36	0.00	27.36	....	-0.18	27.18

Circle used in 12 positions. Probable error of a single observation of a direction (mean D. & R.) = ±0″.65.

San Jacinto, Riverside County, Cal. July 24 to 28, 1899. 50-centimeter direction theodolite No. 114. W. B. Fairfield, observer. (A. T. Mosman, chief of party.)

Number of direction	Object observed	Resulting direction from station adjustment			Reduction to sea level	Resulting seconds	Correction from previous figure adjustments	Correction from present adjustment	Final seconds in triangulation
		°	′	″	″	″	″	″	″
29	Cuyamaca	0	00	00.00	−0.02	−00.02	.....	+0.16	00.14
30	Santiago	85	58	34.59	+0.04	34.63	.....	+0.33	34.96
31	San Juan	100	44	04.06	−0.02	04.04	.....	−0.18	03.86
32	Wilson Peak	113	59	31.83	−0.08	31.75	.....	−0.30	31.45
	San Bernardino Meridian	150	45	47.50	....	.....	....	.....	.....
	San Bernardino, cairn	154	05	13.35	....	.....	....	.....	.....

Circle used in 12 positions. Probable error of a single observation of a direction (mean D. & R.) = ±0″.70.

Soledad, San Diego County, California. January 6 to January 24, 1899. A. T. Mosman, observer. 50-centimeter direction theodolite No. 115.

		°	′	″	″	″	″	″	″
	Azimuth Mark	0	00	00.00	....	00.00	...	....	.....
24	Cuyamaca	80	10	51.14	+0.06	51.20	−0.19	....	51.01
	San Miguel	119	36	45.63	−0.05	45.58	...	....	.....
3	Boundary Mon. 258	161	39	48.74	0.00	48.74	...	−0.36	48.38
4	Point Loma L. H. (old)	178	07	50.27	0.00	50.27	...	+1.01	51.28
22	Niguel	330	31	45.46	−0.02	45.44	+0.35	....	45.79
23	Santiago	346	19	42.71	−0.07	42.64	−0.16	....	42.48

Circle used in 12 positions. Probable error of a single observation of a direction (mean D. & R.) = ±1″.08.

Boundary Monument 258. United States and Mexico. January, 1899. F. Morse, observer. 20-centimeter repeating theodolite No. 148.

Number of direction.	Object observed.	Resulting direction at station.			At sea level.	Correction from adjustment.	Final seconds in triangulation.
		°	′	″	″	″	″
9	Soledad	0	00	00.00	$\overline{59.99}$	+0.96	00.95
10	Cuyamaca	66	11	31.34	31.49	−0.13	31.36
8	Point Loma Light-house (old)	343	43	18.39	18.39	−0.83	17.56

Point Loma Light-house (*old*), San Diego County, California. January, 1899. F. Morse, observer. 20-centimeter repeating theodolite No. 148.

		°	′	″	″	″	″
5	Soledad	0	00	00.00	00.00	−1.31	$\overline{58.69}$
6	Cuyamaca	65	59	16.51	16.63	+0.77	17.40
	San Miguel	87	49	02.07	02.08	....	.....
7	Boundary Monument 258	147	15	12.34	12.34	+0.54	12.88

From the preceding abstracts of directions it may be seen that there was no uniformity among the observers as to the number of positions in which to put the horizontal circle of their instruments; thus Assistant Tittmann was satisfied with seven, Assistant Mosman with twelve, Assistants Lawson and Dickins with thirty-three, while in one case Assistant Davidson went to the extreme of fifty-one positions, thus shifting the circle after *every* series. The latter observer was also in the habit of making a half dozen, more or less, pointings with the eyepiece micrometer before reading the microscopes of the horizontal circle, in the place of the single pointing of the telescope. In this practice he was followed at some stations by Assistants Lawson, Dickins, and Marr who acted, in part, under his direction. It is doubtful whether much advantage was gained by the use of the eyepiece micrometer, since the telescope is likely to be disturbed in direction by frequent handling of the screw. The climatic influence relative to proximity of the sea and altitude of station may also be a factor in the probable error e_1 of a single observation of a direction, that is, with telescope direct and telescope reversed. For the coast region between the Golden Gate and the Santa Barbara Channel and for the two 50-centimeter theodolites with a large number of positions, from 8 stations

$$e_1 = \pm 0''.60;$$

but for the Santa Barbara region, and inclusive of 5 stations farther toward the Mexican boundary, with a small number of positions and no eyepiece micrometer measures, from 14 stations

$$e_1 = \pm 0''.78.$$

The values of e_1 for the other two smaller and older instruments are, for the 45-centimeter circle from 7 stations, ±1''.17; and for the 30-centimeter circle at the same number of stations, ±1''.27. The number of series taken at a station varies greatly, depending largely on the weather encountered, in order to secure a sufficient number of pointings on *every* signal.

CONDITION EQUATIONS.

In the following condition equations the numbers assigned to the directions correspond to those shown in illustrations 2 to 4. The number of a direction inclosed in parentheses, thus (1), means the required correction to that direction. In each set of condition equations those which refer to closures of triangles are given first, those which refer to ratios of sides next, and the length equation last. In the side and length equations the absolute term is expressed in units of the sixth decimal place of logarithms.

Yolo base net to Los Angeles base net.

No.

I $0=+0.089-(2)+(3)-(4)+(5)$

II $0=-0.338+(2)-(5)+(6)-(11)$

III $0=-1.1-1.98(2)+1.57(3)+1.86(11)$

IV $0=+1.294-(1)+(2)-(5)+(7)-(12)+(13)$

V $0=+1.345-(6)+(7)-(10)+(11)-(12)+(14)$

VI $0=+1.1-3.49(1)+0.81(2)+1.77(5)-3.85(6)+2.08(7)+0.26(12)-2.88(13)+2.62(14)$

VII $0=+0.151-(9)+(10)-(14)+(16)-(22)+(23)$

VIII $0=+0.112-(15)+(16)-(19)+(20)-(22)+(24)$

IX $0=-0.404-(8)+(9)-(19)+(21)-(23)+(24)$

X $0=-0.2+1.39(8)--3.70(9)+2.31(10)+0.59(19)-2.86(20)+2.27(21)+4.27(22)-5.67(23)+1.40(24)$

XI $0=-0.239-(17)+(19)-(24)+(25)-(30)+(31)$

XII $0=+0.179-(18)+(19)-(24)+(26)-(32)+(33)$

XIII $0=+0.973-(17)+(18)-(29)+(31)-(33)+(34)$

XIV $0=-2.6+0.85(17)-4.04(18)+3.19(19)+2.71(29)-5.03(30)+2.32(31)+3.32(32)-3.23(33)-0.09(34)$

Yolo base net to Los Angeles base net—Continued.

No.

XV $0=-2.441-(28)+(29)-(34)+(36)-(42)+(43)$

XVI $0=-1.383-(27)+(29)-(34)+(35)-(40)+(41)$

XVII $0=-0.598-(27)+(28)-(39)+(41)-(43)+(44)$

XVIII $0=+5.3+2.87(34)-3.31(35)+0.44(36)+0.82(39)-3.61(40)+2.79(41)+1.93(42)$
$-3.80(43)+1.87(44)$

XIX $0=+2.311-(45)+(46)-(50)+(51)-(53)+(55)$

XX $0=+1.597-(37)+(39)-(44)+(45)-(51)+(52)$

XXI $0=-1.607-(37)+(38)-(50)+(52)-(54)+(55)$

XXII $0=+23.2+5.58(37)-7.36(38)+1.78(39)+0.82(44)-7.74(45)+6.92(46)+2.88(50)$
$-2.75(51)-0.13(52)$

XXIII $0=-2.311-(45)+(47)-(49)+(51)-(58)+(60)$

XXIV $0=-4.648-(46)+(47)+(53)-(57)-(58)+(59)$

XXV $0=-8.5+7.74(45)-13.31(46)+5.57(47)+1.90(49)-4.65(50)+2.75(51)+3.50(58)$
$-7.50(59)+4.00(60)$

XXVI $0=+1.568-(48)+(50)-(55)+(56)-(67)+(68)$

XXVII $0=+2.226-(48)+(49)-(60)+(61)-(66)+(68)$

XXVIII $0=-1.7-0.03(48)-1.90(49)+1.93(50)+3.69(59)-4.00(60)+0.31(61)+1.60(66)$
$-5.20(67)+3.60(68)$

XXIX $0=+0.272-(61)+(62)-(64)+(66)-(79)+(80)$

XXX $0=+0.242-(64)+(65)-(70)+(71)-(78)+(80)$

XXXI $0=+1.109-(62)+(63)-(69)+(71)-(78)+(79)$

XXXII $0=+1.2+0.14(61)-3.12(62)+2.98(63)+2.33(64)-4.52(65)+2.19(66)+2.57(78)$
$-3.09(79)+0.52(80)$

XXXIII $0=-0.032-(76)+(77)-(82)+(83)-(84)+(86)$

XXXIV $0=-0.947-(72)+(73)-(81)+(83)-(84)+(85)$

XXXV $0=-0.242-(71)+(72)-(76)+(78)-(85)+(86)$

XXXVI $0=+4.5+2.66(71)-3.88(72)+1.22(73)+3.18(81)-4.10(82)+0.92(83)+0.92(84)$
$-6.60(85)+5.68(86)$

XXXVII $0=-1.127-(75)+(76)-(86)+(88)-(94)+(95)$

XXXVIII $0=+0.744-(87)+(88)-(91)+(92)-(94)+(96)$

XXXIX $0=-0.166-(74)+(75)-(91)+(93)-(95)+(96)$

XL $0=+2.0+2.29(74)-4.19(75)+1.90(76)+1.46(86)-2.37(87)+0.91(88)+0.91(94)$
$-3.67(95)+2.76(96)$

XLI $0=+2.13-(90)+(91)-(96)+(99)-(104)+(105)$

XLII $0=+1.20-(97)+(99)-(101)+(102)-(104)+(106)$

XLIII $0=-1.48-(89)+(90)-(101)+(103)-(105)+(106)$

XLIV $0=+4.2+9.65(89)-11.27(90)+1.62(91)+1.32(96)-3.48(97)+2.16(99)+1.88(104)$
$-9.78(105)+7.90(106)$

XLV $0=-1.94-(100)+(101)-(106)+(107)-(112)+(114)$

XLVI $0=-0.95-(98)+(99)-(104)+(107)-(112)+(113)$

XLVII $0=+6.4+3.69(97)-5.85(98)+2.16(99)+1.88(104)-3.38(106)+1.50(107)$
$+0.43(112)-4.35(113)+3.92(114)$

XLVIII $0=+2.05-(107)+(108)-(111)+(112)-(115)+(116)$

XLIX $0=+0.20-(110)+(111)-(116)+(117)-(122)+(123)$

L $0=-1.86-(108)+(109)+(115)-(119)-(124)+(125)$

LI $0=-1.14-(117)+(119)-(121)+(122)-(125)+(126)$

LII $0=-9.4+0.003(107)-4.50(108)+4.50(109)+1.80(110)-3.76(111)+1.96(112)$
$+1.59(121)-2.94(122)+1.35(123)+10.56(124)-14.68(125)+4.12(126)$

LIII $0=-1.28-(120)+(121)-(126)+(128)$

LIV $0=-0.01-(118)+(119)-(125)+(127)$

LV $0=+5.4+2.49(117)-2.12(118)-0.37(119)+4.12(125)-6.14(126)$
$-4.28(127)+3.83(128)$

LVI $0=+1.3+0.81(2)+1.77(5)-3.85(6)+2.08(7)-1.39(8)+1.39(10)+0.26(12)$
$-0.26(14)-1.80(15)+1.80(16)-2.47(17)+2.47(18)+2.27(20)-2.27(21)$
$+1.40(22)-2.18(24)+0.78(25)-1.08(27)+1.08(28)+2.32(30)-2.32(31)$
$+1.25(33)-1.69(34)+0.44(36)-0.75(37)+1.57(39)-0.82(41)$
$+1.93(42)-1.93(43)-2.90(45)+2.90(47)-2.26(48)+2.26(49)$
$+1.42(51)-1.42(52)+1.28(58)-1.28(60)-0.14(61)+0.14(63)$
$-2.33(64)+2.33(65)+0.26(66)-0.26(68)+1.76(69)-1.76(70)$
$-3.88(71)+3.88(72)-1.90(74)+1.90(76)+0.52(78)-0.52(80)$
$+6.60(85)-6.60(86)-0.91(87)+0.91(88)-1.62(89)+1.62(91)$
$+0.49(92)-0.49(93)+0.91(94)-0.91(96)-2.16(97)+2.16(99)$
$-1.97(100)+1.97(101)+0.77(102)-0.77(103)+1.88(104)$
$-1.88(106)-0.003(107)+0.003(108)-1.80(110)+1.80(111)$
$+0.43(112)-0.43(114)+2.25(115)-2.25(116)-1.46(118)$
$+1.46(119)-1.59(121)+2.94(122)-1.35(123)+4.12(125)$
$-4.12(126)-1.67(127)$

Los Angeles base net.

No.	
I	$0=-1.03-(2)+(3)-(6)+(8)-(9)+(11)$
II	$0=+0.10-(3)+(4)-(5)+(6)-(14)+(16)$
III	$0=-1.71-(1)+(2)-(11)+(12)-(17)+(19)$
IV	$0=-0.84-(7)+(8)-(9)+(12)-(17)+(18)$
V	$0=+1.26-(10)+(12)+(13)+(15)-(17)+(20)$
VI	$0=+0.80+(1)-(4)-(13)+(14)-(19)+(20)$
VII	$0=+18.2-1.66(2)+1.66(3)-4.05(9)+6.92(10)-2.87(11)-3.90(14)+11.30(15)-7.40(16)$
VIII	$0=-13.8-1.18(5)+5.82(6)-4.64(7)-3.97(13)+7.87(14)-3.90(16)-9.64(18)+13.89(19)-4.25(20)$
IX	$0=-4.8-1.18(5)+1.17(6)+0.01(8)-2.87(9)+4.75(11)-1.88(12)-3.97(13)+7.87(14)-3.90(16)-2.47(17)+6.72(19)-4.25(20)$

Los Angeles base net to Soledad-Cuyamaca.

No.	
I	$0=-0.25+(2)-(5)-(6)+(7)$
II	$0=+0.87+(1)-(4)-(19)+(20)$
III	$0=+0.84-(1)+(2)-(6)+(9)-(18)+(19)$
IV	$0=+2.53+(5)-(7)+(8)-(14)$
V	$0=+2.15+(1)-(13)-(19)+(21)$
VI	$0=+2.17-(9)+(11)-(17)+(18)-(22)+(23)$
VII	$0=-0.18-(9)+(10)-(16)+(18)-(26)+(27)$
VIII	$0=+1.46-(10)+(11)-(22)+(24)-(25)+(26)$
IX	$0=+0.28-(15)+(16)-(27)+(28)-(29)+(30)$
X	$0=+0.09-(12)+(13)+(15)-(21)-(30)+(31)$
XI	$0=-1.57-(3)+(12)-(31)+(32)$
XII	$0=+2.947-0.0535(1)+3.508(4)-0.0197(19)+2.266(20)-2.2463(21)$
XIII	$0=-0.4+2.22(2)-5.80(5)+1.00(6)-5.63(7)+4.63(8)$
XIV	$0=-0.1-10.56(1)+5.23(2)-0.57(6)-2.46(8)+3.03(9)+3.38(13)-2.55(14)$
XV	$0=-6.4+0.14(16)-1.45(17)+1.31(18)+8.19(22)-7.44(23)-0.75(24)+2.33(25)-11.06(26)+8.73(27)$
XVI	$0=+11.5+2.46(8)-2.81(9)+0.35(10)+2.19(12)-4.74(13)+2.55(14)+8.73(26)-11.13(27)+2.40(28)+0.15(29)-8.14(30)+7.99(31)$
XVII	$0=-0.1+5.35(1)+3.68(3)-1.28(15)+1.97(19)-0.69(21)+7.99(30)-16.92(31)+8.93(32)$

Soledad-Cuyamaca to Mexican boundary.

No.	
I	$0=+1.26-(1)+(3)-(9)+(10)$
II	$0=-3.26-(2)+(4)-(5)+(6)$
III	$0=-5.01-(3)+(4)-(5)+(7)-(8)+(9)$
IV	$0=+1.5+7.22(1)-14.54(2)-7.13(3)+7.42(4)+6.94(8)-7.21(9)+0.27(10)$

ACCURACY AS INDICATED BY CORRECTIONS TO OBSERVED DIRECTIONS.

The corrections to observed directions resulting from the figure adjustments which precede are given below. The numbers of the directions are shown on illustrations 2 to 4 as well as in the first column of the abstracts of horizontal directions.

Yolo base net to Los Angeles base net.

Number of direction.	Correction to direction.	Number of direction.	Correction to direction.	Number of direction.	Correction to direction.	Number of direction.	Correction to direction.
	″		″		″		″
1	+0.011	33	−0.074	65	+0.315	97	−0.188
2	−0.234	34	−0.608	66	+0.059	98	+0.280
3	+0.328	35	+0.317	67	+0.157	99	−0.469
4	+0.326	36	+0.245	68	−0.559	100	−0.482
5	−0.325	37	−0.370	69	+0.302	101	+0.460
6	+0.313	38	+1.342	70	−0.299	102	−0.273
7	−0.314	39	−0.905	71	−0.402	103	+0.295
8	−0.157	40	+0.029	72	+0.151	104	+0.130
9	+0.189	41	−0.096	73	+0.249	105	−0.714
10	+0.215	42	−0.302	74	−0.313	106	−0.056
11	+0.065	43	+0.482	75	−0.216	107	+0.407
12	+0.555	44	+0.492	76	+0.202	108	−0.540
13	−0.504	45	+0.173	77	+0.019	109	+0.773
14	−0.013	46	−1.158	78	+0.324	110	−0.272
15	+0.006	47	+0.314	79	+0.087	111	−0.020
16	−0.045	48	+0.654	80	−0.102	112	−0.555
17	−0.055	49	−0.804	81	−0.235	113	+0.868
18	−0.018	50	+0.114	82	−0.032	114	−0.021
19	+0.015	51	+0.390	83	+0.267	115	+0.465
20	+0.042	52	−0.353	84	−0.261	116	−0.103
21	+0.016	53	+1.179	85	+0.086	117	−0.558
22	+0.074	54	−0.440	86	−0.347	118	+0.420
23	−0.071	55	−0.077	87	+0.485	119	−0.224
24	−0.014	56	−0.389	88	+0.037	120	−0.874
25	+0.045	57	−0.273	89	−0.330	121	+0.310
26	−0.034	58	−0.797	90	+0.657	122	+0.280
27	−0.093	59	+0.927	91	−0.083	123	+0.283
28	−0.314	60	+0.181	92	−0.467	124	−0.327
29	+0.489	61	+0.029	93	+0.223	125	−0.468
30	−0.095	62	−0.086	94	−0.012	126	+0.368
31	+0.014	63	−0.253	95	+0.313	127	+0.184
32	+0.120	64	+0.028	96	+0.076	128	+0.464

Los Angeles base net.

Number of direction.	Correction to direction.	Number of direction.	Correction to direction.	Number of direction.	Correction to direction.	Number of direction.	Correction to direction.
	″		″		″		″
1	−0.375	6	−0.217	11	−0.121	16	+0.698
2	+0.207	7	−0.130	12	+0.253	17	−0.080
3	+0.307	8	+0.598	13	+0.133	18	−0.456
4	−0.140	9	−0.236	14	+0.385	19	−0.676
5	−0.251	10	+0.104	15	−1.215	20	−0.141

Los Angeles base net to Soledad-Cuyamaca.

Number of direction.	Correction to direction.	Number of direction.	Correction to direction.	Number of direction.	Correction to direction.	Number of direction.	Correction to direction.
	″		″		″		″
1	−0.216	9	−0.050	17	+0.757	25	+0.082
2	−0.916	10	−0.078	18	−0.050	26	−0.019
3	−0.869	11	−0.898	19	+0.500	27	+0.335
4	−0.590	12	+0.820	20	−0.744	28	−0.393
5	−1.154	13	+1.075	21	−0.360	29	+0.164
6	+0.640	14	+0.458	22	+0.350	30	+0.323
7	+0.652	15	−0.198	23	−0.163	31	−0.183
8	−0.265	16	+0.096	24	−0.187	32	−0.304

Soledad–Cuyamaca to Mexican Boundary

Number of direction	Correction to direction	Number of direction	Correction to direction	Number of direction	Correction to direction
	″		″		″
1	−0.18	5	−1.31	8	−0.83
2	−0.17	6	+0.77	9	+0.96
3	−0.36	7	+0.54	10	−0.13
4	+1.01				

The maximum correction to a direction in the first section was 1″.34, to the direction from Castle Mount to San Luis. The maximum in the second section, the Los Angeles base net, was 1″.22, to the direction from San Pedro to San Juan; in the third section, 1″.15, to the direction from Wilson Peak to Niguel, and in the fourth section, 1″.31, to the direction from Point Loma Light-house (old) to Soledad. Of the 50 sections of triangulation of which statistics were printed in Appendix 4, Report for 1903 (pp. 870–871), there were 17 for which the maximum correction was greater than 1″.34 and 24 for which it was less than 1″.15, the extremes in this triangulation.

The probable error of an observed direction is:

$$d=0.674\sqrt{\frac{\Sigma v^2}{c}}$$

in which Σv^2 is the sum of the squares of the corrections to directions and c is the number of conditions.

The probable error for observed direction for each of the four sections is as follows:

Yolo base net to Los Angeles base net	±0″.41 from	128 directions
Los Angeles base net	±0″.44 from	20 directions
Los Angeles base net to Soledad–Cuyamaca	±0″.50 from	32 directions
Soledad-Cuyamaca to Mexican boundary	±0″.78 from	10 directions

As this is the most severe and, therefore, the best test of the accuracy of a triangulation, another reference to the statistics of the 50 sections of primary triangulation should be made. This places these four sections as serial Nos. 29, 32, 39, and 49 of that table when arranged according to their accuracy. The mean for all four sections is ±0.45, which places it as No. 33 of that list

ACCURACY AS INDICATED BY CORRECTIONS TO ANGLES AND CLOSURES OF TRIANGLES.

The correction to each angle is the algebraic sum of the corrections to two directions. In order to make it possible to study the corrections to the separate angles, they are shown in the following table for every triangle in the primary scheme from the Yolo base net to the Mexican boundary, together with the error of closure of the triangles, the corrected spherical angles, and the spherical excess. The plus sign prefixed to the error of closure of a triangle indicates that the sum of the angles is less than 180° plus the spherical excess. The spherical excess is a convenient indication of the size of the triangle, since it is proportional to the area.

Yolo base net to Los Angeles base net

Stations	Corrections to angles	Error of closure of triangle	Corrected spherical angles			Spherical excess
	″	″	°	′	″	″
Mocho	−0.166		26	16	13.008	
Mount Tamalpais*	+0.422	+0.275	23	47	56.387	6.435
Mount Diablo	+0.019		129	55	57.040	
Sierra Morena	−0.651		57	27	09.013	
Mount Tamalpais	+0.328	−0.089	61	37	29.974	8.397
Mount Diablo	+0.234		60	55	29.410	
Sierra Morena	+0.638		49	53	07.162	
Mount Diablo	−0.234	+0.338	69	00	27.630	8.178
Mocho	−0.066		61	06	33.386	
Sierra Morena	−0.013		107	20	16.175	
Mount Tamalpais	+0.328	+0.249	37	49	33.587	10.140
Mocho	−0.066		34	50	20.378	
Loma Prieta	+0.491		36	11	04.456	
Mount Diablo	+0.011	+0.287	31	05	54.364	6.175
Mocho	−0.215		112	43	07.355	
Loma Prieta	−1.059		46	51	45.970	
Sierra Morena	+0.011	−1.294	95	13	49.174	8.409
Mount Diablo	−0.246		37	54	33.265	
Loma Prieta	−0.568		83	02	50.426	
Sierra Morena	−0.627	−1.345	45	20	42.012	6.406
Mocho	−0.150		51	36	33.968	
Santa Ana	−0.026		42	50	14.583	
Loma Prieta	+0.019	+0.365	80	33	21.932	7.095
Mocho	+0.372		56	36	30.580	
Mount Toro	−0.145		20	22	10.805	
Loma Prieta	−0.032	−0.151	130	00	01.482	6.373
Mocho	+0.026		29	37	54.086	
Mount Toro	−0.088		56	18	32.776	
Loma Prieta	−0.051	−0.112	49	26	39.550	7.762
Santa Ana	+0.027		74	14	55.436	
Mount Toro	+0.057		35	56	21.971	
Mocho	+0.346	+0.404	26	58	36.494	8.484
Santa Ana	+0.001		117	05	10.019	

*Reprinted from p. 588 of Special Publication No. 4.

Yolo base net to Los Angeles base net—Continued

Stations	Corrections to angles	Error of closure of triangle	Corrected spherical angles			Spherical excess
	″	″	°	′	″	″
Hepsedam	+0.109		42	17	43.327	
Mount Toro	+0.059	+0.239	69	40	43.759	9.518
Santa Ana	+0.071		68	01	42.432	
Santa Lucia	−0.193		33	07	17.480	
Mount Toro	−0.020	−0.179	119	21	05.520	5.430
Santa Ana	+0.034		27	31	42.430	
Santa Lucia	−0.728		92	30	24.831	
Mount Toro	−0.079	−1.391	49	40	21.761	6.545
Hepsedam	−0.584		37	49	19.953	
Santa Lucia	−0.535		59	23	07.351	
Santa Ana	+0.037	−0.973	40	30	00.002	10.633
Hepsedam	−0.475		80	06	03.280	
Rocky Butte	+0.785		47	32	29.783	
Santa Lucia	+0.853	+2.441	78	04	28.396	8.782
Hepsedam	+0.803		54	23	10.603	
Castle Mount	−0.125		30	15	49.770	
Santa Lucia	+0.926	+1.383	32	28	00.954	7.712
Hepsedam	+0.582		117	16	16.988	
Castle Mount	+0.934		38	25	06.514	
Rocky Butte	+0.794	+1.656	95	58	37.355	11.312
Santa Lucia	−0.072		45	36	27.443	
Castle Mount	+0.809		68	40	56.284	
Rocky Butte	+0.010	+0.598	48	26	07.573	10.242
Hepsedam	−0.221		62	53	06.385	
San Luis	−1.619		61	30	41.479	
Rocky Butte	−1.650	−5.515	68	40	51.354	10.591
Castle Mount	−2.246		49	48	37.758	
San Jose	−0.743		56	02	56.990	
Rocky Butte	−0.319	−1.597	53	28	15.135	11.943
Castle Mount	−0.535		70	28	59.818	
San Jose	−0.467		93	30	48.745	
San Luis	+0.362	+1.607	65	48	53.935	4.741
Castle Mount	+1.712		20	40	22.061	
San Jose	+0.276		37	27	51.755	
San Luis	−1.256	−2.311	127	19	35.415	3.389
Rocky Butte	−1.331		15	12	36.219	
Lospe	+0.978		58	46	49.621	
Rocky Butte	+0.140	+2.311	35	55	05.998	11.546
San Jose	+1.193		85	18	15.927	
Lospe	+1.724		31	00	49.427	
Rocky Butte	+1.472	+4.648	20	42	29.780	5.324
San Luis	+1.452		128	16	46.117	
Lospe	−0.747		27	46	00.193	
San Luis	−0.196	−0.026	104	23	38.468	2.833
San Jose	+0.917		47	50	24.172	
Tepusquet	−0.716		30	20	49.947	
San Luis	−0.312	−1.568	58	51	44.308	3.114
San Jose	−0.540		90	47	28.859	

Yolo base net to Los Angeles base net—Continued

Stations.	Corrections to angles	Error of closure of triangle	Corrected spherical angles			Spherical excess
	"	"	°	'	"	"
Tepusquet	—0. 617		83	03	56. 706	
Lospe	—0. 152	—2. 226	53	59	03. 019	4. 412
San Jose	—1. 457		42	57	04. 687	
Tepusquet	+0. 098		52	43	06. 758	
Lospe	—0. 898	—0. 684	81	45	03. 213	4. 131
San Luis	+0. 116		45	31	54. 160	
Arguello	—0. 601		50	01	59. 843	
Lospe	—0. 282	—1. 139	86	03	08. 111	3. 381
Tepusquet	—0. 256		43	54	55. 427	
Gaviota	—0. 189		41	56	00. 352	
Lospe	—0. 114	—0. 272	52	04	21. 721	4. 409
Tepusquet	+0. 031		85	59	42. 336	
Gaviota	—0. 426		76	12	10. 052	
Arguello	—0. 103	—0. 242	61	43	06. 894	3. 855
Tepusquet	+0. 287		42	04	46. 909	
Gaviota	—0. 237		34	16	09. 700	
Arguello	—0. 704	—1. 109	111	45	06. 737	2. 827
Lospe	—0. 168		33	58	46. 390	
New San Miguel	+0. 202		33	29	59. 743	
Arguello	+0. 651	+1. 157	59	59	40. 129	4. 732
Gaviota	+0. 304		86	30	24. 860	
Santa Cruz West	—0. 085		66	19	05. 178	
New San Miguel	+0. 300	+0. 032	66	22	57. 919	5. 469
Gaviota	—0. 183		47	18	02. 372	
Santa Cruz West	+0. 347		48	37	22. 617	
New San Miguel	+0. 502	+0. 947	99	52	57. 662	6. 778
Arguello	+0. 098		31	29	46. 499	
Santa Cruz West	—0. 433		17	41	42. 560	
Arguello	+0. 554	+0. 242	28	29	53. 631	3. 423
Gaviota	+0. 121		133	48	27. 232	
Santa Barbara	+0. 690		76	48	03. 022	
Santa Cruz West	+0. 832	+2. 037	55	18	31. 563	4. 665
Gaviota	+0. 515		47	53	30. 080	
Santa Cruz East	+0. 325		36	50	59. 785	
Santa Cruz West	+0. 383	+1. 127	121	55	22. 325	3. 815
Gaviota	+0. 419		21	13	41. 705	
Santa Cruz East	+0. 088		66	41	41. 847	
Santa Cruz West	—0. 449	—0. 744	66	36	50. 762	3. 144
Santa Barbara	—0. 383		46	41	30. 535	
Santa Cruz East	—0. 237		29	50	42. 062	
Gaviota	+0. 097	+0. 166	26	39	48. 376	3. 994
Santa Barbara	+0. 306		123	29	33. 556	
Chaffee	+0. 57		69	47	58. 70	
Santa Cruz East	—0. 26	+0. 55	57	52	57. 14	3. 08
Santa Barbara	+0. 24		52	19	07. 24	
Laguna	—0. 84		36	09	08. 79	
Santa Cruz East	—0. 55	—2. 13	102	06	57. 47	4. 76
Santa Barbara	—0. 74		41	43	58. 50	

Yolo base net to Los Angeles base net—Continued

Stations.	Corrections to angles	Error of closure of triangle	Corrected spherical angles			Spherical excess
	″	″	°	′	″	″
Laguna	+0.66		12	08	49.51	
Santa Barbara	+0.99	+1.48	10	35	08.75	1.19
Chaffee	−0.17		157	16	02.93	
Laguna	−0.19		48	17	58.29	
Santa Cruz East	−0.28	−1.20	44	14	00.34	2.87
Chaffee	−0.73		87	28	04.24	
Santa Clara	−0.89		25	50	24.10	
Santa Cruz East	+0.47	−0.21	19	47	13.89	1.71
Chaffee	+0.21		134	22	23.72	
Santa Clara	+1.42		52	41	44.90	
Laguna	+0.28	+0.95	102	51	31.44	2.79
Santa Cruz East	−0.75		24	26	46.45	
Santa Clara	+0.54		78	32	09.01	
Laguna	+0.46	+1.94	54	33	33.14	1.63
Chaffee	+0.94		46	54	19.48	
Castro	−0.57		43	05	43.11	
Laguna	−0.95	−2.05	89	55	34.27	1.59
Santa Clara	−0.53		46	58	44.21	
San Fernando	0.00		57	15	59.27	
Castro	−0.45	−0.20	73	18	20.51	2.76
Santa Clara	+0.25		49	25	42.98	
San Pedro	−0.14		11	16	24.82	
Laguna	+1.31	+1.86	25	03	51.09	2.19
Castro	+0.69		143	39	46.28	
San Pedro	+0.84		27	04	26.68	
Castro	+0.33	+1.14	99	56	10.10	4.49
San Fernando	−0.03		52	59	27.71	
Wilson Peak	+0.28		26	11	24.97	
Castro	+0.98	+2.41	44	46	22.56	3.92
San Fernando	+1.15		109	02	16.39	
Wilson Peak	+0.18		51	38	38.84	
San Pedro	+0.47	+0.01	73	11	41.63	8.02
Castro	−0.64		55	09	47.55	
Wilson Peak	+0.46		77	50	03.81	
San Pedro	−0.37	+1.28	46	07	14.95	7.45
San Fernando	+1.19		56	02	48.69	

Los Angeles base net.

	″	″	°	′	″	″
San Juan	+0.11		36	20	16.93	
Los Angeles Southeast Base	+0.82	+1.03	91	56	42.93	1.03
Los Angeles Northwest Base	+0.10		51	43	01.17	
San Pedro	+0.32		28	21	14.25	
Los Angeles Northwest Base	−0.45	−0.10	91	03	14.55	1.43
Los Angeles Southeast Base	+0.03		60	35	32.63	
San Juan	−0.22		19	25	26.31	
San Pedro	−1.60	−2.16	17	48	19.42	1.46
Los Angeles Northwest Base	−0.34		142	46	15.73	

Los Angeles base net—Continued

Stations	Corrections to angles	Error of closure of triangle	Corrected spherical angles			Spherical excess
	″	″	°	′	″	″
Los Angeles Southeast Base	+0. 84	+3. 09	152	32	15. 55	1. 00
San Pedro	+1. 91		10	32	54. 82	
San Juan	+0. 34		16	54	50. 63	
Wilson Peak	+0. 76	+1. 71	40	21	46. 61	2. 54
San Juan	+0. 37		48	06	04. 58	
Los Angeles Northwest Base	+0. 58		91	32	11. 35	
Wilson Peak	−0. 38	+0. 84	28	02	41. 16	2. 67
San Juan	+0. 49		84	26	21. 52	
Los Angeles Southeast Base	+0. 73		67	30	59. 99	
Los Angeles Northwest Base	+0. 68	+1. 90	143	15	12. 52	0. 90
Wilson Peak	+1. 13		12	19	05. 44	
Los Angeles Southeast Base	+0. 09		24	25	42. 94	
Wilson Peak	−0. 06	−1. 26	66	42	20. 16	6. 24
San Juan	+0. 15		67	31	30. 89	
San Pedro	−1. 35		45	46	15. 19	
Wilson Peak	+0. 32	+1. 00	38	39	39. 00	4. 58
Los Angeles Southeast Base	+0. 12		85	01	15. 57	
San Pedro	+0. 56		56	19	10. 01	
Los Angeles Northwest Base	−0. 23	−0. 80	125	41	32. 93	2. 25
San Pedro	+0. 25		27	57	55. 77	
Wilson Peak	−0. 82		26	20	33. 55	

Los Angeles base net to Soledad–Cuyamaca

	″	″	°	′	″	″
Niguel	+0. 01	+0. 25	44	01	11. 54	9. 19
San Pedro	−0. 91		89	14	28. 42	
Wilson Peak	+1. 15		46	44	29. 23	
Niguel	−0. 91	−2. 29	64	28	06. 47	6. 28
San Pedro	−0. 92		43	28	13. 22	
San Juan	−0. 46		72	03	46. 59	
San Juan	−0. 46	−2. 53	139	35	17. 48	3. 34
Niguel	−0. 92		20	26	54. 93	
Wilson Peak	−1. 15		19	57	50. 93	
Santiago	−1. 25	−0. 87	46	18	47. 25	10. 25
San Pedro	−0. 21		67	19	39. 87	
Wilson Peak	+0. 59		66	21	43. 13	
Santiago	−0. 86	−2. 15	46	50	43. 39	4. 06
San Pedro	−0. 21		21	33	24. 68	
San Juan	−1. 08		111	35	55. 99	
Santiago	−0. 70	−1. 96	99	19	39. 32	5. 41
Niguel	−0. 70		61	03	12. 19	
Wilson Peak	−0. 56		19	37	13. 90	
Santiago	−0. 31	−0. 71	99	51	35. 46	2. 12
Niguel	+0. 22		40	36	17. 26	
San Juan	−0. 62		39	32	09. 40	

Los Angeles base net to Soledad–Cuyamaca—Continued

Stations	Corrections to angles	Error of closure of triangle	Corrected spherical angles			Spherical excess
	″	″	°	′	″	″
Santiago	+0.385		0	31	56.135	
Wilson Peak	−0.590	−1.278	0	20	37.030	0.052
San Juan	−1.073		179	07	26.887	
Niguel	−0.69		105	04	23.73	
San Pedro	−0.70	−0.84	21	54	48.55	4.35
Santiago	+0.55		53	00	52.07	
San Jacinto	−0.63		28	00	56.49	
Santiago	+0.55	+0.20	121	53	14.10	12.94
Wilson Peak	+0.28		30	06	02.35	
San Jacinto	−0.12		13	15	27.59	
San Juan	+0.82	+1.57	136	59	14.87	7.78
Wilson Peak	+0.87		29	45	25.32	
San Jacinto	−0.51		14	45	28.90	
Santiago	+0.16	−0.09	121	21	17.96	5.11
San Juan	+0.26		43	53	18.25	
Cuyamaca	−0.73		41	17	37.40	
Santiago	+0.29	−0.28	52	44	07.37	19.58
San Jacinto	+0.16		85	58	34.81	
Niguel	−0.03		80	23	42.35	
Santiago	−0.15	+0.18	86	02	59.20	8.82
Cuyamaca	+0.36		13	33	27.27	
Soledad	−0.51		15	47	56.69	
Niguel	−0.85	−2.17	108	40	31.94	6.03
Santiago	−0.81		55	31	37.40	
Soledad	−0.02		93	51	08.54	
Santiago	+0.66	+0.90	30	31	21.80	15.63
Cuyamaca	+0.26		55	37	45.29	
Cuyamaca	−0.10		42	04	18.02	
Soledad	−0.54	−1.46	109	39	05.22	12.83
Niguel	−0.82		28	16	49.59	

Soledad–Cuyamaca to Mexican boundary.

	″	″	°	′	″	″
Boundary Monument 258	−1.08		66	11	30.42	
Soledad	−0.36	−1.26	81	28	57.37	5.57
Cuyamaca	+0.18		32	19	37.78	
Point Loma Light-house (old)	+2.08		65	59	18.71	
Soledad	+1.01	+3.26	97	57	00.27	2.89
Cuyamaca	+0.17		16	03	43.91	
Point Loma Light-house (old)	−0.23		81	15	55.48	
Cuyamaca	+0.02	+0.49	16	15	53.88	3.16
Boundary Monument 258	+0.70		82	28	13.80	
Point Loma Light-house (old)	+1.85		147	15	14.19	
Soledad	+1.37	+5.01	16	28	02.90	0.48
Boundary Monument 258	+1.79		16	16	43.39	

The maximum correction of any angle is $2''.25$, to the angle at Castle Mount between San Luis and Rocky Butte in the section Yolo base net to Los Angeles base net.

The statistics as to closures of triangles and in regard to the mean error of an angle, $a=\sqrt{\frac{\Sigma \Delta^2}{3n}}$ (in which $\Sigma \Delta^2$ is the sum of the squares of the closing errors of the triangles, and n the number of triangles), are given in the following table:

Section	Number of triangles	Number of plus closures	Number of minus closures	Average closure	Maximum closure	Mean error of an angle
				″	″	″
Yolo to Los Angeles	54	28	26	1. 16	5. 52	±0. 91
Los Angeles base net	10	6	4	1. 39	3. 09	±0. 91
Los Angeles to Soledad	17	5	12	1. 16	2. 53	±0. 82
Soledad to Mexican boundary	4	3	1	2. 50	5. 01	±1. 78
Whole triangulation	85	42	43	1. 25	5. 52	±0. 93

The following general comparison may be made for triangulation extending over a considerable portion of the United States and necessarily embracing various conditions as to climate, topography, and length of lines:

	Average closing error	a (mean value)
	″	″
California triangulation	1. 25	±0. 93
Eastern oblique arc	1. 19	±0. 82
Transcontinental triangulation	1. 06	±0. 77
Ninety-eighth meridian previous to 1902	0. 67	±0. 46
Ninety-eighth meridian in 1902	0. 94	±0. 72

THE ACCORD OF BASES.

The accord in length between the Los Angeles Base as measured and its value as computed through the triangulation from the Yolo Base furnishes a valuable test of the accuracy of the triangulation.

In solving the normal equations of the figure adjustment, the length equation was, as usual, assigned to the last place, so that the discrepancy in length, after all the conditions relating to closures of triangles and ratios of lengths had been satisfied, became known. It developed that the Los Angeles Base was longer as measured than as computed through the triangulation by an amount equivalent to forty-one, expressed in terms of the seventh decimal place of logarithms, or, expressed as a ratio, $\frac{1}{110000}$. Comparing this with the ninety-eighth meridian triangulation as a standard, it develops that, of the seven similar discrepancies already published, only two are smaller.

TREATMENT OF THE SUBORDINATE TRIANGULATION.

The method of treatment of the observations by the computer may, in general, be stated briefly as follows: starting from the results of the primary triangulation, whose adjustment is treated in the earlier part of this Appendix, the position of that particular station which is connected *most strongly* with the main triangulation is first fixed by adjustment, taking into consideration the lines directed to it from primary stations as well as lines diverging from it and intersecting the latter. Should there be more than one such point, say two or more, having equal strength of connection, they are treated together in one least square adjustment.

In this manner, point after point is adjusted in position, so that the sum of the squares of the corrections to the observed horizontal directions shall be a minimum, the geometrical relations of the *preceding* points being always considered as fixed with respect to the variable elements of the new point under treatment. The principal secondary and tertiary stations having thus become known in position, the less important tertiary positions are determined in the same systematic though somewhat less elaborate manner than that followed for the principal stations, but generally with a least square adjustment which used only three or four lines to the point. Where more directions had been observed, each line so observed was fixed in azimuth and length by solving a triangle which had the ends of this line as two of its vertices and any one of the points already fixed and connected directly with these, as its third vertex. Such a triangle had two of its sides already fixed in length and the difference of the fixed directions at the third vertex made the required included angle for its solution. The final result of this systematic treatment may be summarized by stating that no discrepancy remains in the results themselves, and that the length and direction of any side of a triangle may be computed from any starting side, and through any series of connecting triangles, and yet the same results will be reached.

Whenever, in the course of adjusting a chain of subordinate triangulation, it closes a loop on the primary triangulation, disclosing a discrepancy in latitude and longitude, or in latitude, longitude, azimuth, and length, a further least square adjustment of this subordinate triangulation was made to distribute this discrepancy.

ACCURACY OF THE SUBORDINATE TRIANGULATION.

Very little information is available by which the accuracy of small triangulations may be judged. It seems advisable to follow the computer in a general survey of these triangulations to disclose the discrepancies which developed, and, where a loop has been closed on the primary, the error of closure with a definition of the meaning of such closure. Each of the sixteen sections in which there are closed triangles will be treated. These sections are shown on the sketches at the end of this Appendix.

MEXICAN BOUNDARY TO POINT LA JOLLA.

All of the triangulation in this group depends for its length and azimuth on the two lines, Soledad–Boundary Monument 258 and Soledad–Point Loma Lighthouse (old). The old San Diego Base measured in May, 1851, with four meter iron rods, was not allowed to affect the lengths of the later triangulation, and the discrepancy of 17 in the sixth decimal place of logarithms was distributed through the three triangles of 1851 adjoining the base. The greater portion of this triangulation was executed by Assistant A. F. Rodgers, who used a 10-inch Gambey repeating theodolite and employed the method of directions. Generally two sets of directions were taken; 138 triangles had an average closure of 6″.1 and a maximum of 30″.2.

POINT LA JOLLA TO SAN MATEO POINT.

The triangulation of this section was all executed by Assistant A. F. Rodgers in 1886 and 1887, in the manner described in previous paragraph, and serves to join the ends of the long primary line, Soledad–Niguel, thus forming a loop of triangulation with that line. The length at the north and west end is furnished by the triangulation of the section San Mateo Point to Newport Bay and at the south and east end by the triangulation described in the previous paragraph. The length as computed from the south was shorter than the length from the north by an amount equivalent to 108, expressed in terms of the sixth decimal place, or expressed as a ratio, 1/4000; 108 triangles have a mean closing error of 6″.7 and a maximum of 36″.7. The azimuth computed from the south was smaller than that from the north by 21″.9. The latitude and longitude were smaller from the south than from the north by 0″.352 and 0″.271, respectively. This is equivalent to a distance of 12.9 meters. If this narrow chain of coast triangles be considered as a straight line as long as Soledad–Niguel, and lying at the same angle with the meridian, it would be necessary to increase the length of the line one part in 6 800, and decrease its azimuth by 0″.9.

SAN MATEO POINT TO NEWPORT BAY.

The triangulation of this section was in great part executed by Assistant A. F. Rodgers in 1884, the balance by Assistant A. W. Chase in 1874 and 1875.

The method of repetitions was employed throughout the section; twelve repetitions were observed on each angle and several condition angles were measured; 238 triangles have a mean closing error of 6″.3 and a maximum of 25″.7. This section depends for its length on the line Los Cerritos–Las Bolsas of the primary scheme.

NEWPORT BAY TO POINT DUME.

The triangulation of this section was done at many different dates, from 1855 to 1899, and the method of repetitions was used almost entirely. The section depends for its control both in length and azimuth on several lines of the primary triangulation; 85 triangles have a mean closure of 8″.9 and a maximum of 40″.3.

POINT DUME TO SANTA BARBARA.

This section comprises triangulation covering several seasons, 1862–63 and 1866 and 1867, and the observations were made by Assistant W. E. Greenwell, using the method of repetitions. The triangles at the east end of the section depend for their length and azimuth on the two primary lines, San Buenaventura–Laguna and San Buenaventura–Chaffee. At the west end of the section the primary line Santa Barbara–Santa Cruz West provides the position, length, and azimuth. The primary line Santa Barbara–Chaffee, therefore, forms a loop of triangulation with the smaller triangles along the coast; 42 triangles in this section which are involved in this loop have a mean closing error of 3″.2 and a maximum of 8″.9.

The length as computed from the east was longer than the length from the west by an amount equivalent to 31, expressed in terms of the sixth decimal place, or expressed as a ratio, 1/14000. The azimuth computed from the east was smaller by 0".2 than that from the west. The latitude from the east was larger and the longitude smaller than from the west by 0".009 and 0".004, respectively. This is equivalent to a distance of only 0.295 meter. If this chain of coast triangles be considered as a straight line as long as Chaffee–Santa Barbara, and lying at the same angle with the meridian, it would be necessary to increase the length of the line one part in 130 000, and decrease its azimuth by 0".1.

SANTA BARBARA TO POINT ARGUELLO.

This section of triangulation was executed in the years 1863, 1869, 1872, and 1874. At the west end the length for this section is furnished by the primary line Arguello–Point Conception Light-house; and at the east end the primary line Santa Barbara–Santa Cruz West determines the length. The length as computed from the east was shorter than the length as computed from the west by an amount equivalent to 242, expressed in terms of the sixth decimal place, or, expressed as a ratio, 1/1 800. The triangulation forms a loop on the primary line Point Conception Light-house–Santa Barbara; 65 triangles involved in this loop have a mean closing error of 6".0 with a maximum of 15".5.

The azimuth computed from the east was smaller than that from the west by 20". The latitude and longitude were smaller than from the west by 0".067 and 0".329, respectively. This is equivalent to a distance of 8.65 meters. If this narrow chain of coast triangles be considered as a straight line as long as the line Point Conception Light-house–Santa Barbara and lying at the same angle with the meridian, it would be necessary to increase the length of the line one part in 8 200 and increase its azimuth by 4".3.

SAN CLEMENTE ISLAND.

The triangulation of this island depends for its length on the base line measured by Assistant W. E. Greenwell in 1862. This base, 807.926 meters long, was measured with the 8-meter wooden bars Nos. 1 and 2, and the bars tested by a standard meter scale; 33 triangles on this island have an average closure of 6".2 and a maximum of 17".1.

The triangulation station Boulder was observed and computed as a primary point, though without a check on its position. The line Boulder–Harbor was considered fixed as so computed and the triangulation with its length from the 1862 base formed a loop on this line. No length and azimuth discrepancies were developed directly. The latitude and longitude from the north and west were smaller than found at Boulder by 0".250 and 0".208, respectively. This is equivalent to a distance of 9.4 meters. If this narrow chain of triangles be considered as a straight line as long as Boulder–Harbor and lying at the same angle with the meridian, it would be necessary to decrease the length of the line one part in 1 500 and decrease its azimuth by 5".9.

SANTA CATALINA ISLAND.

The triangulation of this island depends for its length on the primary line West Peak–Catalina Peak, and on a short base line measured in 1875 by Assistant Forney, who also executed the triangulation. This base, 756.954 meters in length, was measured with the 4-meter iron bars Nos. 3 and 4. The lengths of the lines on the west end of the island are controlled entirely by this base, and those of the east end by both the base and the primary line. That is, these lengths were derived through the line Catalina Peak–Cliff, as computed from the triangle Catalina Peak–West Peak–Cliff, holding as fixed three parts, namely, the length of the primary line West Peak–Catalina Peak, the length of the line West Peak–Cliff computed from the base, and the included angle at West Peak. Seventy-three triangles have an average closing error of 4″.1 with a maximum of 12″.8.

SAN NICOLAS AND SANTA BARBARA ISLANDS.

The triangulation of San Nicolas Island depends for its length on a base line measured with a chain by Assistant W. E. Greenwell in 1858. This base is 771.26 meters long. The position and azimuth for the triangulation come through the station San Nicolas, observed from the primary stations Anacapa and Santa Barbara Island; 19 triangles on this island have an average closing error of 8″.6 and a maximum of 35″.1. On Santa Barbara Island, Assistant A. W. Chase measured with a 20-meter chain a base 600.00 meters in length, which is ample to control the few triangles of the island. The position and azimuth come from the primary station, Santa Barbara Island.

SANTA CRUZ ISLAND.

The length of the primary line New San Miguel–Santa Cruz West supplies the length for the triangulation of Santa Cruz Island. The base measured in 1857 by Assistant Greenwell was not introduced into the triangulation. The base was measured with two pine bars 4 meters long, and the length discrepancy indicated that the computed length was too short by one part in 4 300; 25 triangles of this island have an average closure of 5″.2 and a maximum of 17″.2.

The triangulation forms a small loop on the primary line Santa Cruz West–Santa Cruz East, but in such a way that the azimuth and length discrepancies do not develop directly. The latitude at Santa Cruz East from the east is greater by 0″.042 and the longitude less by 0″.239 than that computed from the west. This is equivalent to a distance of 6.3 meters. If this chain of triangles be considered as a straight line as long as the line Santa Cruz West–Santa Cruz East and lying at the same angle with the meridian, it would be necessary to increase the length of the line one part in 5 400 and decrease its azimuth by 10″.6.

SANTA ROSA AND SAN MIGUEL ISLANDS.

The primary line New San Miguel–Santa Cruz West controls the length of the sides of all the triangles on these islands. A base line on San Miguel Island measured with a chain in 1858 was rejected. The computation of this base from the primary line disclosed a discrepancy of one part in 1 600, the measured length being smaller. The base on Santa Rosa Island was measured with the 8-meter wooden bars Nos. 1 and 2 in 1860 by Assistant W. E. Greenwell. This measured length was not introduced into the triangulation, but the computation gave as a length 1 277.27 meters and the measured length was 1 277.26 meters, a discrepancy of only one part in 130 000. Twenty-nine triangles on Santa Rosa Island have an average closure of 5''.5 and a maximum of 15''.3. On San Miguel Island, 23 triangles have an average closure of 5''.7 and a maximum of 14''.9.

POINT ARGUELLO TO POINT SAL.

Mr. Paul Schumacher, under the direction of Assistant W. E. Greenwell, executed the triangulation of this section in the years 1878 and 1879; 72 triangles have an average closure of 5''.8 and a maximum of 19''.7. The length from the north end of this section is that derived from the adjustment of the loop in the section Point Sal to Saddle Peak; and at the south end the length is computed from the primary line Arguello–Point Conception Light-house. The length as computed from the south was shorter than the length as computed from the north by an amount equivalent to 213, expressed in terms of the sixth decimal place, or, expressed as a ratio, 1/2 000. This triangulation forms a loop on the primary line Lospe–Arguello. The azimuth computed from the south was smaller than from the north by 34''.6. The latitude and longitude from the south were smaller than from the north by 0''.181 and 0''.011, respectively. This is equivalent to a distance of 5.58 meters. If this narrow chain of coast triangles be considered as a straight line as long as the line Lospe–Arguello and lying at the same angle with the meridian, it would be necessary to increase the length of the line one part in 6 200 and increase its azimuth by 2''.2.

POINT SAL TO SADDLE PEAK.

The length of the triangle sides in this section is controlled by the length as computed from the north, i. e., from the primary line Rocky Butte–Saddle Peak. This triangulation forms a loop on the primary line Saddle Peak–Lospe. The measurement of the San Luis Obispo Base in 1871 was not neglected. The discrepancy of approximately one part in 4 000 was distributed in the few triangles which immediately surround the base. The base, 955.643 meters long, was measured by Assistant L. A. Sengteller, and the 4-meter contact slide rods Nos. 3 and 4 were used. The computed length was greater than the length as measured. The latitude and longitude as computed from the north were smaller than from the south by 0''.148 and 0''.063, respectively. This is equivalent to a distance of 4.8 meters. If this narrow chain of coast triangulation be considered as a straight line as long as Saddle Peak–Lospe and lying at the same angle with the meridian, it would be necessary to increase the length of the line one part in 8 400 and increase its azimuth by 2''.5.

SADDLE PEAK TO PIEDRAS BLANCAS.

This section of triangulation depends for its length and position on the primary line Rocky Butte–Saddle Peak. The length of the San Simeon base was preserved as measured by a length equation in the base figure. Thus the small discrepancy, amounting to approximately 1 part in 140 000, was distributed in the figure immediately adjoining the base. This base, 815.981 meters in length, was measured by Assistant C. Rockwell in 1871 with the 4-meter contact slide rods Nos. 3 and 4; 87 triangles have an average closure of 5''.8 and a maximum of 19''.8.

PIEDRAS BLANCAS TO POINT SUR.

A great portion of the triangulation of this section was executed by Assistant A. F. Rodgers in the years 1888 and 1890. The triangulation of this entire section is based on the primary line Santa Lucia–Rocky Butte; 145 triangles have an average closure of 5″.6 and a maximum of 20″.3.

POINT SUR TO MONTEREY BAY.

The length for the triangles of this section is furnished by the triangulation at the north end of the previous section. This triangulation forms a loop on the primary triangulation by connecting the previous section with Point Pinos Latitude Station. An old adjustment of this triangulation was adopted which did not show the latitude and longitude discrepancy on the same basis as in foregoing sections; 62 triangles have an average closure of 6″ .0 and a maximum of 23″.7.

RECAPITULATION.

In the following table the results of the preceding paragraphs are assembled. No attempt has been made to show the signs for the computed discrepancies in this table. It is interesting to note in the preceding paragraphs that the length discrepancies of the two kinds indicated by the fifth and ninth columns of the following table are of the same sign for each section, with the exception of one section on which the equivalent length discrepancy is nearly zero.

Section	Number of triangles	Average closing error	Maximum closing error	Discrepancy in—		Latitude and longitude closure.			
				Length, 1 part in—	Azimuth	Latitude	Longitude	Equivalent to—	
								Length, 1 part in—	Azimuth
		″	″		″	″	″		″
Mexican Boundary to Point La Jolla	138	6.1	30.2	26 000					
Point La Jolla to San Mateo Point	108	6.7	36.7	4 000	21.9	0.352	0.271	6 800	0.9
San Mateo Point to Newport Bay	238	6.3	25.7						
Newport Bay to Point Dume	85	8.9	40.3						
Point Dume to Santa Barbara	42	3.2	8.9	14 000	0.2	0.009	0.004	130 000	0.1
Santa Barbara to Point Arguello	65	6.0	15.5	1 800	20.0	0.069	0.329	8 200	4.3
San Clemente Island	33	6.2	17.1			0.250	0.208	1 500	5.9
Santa Catalina Island	73	4.1	12.8						
San Nicolas Island	19	8.6	35.1						
Santa Cruz Island	25	5.2	17.2	4 300		0.042	0.239	5 400	10.6
Santa Rosa and San Miguel islands	52	5.6	15.3	130 000					
Point Arguello to Point Sal	72	5.8	19.7	2 000	34.6	0.181	0.011	6 200	2.2
Point Sal to Saddle Peak	97	4.3	30.1	4 000		0.148	0.063	8 400	2.5
Saddle Peak to Piedras Blancas	87	5.8	19.8	140 000					
Piedras Blancas to Point Sur	145	5.6	20.3						
Point Sur to Monterey Bay	62	6.0	23.7						

It will be noted from the preceding comparison that the azimuth through a chain of small triangulation is much more accurately preserved than the length, an error of one second in azimuth being equivalent to an error of 1/206300 in length. In reconnaissance for triangulation of this character it would seem advisable in the future to exercise more care in selecting well-shaped triangles through which the length would be computed. In this way fewer measures of the angles would be required to secure a given degree of accuracy.

EXPLANATION OF POSITIONS, LENGTHS, AND AZIMUTHS, AND OF THE UNITED STATES STANDARD DATUM.

The lengths, as already fully explained in connection with the adjustments, all depend upon the Yolo and Los Angeles bases. The lengths as given are all reduced to sea level. If the actual length of a line simply reduced to the horizontal is desired, it may be obtained with all the accuracy ordinarily needed by adding to the sea level length as given a correction $=$ (length of line as given) $\left(\frac{\text{mean elevation of two ends of line in meters}}{6370000}\right)$. The maximum value of this correction does not exceed $\frac{1}{1800}$ of the length for any portion of the triangulation here published. The maximum error made in the use of the above approximate formula for the correction does not exceed $\frac{1}{1000000}$ of the length for any portion of this triangulation.

The positions—that is, the latitudes, longitudes, and the azimuths—need a special explanation.

All of the positions and azimuths have been computed upon the Clarke spheroid of 1866, which has been in use in the Coast and Geodetic Survey for many years.

After a spheroid has been adopted and all the angles and lengths in a triangulation have been fully fixed, it is still necessary, before the computation of latitudes, longitudes, and azimuths can be made, to adopt a standard latitude and longitude for a specified station and a standard azimuth of a line from that station. For convenience the adopted standard position (latitude and longitude) of a given station, together with the adopted standard azimuth of a line from that station, is called the *geodetic datum*.

The primary triangulation in the United States was commenced at various points, and existed at first as a number of detached portions in each of which the geodetic datum was necessarily dependent only upon the astronomic stations connected with that particular portion. As examples of such detached portions of triangulation there may be mentioned the early triangulation in New England and along the Atlantic coast, a detached portion of the transcontinental triangulation centering on St. Louis and another portion of the same triangulation in the Rocky Mountain region, and three separate portions of triangulation in California in the latitude of San Francisco, in the vicinity of Santa Barbara Channel, and in the vicinity of San Diego. With the lapse of time these separate pieces have expanded until they have touched or overlapped.

The transcontinental triangulation, of which the office computation was completed in 1899, joins all of the detached portions mentioned and makes them one continuous triangulation. As soon as this took place the logical necessity existed of discarding the old geodetic data used in these various pieces and substituting one datum for the whole country, or at least for as much of the country as is covered by continuous triangulation. To do this is a very heavy piece of work, and involved much preliminary study to determine the best datum to be adopted. On March 13, 1901, the Superintendent adopted what is now known as the United States Standard Datum, and it was decided to reduce the positions to that datum as rapidly as possible. The datum adopted was that formerly in use in New England, and therefore its adoption did not affect the positions which had been used for geographic purposes in New England* and along the Atlantic coast to North Carolina, nor those in the States of New York, Pennsylvania, New Jersey, and Delaware. The adopted datum does not agree, however, with that used in "The Transcontinental Triangulation" and in "The Eastern Oblique Arc of the United States," publications which deal primarily with the purely scientific problem of the determination of the figure of the earth, and which were prepared for publication before the adoption of the new datum.

The former publications by this Office which contain positions in California are Appendix 9, Report for 1885, and "The Transcontinental Triangulation." The positions published therein being based upon different standard data are therefore superseded.

As the adoption of such a standard datum is a matter of considerable importance, it is in order here to explain the desirability of this step more fully.

The main objects to be attained by the geodetic operations of the Coast and Geodetic Survey are, first, the control of the charts published by the Survey; second, the furnishing of geographic positions (latitudes and longitudes), of accurately determined elevations, and of distances and azimuths, to officers connected with the Coast and Geodetic Survey and to other organizations; third, the determination of the figure of the earth. The first two of these objects are purely practical; the third is purely scientific. For the first and second objects it is not necessary that the reference spheroid should be accurately that which most closely fits the geoid within the area covered, nor that the adopted geodetic datum should be absolutely the best that can be derived from the astronomic observations at hand. It is simply desirable that the reference spheroid and the geodetic datum adopted shall be, if possible, such a close approximation to the truth that any correction which may hereafter be derived from the observations which are now or may become available shall not greatly exceed the probable errors of such corrections. It is, however, very desirable that one spheroid and one geodetic datum be used for the whole country. In fact, this is absolutely necessary if a geodetic snrvey is to perform fully the function of accurately coordinating all surveys within the area which it covers. This is the most important function of a geodetic survey. To perform this function it is also highly desirable that when a certain spheroid and geodetic datum have been adopted for a country they should be rigidly adhered to without change for all time, unless shown to be largely in error.

In striving to attain the third object, the determination of the figure of the earth, the conditions are decidedly different. This problem concerns itself primarily with astronomic observations of latitude, longitude, and azimuth, and with the geodetic positions of the points at which the astronomic observations were made, but is not

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*Many such positions had been published in Appendix No. 8, Report for 1885, Appendix No. 8 for 1888, and Appendix No. 10, for 1894. Since the adoption of the United States Standard Datum many positions in Texas, Indian Territory, Oklahoma, Kansas, and Nebraska reduced to that datum have been published in Appendix 6, Report for 1901, Appendix 3, 1902, and Appendix 4, 1903.

concerned with the geodetic positions of other points fixed by the triangulations. The geodetic positions (latitudes and longitudes) of comparatively few points are therefore concerned in this problem. However, in marked contrast to the statements made in preceding paragraphs, it is desirable in dealing with this problem that, with each new important accession of data, a new spheroid fitting the geoid with the greatest possible accuracy, and new values of the geodetic latitudes, longitudes, and azimuths of the highest degree of accuracy, should be derived.

The United States Standard Datum was adopted with reference to positions furnished for geographic purposes, but has no reference to the problem of the determination of the figure of the earth. It is adopted with reference to the engineer's problem of furnishing standard positions, and does not affect the scientist's problem of the determination of the figure of the earth.

The principles which guided in the selection of the datum to be adopted were: first, that the adopted datum should not differ widely from the ideal datum for which the sum of the station errors in latitude, longitude, and azimuth should each be zero; second, it was desirable that the adopted datum should produce minimum changes in the publications of the Survey, including its charts; and, third, it was desirable, other things being equal, to adopt that datum which allowed the maximum number of positions already in the office registers to remain unchanged, and therefore necessitated a minimum amount of new computation. These considerations led to the adoption as the United States Standard of the datum which had been in use for many years in the northeastern group of States and along the Atlantic coast as far as North Carolina.

An examination of the station errors available in 1903, on the United States Standard Datum, at 246 latitude stations, 76 longitude stations, and 152 azimuth stations, scattered widely over the United States from Maine to Louisiana and to California, indicated that this datum approaches closely the ideal with which the algebraic sum of the station errors of each class would be zero.

The adopted United States Standard Datum, upon which the positions and azimuths given in this publication depend, may be defined in terms of the position of the station Meades Ranch as follows:

° ′ ″
φ =39 13 26.686
λ =98 32 30.506
α to Waldo=75 28 14.52

The positions here published on the United States Standard Datum therefore differ considerably from those given in "The Transcontinental Triangulation" (pp. 854–865), which depend upon a special geodetic datum which was adopted for the special purpose of that publication, and which was based upon the astronomic observations connected with that triangulation alone.

The position given for the station Meades Ranch, in "The Transcontinental Triangulation" (p. 862), is—

° ′ ″
φ =39 13 25.006
λ =98 32 30.469
α to Waldo=75 28 16.52

The corrections to reduce this position to the United States Standard Datum are—

$$\begin{aligned} &\quad '' \\ \Delta\varphi &= +1.680 \\ \Delta\lambda &= +0.037 \\ \Delta\alpha &= -2.00 \end{aligned}$$

Such corrections to reduce a position from one datum to another are not constant, but vary slightly from station to station.

TABLE OF POSITIONS, AZIMUTHS, AND LENGTHS.

The following tables give the positions of all points, and the azimuths and lengths of all lines of the primary triangulation of California completed before 1900 and of all the subordinate triangulation south of Monterey Bay.

These tables may be conveniently consulted by using as finders the twenty-one sketches and the index at the end of this appendix. In the third column of the index will be found for each point a reference to the page on which its description is given, and in the fourth column the page on which its elevation above sea level may be found.

The azimuth and length of every line over which observations have been made in one or both directions are given in the list in connection with the position of one end only of the line.

The positions of all points for which the latitudes and longitudes are given to thousandths of seconds have been fixed by a complete adjustment of the triangulation concerned, so as to make all the triangles close and remove all discrepancies between lengths, azimuths, and positions. Such adjustments are of a very high degree of accuracy, as indicated in the preceding pages, for points on the primary scheme, of a less degree of accuracy for secondary points, and of a still more approximate character for tertiary points determined by intersections only. In each class all discrepancies are removed to the limit given by the decimal place shown. The above statements in regard to the various degrees of accuracy refer to the manner in which the discrepancies were removed.

If less than three decimal places are given in the latitudes and longitudes, the point in question has not been fixed by fully adjusted triangulation, or is fixed in such a way as to furnish no check on its position, and the accuracy with which its position is known is indicated in part by the number of decimal places given.

In the case of the mountain peaks the complete adjustment has been made in every case.

The seconds of latitude and longitude are also given in meters for the convenience of draftsmen.

In the column giving azimuths, distances, and logarithms of distances various numbers of decimal places are given, the intention being to indicate the accuracy to a certain extent, it being understood that in each quantity two doubtful figures are given. In some cases there is very little doubt of the correctness of the second figure from the right, and in a few cases some doubt may be cast upon the third figure.

To facilitate reference to the table of positions, and the elevations and descriptions of stations corresponding, these stations have been subdivided geographically, as follows:

	Number of stations.
Primaries	93
Mexican boundary to Point La Jolla	167
Point La Jolla to San Mateo Point	86
San Mateo Point to Newport Bay	95
Newport Bay to Point Dume	98
Point Dume to Santa Barbara	67
Santa Barbara to Point Arguello	67
San Clemente Island	38
Santa Catalina Island	54
San Nicolas and Santa Barbara islands	28
Santa Cruz Island	41
Santa Rosa and San Miguel islands	58
Point Arguello to Point Sal	39
Point Sal to Saddle Peak	44
Saddle Peak to Piedras Blancas	87
Piedras Blancas to Point Sur	130
Point Sur to Monterey Bay	88
Inland Peaks	58
	1 338

For the convenience of those who may wish to compare the lengths here given with others which are expressed in feet, or vice versa, the following conversion table is here inserted:

Meters	Feet	Feet	Meters
1	3.280833	1	0.3048006
2	6.561667	2	0.6096012
3	9.842500	3	0.9144018
4	13.123333	4	1.2192024
5	16.404167	5	1.5240030
6	19.685000	6	1.8288037
7	22.965833	7	2.1336043
8	26.246667	8	2.4384049
9	29.527500	9	2.7432055
10	32.808333	10	3.0480061

Primaries.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Pah Rah (Nevada)	39 47 41.413	1277.2					
1878	119 28 24.692	587.5					
Mount Como (Nevada)	39 01 18.060	557.0	179 58 58.795	359 58 58.115	Pah Rah	85836.42	4.9336716
1879	119 28 23.621	568.3					
Mount Grant (Nevada)	38 34 14.439	445.2	130 23 24.217	309 57 44.739	Mount Como	77603.44	4.8898809
1879	118 47 26.593	643.8	156 44 54.272	336 19 01.156	Pah Rah	148154.59	5.1707151
Round Top	38 39 50.316	1551.5	228 53 07.514	49 12 57.614	Mount Como	60587.94	4.7823862
1879	120 00 01.126	27.2	275 14 13.386	95 59 31.182	Mount Grant	105854.45	5.0247091
Mount Conness	37 58 02.590	79.8	142 39 27.366	322 14 10.265	Round Top	97529.81	4.9891374
1890	119 19 14.227	347.3	214 32 19.156	34 52 00.680	Mount Grant	81453.53	4.9109099
Mount Lola	39 26 00.061	1.9	242 01 58.984	62 36 03.783	Pah Rah	86386.11	4.9364439
1879	120 21 51.594	1233.9	300 25 32.092	120 59 20.857	Mount Como	89495.56	4.9518015
			339 38 00.326	159 51 45.915	Round Top	91039.14	4.9592282
Mount Diablo	37 52 55.482	1710.5	217 34 51.452	38 32 55.516	Mount Lola	218704.43	5 3398576
1876	121 54 48.355	1181.7	242 00 24.337	63 11 30.694	Round Top	188566.86	5.2754654
			266 49 30.693	88 25 08.300	Mount Conness	228160.48	5.3582404
Mocho	37 28 39.696	1223.8	144 57 40.026	324 44 31.769	Mount Diablo	54890.12	4.7394942
1887	121 33 18.781	461.4	225 32 32.159	46 30 04.187	Round Top	189609.73	5.2778606
			253 53 43.874	75 15 46.277	Mount Conness	204365.52	5.3104077
Mount Helena	38 40 11.080	341.6	245 56 18.019	67 22 03.416	Mount Lola	213873.23	5.3301564
1876	122 37 57.817	1397.7	269 20 15.615	90 58 57.203	Round Top	229100.84	5.3600267
			324 01 34.822	144 28 18.913	Mount Diablo	107728.96	5.0323325
Mount Tamalpais	37 55 27.507	848.0	177 46 54.317	357 45 32.153	Mount Helena	82806.00	4.9180618
1882	122 35 45.242	1104.9	274 15 19.460	94 40 28.809	Mount Diablo	60205.71	4.7796377
			298 03 15.847	118 41 27.018	Mocho	104307.60	5.0183159
Vaca	38 22 33.808	1042.4	344 42 00.556	164 48 19.438	Mount Diablo	56830.39	4.7545806
1880	122 05 01.988	48.2	41 59 19.676	221 40 21.039	Mount Tamalpais	67294.58	4.8279801
			124 25 48.796	304 05 18.186	Mount Helena	57910.57	4.7627578
Monticello	38 39 50.645	1561.6	343 53 24.673	163 57 21.544	Vaca	33271.52	4.5220726
1880	122 11 22.327	539.8	344 21 34.456	164 31 50.148	Mount Diablo	90100.14	4.9547254
			23 32 08.728	203 17 02.140	Mount Tamalpais	89478.04	4.9517165
			91 04 27.641	270 47 50.788	Mount Helena	38577.56	4.5863347
Yolo Southeast Base	38 31 42.185	1300.7	7 56 54.564	187 52 41.082	Mount Diablo	72428.38	4.8599088
1880	121 47 58.518	1417.4	55 49 13.774	235 38 37.316	Vaca	30029.78	4.4775521
			114 01 55.200	293 47 19.462	Monticello	37160.80	4.5700850
Yolo Northwest Base	38 40 44.806	1381.6	343 05 07.928	163 07 18.975	Yolo Southeast Base	17486.512	4.2427032
1880	121 51 28.553	690.2	3 09 32.638	183 07 28.854	Mount Diablo	88603.56	4.9474512
			30 25 42.345	210 17 15.660	Vaca	38985.91	4.5909077
			86 47 29.668	266 35 03.730	Monticello	28906.93	4.4610020
Ross Mountain	38 30 20.583	634.7	246 36 09.171	66 54 21.548	Mount Helena	46133.46	4.6640160
1891	123 07 09.221	223.4	302 51 49.822	123 36 33.990	Mount Diablo	126290.35	5.1013702
			324 27 22.348	144 46 47.824	Mount Tamalpais	79153.78	4.8984717
Snow Mountain West	39 22 38.452	1185.8	352 06 02.01	172 10 45.86	Mount Helena	79298.64	4.8992657
1892	122 45 28.619	685.0	18 03 03.98	197 49 26.49	Ross Mountain	101704.73	5.0073412
Mount Sanhedrin	39 30 58.692	1810.0	297 51 47.85	118 04 39.75	Snow Mountain W.	32892.34	4.5170948
1880	123 05 43.527	1039.8	336 46 57.62	157 04 28.01	Mount Helena	102150.49	5.0092405
			1 03 37.35	181 02 43.40	Ross Mountain	112207.62	5.0500224
Cold Spring	39 01 21.370	659.0	213 46 27.49	34 02 40.34	Mount Sanhedrin	66041.97	4.8198200
1878	123 31 20.468	492.4	238 56 46.71	59 25 45.98	Snow Mountain W.	76884.34	4.8858379
			296 36 48.42	117 10 17.26	Mount Helena	86598.42	4.9375100
Great Caspar	39 20 29.499	909.7	249 57 32.77	70 21 20.63	Mount Sanhedrin	57164.25	4.7571245
1878	123 43 11.684	279.8	334 11 50.20	154 19 19.54	Cold Spring	39306.25	4.5944615
Two Rock	39 21 43.523	1342.2	10 02 43.46	189 59 48.09	Cold Spring	38272.70	4.5828891
1879	123 26 42.955	1028.3	84 34 45.22	264 24 18.29	Great Caspar	23783.82	4.3762816
			240 16 19.91	60 29 39.98	Mount Sanhedrin	34644.24	4.5396310
Paxton	39 08 09.197	283.6	55 25 22.50	235 17 25.16	Cold Spring	22123.22	4.3448483
1878	123 18 43.253	1038.8	123 04 58.07	302 49 29.21	Great Caspar	41968.96	4.6229282
			155 25 55.28	335 20 51.78	Two Rock	27621.54	4.4412478
			203 47 14.64	23 55 28.79	Mount Sanhedrin	46178.80	4.6644426

Primaries—Continued.

Station	Latitude and longitude.	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Fisher	39 03 59.721	1841.8	159 22 19.08	339 17 15.73	Great Caspar	32622.87	4.5135222
1891	123 35 11.758	282.6	200 21 53.63	20 27 15.31	Two Rock	35003.06	4.5441060
			251 58 01.46	72 08 24.90	Paxton	24967.75	4.3973794
			311 15 36.59	131 18 02.29	Cold Spring	7401.50	3.8693195
Marysville Butte	39 12 22.361	689.6	258 10 48.681	79 06 09.074	Mount Lola	128028.23	5.1073057
1876	121 49 11.540	276.9	290 18 36.528	111 27 13.322	Round Top	168858.87	5.2275239
			358 39 12.288	178 39 58.108	Yolo S. E. Base	75266.64	4.8766025
			3 12 19.840	183 08 49.947	Mount Diablo	147210.88	5.1679399
			3 14 22.437	183 12 56.316	Yolo N. W. Base	58607.32	4.7679519
			14 03 37.004	193 53 41.545	Vaca	94966.47	4.9775702
			28 09 17.676	207 55 21.344	Monticello	68187.33	4.8337037
			50 03 28.776	229 32 49.632	Mount Helena	92269.81	4.9650596
Pine Hill	38 43 11.112	342.6	214 08 29.350	34 32 08.552	Mount Lola	95939.22	4.9819962
1876	120 59 22.962	554.7	273 48 17.256	94 25 13.899	Round Top	86302.50	4.9360234
			41 16 41.019	220 42 19.882	Mount Diablo	123183.54	5.0905527
			68 32 30.197	247 51 35.460	Vaca	102732.87	5.0117095
			73 29 26.759	252 59 06.823	Yolo S. E. Base	73657.68	4.8672180
			86 51 11.787	266 18 37.534	Yolo N. W. Base	75664.18	4.8788903
			86 59 10.624	266 14 10.387	Monticello	104570.39	5.0194687
			88 17 22.960	267 15 45.009	Mount Helena	143047.52	5.1554802
Sierra Morena	37 24 38.266	1179.7	156 03 23.27	335 52 49.43	Mount Tamalpais	62422.54	4.7953414
1883	122 18 28.006	688.7	213 30 32.29	33 44 59.40	Mount Diablo	62842.01	4.7982501
			263 23 39.45	83 51 06.64	Mocho	67011.26	4.8261478
Loma Prieta	37 06 40.912	1261.3	129 01 13.52	308 44 21.46	Sierra Morena	52911.85	4.7235530
1884	121 50 36.423	899.3	175 52 59.49	355 50 26.13	Mount Diablo	85760.84	4.9332890
			212 04 03.95	32 14 32.67	Mocho	48021.28	4.6814337
Santa Ana	36 54 19.368	597.0	112 59 29.35	292 37 25.88	Loma Prieta	58969.55	4.7706278
1852	121 13 57.738	1429.4	155 49 43.93	335 38 02.09	Mocho	69671.33	4.8430541
Mount Toro	36 31 34.712	1070.0	162 12 31.32	342 04 05.43	Loma Prieta	68212.25	4.8338624
1885	121 36 32.276	803.0	182 34 42.13	2 36 38.58	Mocho	105688.3	5.0240270
			218 31 04.10	38 44 33.91	Santa Ana	53847.56	4.7311660
Hepsedam	36 18 53.603	1652.2	108 39 45.65	288 11 47.86	Mount Toro	74205.98	4.8704389
1885	120 49 26.362	657.6	150 57 28.97	330 42 51.48	Santa Ana	75037.48	4.8752783
Santa Lucia	36 08 45.328	1397.2	157 58 56.29	337 52 09.62	Mount Toro	45547.05	4.6584603
1885	121 25 05.937	148.4	191 06 13.77	11 12 51.48	Santa Ana	85897.71	4.9339816
			250 29 21.13	70 50 25.69	Hepsedam	56625.35	4.7530109
Rocky Butte	35 39 56.026	1726.6	148 46 28.32	328 33 49.52	Santa Lucia	62396.81	4.7951624
1884	121 03 32.063	806.4	196 18 58.11	16 27 15.09	Hepsedam	75096.50	4.8756197
Castle Mount	35 56 21.338	657.6	65 10 20.33	244 45 05.68	Rocky Butte	71752.21	4.8558353
1885	120 20 22.908	574.2	103 35 26.85	282 57 22.08	Santa Lucia	99869.84	4.9994343
			133 51 16.62	313 34 08.71	Hepsedam	60314.14	4.7804191
San Luis	35 16 41.102	1266.7	133 43 16.93	313 25 57.03	Rocky Butte	62363.67	4.7949317
1883	120 33 40.087	1013.0	195 13 58.41	15 21 42.57	Castle Mount	76051.21	4.8811061
San Jose	35 18 55.652	1715.1	81 13 00.12	261 02 52.35	San Luis	26898.41	4.4297266
1884	120 16 08.225	207.8	118 40 51.88	298 13 20.82	Rocky Butte	81529.42	4.9113143
			174 43 48.87	354 41 20.51	Castle Mount	69506.37	4.8420246
Lospe	34 53 38.475	1185.5	154 24 09.50	334 08 26.82	Rocky Butte	95016.09	4.9777971
1875	120 36 19.944	506.4	185 24 58.93	5 26 30.81	San Luis	42799.63	4.6314400
			213 10 59.12	33 22 35.95	San Jose	55925.78	4.7476121
Tepusquet	34 54 37.432	1153.4	87 24 26.30	267 10 02.14	Lospe	38387.04	4.5841846
1875	120 11 09.654	245.1	140 07 33.06	319 54 36.65	San Luis	53234.38	4.7261922
			170 28 23.00	350 25 31.27	San Jose	45568.95	4.6586690
Arguello	34 34 58.957	1816.7	173 14 41.95	353 13 10.25	Lospe	34739.60	4.5408248
1875	120 33 39.011	994.2	223 16 41.80	43 29 30.87	Tepusquet	49967.67	4.6986891
Gaviota	34 30 07.450	229.6	105 12 08.98	284 59 48.69	Arguello	34481.26	4.5375832
1873	120 11 53.426	1363.0	139 28 18.68	319 14 23.86	Lospe	57302.83	4.7581761
			181 24 19.04	1 24 43.96	Tepusquet	45310.40	4.6561979
New San Miguel	34 02 23.753	731.9	165 05 23.69	344 59 28.82	Arguello	62357.94	4.7948918
1873	120 23 09.472	243.0	198 35 23.53	18 41 44.22	Gaviota	54100.86	4.7332042
Santa Cruz West	34 04 24.021	740.2	85 14 06.04	264 58 21.45	New San Miguel	43415.83	4.6376481
1874	119 55 02.762	70.8	133 51 28.66	313 29 42.32	Arguello	81870.08	4.9131252
			151 33 11.21	331 23 41.85	Gaviota	54127.60	4.7334188

Primaries—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Santa Barbara	34 24 17.596	542.2	26 58 33.33	206 51 42.78	Santa Cruz West	41245.53	4.6153769
1857	119 42 53.086	1355.9	103 46 36.35	283 30 11.77	Gaviota	45712.88	4.6600386
Santa Cruz East	34 03 17.886	551.1	93 40 25.95	273 28 33.54	Santa Cruz West	32679.53	4.5142758
1857	119 33 50.872	1304.7	130 31 25.73	310 10 00.15	Gaviota	76605.49	4.8842599
			160 22 07.80	340 17 02.80	Santa Barbara	41220.41	4.6151123
Chaffee	34 18 03.039	93.6	38 22 57.71	218 15 04.94	Santa Cruz East	34760.82	4.5410901
1867	119 19 49.301	1260.7	108 10 56.41	287 57 55.56	Santa Barbara	37200.15	4.5705446
Laguna	34 06 31.665	975.6	82 45 53.48	262 29 05.28	Santa Cruz East	46511.02	4.6675605
1857	119 03 51.742	1326.1	118 55 02.27	298 33 04.30	Santa Barbara	68317.13	4.8345296
			131 03 51.77	310 54 53.47	Chaffee	32477.22	4.5115789
Santa Clara	34 19 33.234	1024.0	5 38 17.07	185 37 24.91	Laguna	24198.47	4.3837879
1898	119 02 18.987	485.4	58 20 01.97	238 02 18.83	Santa Cruz East	57007.34	4.7559308
			84 10 26.08	264 00 33.99	Chaffee	26998.29	4.4313362
Castro	34 05 09.244	284.8	95 42 22.76	275 32 59.18	Laguna	25894.64	4.4132099
1898	118 47 06.433	164.9	138 48 05.87	318 39 32.86	Santa Clara	35418.64	4.5492319
San Fernando	34 19 47.989	1478.7	32 12 40.23	212 06 26.38	Castro	31982.90	4.5049178
1898	118 36 01.454	37.2	89 28 39.48	269 13 49.88	Santa Clara	40330.55	4.6056341
San Pedro	33 44 46.585	1435.2	121 01 15.05	300 36 50.27	Laguna	78487.70	4.8948016
1853	118 20 07.404	190.6	132 17 39.87	312 02 36.48	Castro	56114.10	4.7490720
			159 22 06.55	339 13 12.52	San Fernando	69217.19	4.8402140
Wilson Peak	34 13 26.222	808.0	25 38 33.49	205 29 21.50	San Pedro	58933.99	4.7688895
1890	118 03 39.906	1021.4	77 17 12.33	256 52 48.93	Castro	68502.87	4.8357088
			103 28 37.30	283 10 23.83	San Fernando	51037.69	4.7078910
San Juan	33 54 50.138	1544.7	71 35 34.86	251 15 36.69	San Pedro	58380.39	4.7662670
1886	117 44 15.277	392.5	139 07 05.75	318 56 13.33	Wilson Peak	45545.23	4.6584429
Los Angeles Northwest Base	33 55 05.648	174.0	53 36 36.06	233 27 17.27	San Pedro	32090.07	4.5063707
	118 03 23.777	610.8	179 18 08.98	359 17 59.94	Wilson Peak	33912.58	4.5303608
1889			270 50 20.33	91 01 01.17	San Juan	29506.79	4.4699220
Los Angeles Southeast Base	33 47 34.646	1067.4	82 01 39.21	261 48 31.51	San Pedro	36830.32	4.5662055
	117 56 30.319	780.0	142 37 11.84	322 33 21.50	Los Angeles N.W.B.	17494.239	4.2428950
1889			167 02 54.78	346 58 54.50	Wilson Peak	49059.97	4.6907272
			234 33 54.77	54 40 44.24	San Juan	23174.98	4.3650194
Los Cerritos	33 47 59.793	1842.1	69 36 22.75	249 30 37.71	San Pedro	17044.04	4.2315725
1853	118 09 46.724	1201.9	216 50 57.78	36 54 31.15	Los Angeles N.W.B.	16402.80	4.2149181
			272 06 15.33	92 13 38.33	Los Angeles S.E.B.	20501.40	4.3117834
Las Bolsas	33 40 57.980	1786.3	103 02 24.16	282 51 23.81	San Pedro	31432.54	4.4973794
1853	118 00 17.694	455.8	131 37 31.19	311 32 15.12	Los Cerritos	19581.39	4.2918435
			169 37 42.88	349 35 59.37	Los Angeles N.W.B.	26551.56	4.4240900
			205 34 24.13	25 36 30.41	Los Angeles S.E.B.	13550.37	4.1319510
Santiago	33 42 38.517	1186.6	93 15 43.97	272 49 01.37	San Pedro	74408.22	4.8716209
1899	117 32 01.192	30.7	139 34 31.23	319 16 50.36	Wilson Peak	74946.60	4.8747520
			140 06 27.36	319 59 38.86	San Juan	29403.48	4.4683986
Niguel	33 30 45.473	1401.0	115 03 49.64	294 43 49.92	San Pedro	61553.73	4.7892544
1884	117 44 01.133	29.2	159 05 01.18	338 54 04.26	Wilson Peak	84514.42	4.9269308
			179 31 56.11	359 31 48.27	San Juan	44510.80	4.6484654
			220 08 13.37	40 14 51.90	Santiago	28758.53	4.4587667
Soledad	32 50 23.935	737.3	149 04 34.15	328 48 45.31	Niguel	87080.70	4.9399219
1887	117 15 07.227	187.9	164 52 30.84	344 43 14.50	Santiago	100069.29	5.0003008
Cuyamaca	32 56 48.643	1498.4	79 04 41.88	258 43 39.38	Soledad	61572.31	4.7893855
1898	116 36 22.527	585.2	121 08 59.90	300 31 55.72	Niguel	122393.97	5.0877600
			134 42 27.17	314 11 52.70	Santiago	120965.43	5.0826613
San Jacinto	33 48 53.459	1647.0	355 57 40.60	176 00 04.57	Cuyamaca	96505.82	4.9845535
1898	116 40 44.187	1136.3	81 56 15.41	261 27 45.33	Santiago	80021.98	4.9032093
			96 41 44.31	276 06 20.61	San Juan	98573.23	4.9937590
			109 57 11.90	289 10 48.01	Wilson Peak	135486.25	5.1318952
San Miguel	32 41 47.460	1461.9	118 19 50.40	298 09 34.54	Soledad	33618.64	4.5265802
1898	116 56 09.362	243.8	227 56 52.19	48 07 35.49	Cuyamaca	41517.87	4.6182351
Point Loma L. H. (old)	32 40 19.539	601.9	176 41 02.09	356 40 39.65	Soledad	18649.49	4.2706668
	117 14 25.746	670.8	242 40 20.80	63 00 57.97	Cuyamaca	66757.66	4.8245011
			264 30 04.44	84 39 56.50	San Miguel	28690.93	4.4577446

Primaries—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Boundary Monument 258	32 32 04.406	135.7	144 00 05.52	323 56 16.28	Pt. Loma L. H. (old)	18859.77	4.2755365
1892	117 07 20.303	529.8	160 16 48.91	340.12 36.75	Soledad	35938.17	4.5561598
			226 28 19.32	46.45 04.09	Cuyamaca	66557.32	4.8231958
Tecate	32 34 45.99	1416.6	119 15 52.1	299 07 51.4	San Miguel	26613.7	4.425106
1899	116 41 18.06	471.0	190 40 09.9	.10 42 49.8	Cuyamaca	41463.8	4.617669
Dominguez Hill	33 51 55.639	1714.1	313 17 37.95	133 25 21.56	Las Bolsas	29512.8	4.4700105
1854	118 14 11.638	299.2	316 49 44.70	136 52 12.20	Los Cerritos	9960.0	3.9982594
			34 43 11.59	214 39 53.65	San Pedro	16077.3	4.2062141
West Beach	33 52 39.235	1208.8	275 12 31.20	95 17 48.03	Dominguez Hill	14672.2	4.1664964
1854	118 23 40.110	1030.8	291 49 33.31	111 57 17.39	Los Cerritos	23092.5	4.3634714
			339 23 37.30	159 25 35.66	San Pedro	15556.0	4.1918983
San Pedro Northwest	33 56 07.093	218.5	307 00 09.98	127 03 52.89	Dominguez Hill	12863.3	4.1093532
Base	118 20 51.302	1317.6	311 15 44.77	131 21 55.12	Los Cerritos	22741.9	4.3568259
1853			356 54 54.90	176 55 19.35	San Pedro	20996.9	4.3221542
			34 07 07.01	214 05 32.84	West Beach	7734.5	3.8884297
San Pedro Southeast	33 52 42.717	1316.0	24 57 48.00	204 55 20.38	San Pedro	16178.6	4.2089403
Base	118 15 42.127	1082.6	89 32 12.20	269 27 45.76	West Beach	12284.4	4.0893555
1853			128 25 48.01	308 22 55.54	San Pedro N. W. B.	10136.2	4.0058750
San Buenaventura	34 15 54.801	1688.5	312 59 31.00	133 06 18.61	Laguna	25418.7	4.4051538
1858	119 15 57.154	1462.0	49 47 12.36	229 37 09.47	Santa Cruz East	36060.0	4.5570255
			110 41 08.48	290 25 57.05	Santa Barbara	44115.9	4.6445947
			123 39 36.09	303 37 24.93	Chaffee	7132 3	3.8532298
Santa Barbara L. H.	34 23 51.670	1592.1	217 04 48.50	37 05 01.86	Santa Barbara	1001.4	3.0005942
1876	119 43 16.725	427.2	339 06 00.73	159 11 19.00	Santa Cruz East	40680.7	4.6093887
			26 43 19.61	206 36 42.38	Santa Cruz West	40260.1	4.6048748
			104 56 08.28	284 39 57.16	Gaviota	45326.0	4.6563476
Anacapa	34 00 30.661	944.7	107 16 45.53	287 10 43.06	Santa Cruz East	17395.4	4.2404351
1876	119 23 03.206	82.3	145 22 37.51	325 11 28.58	Santa Barbara	53488.1	4.7282569
			200 56 32.02	21 00 31.11	San Buenaventura	30495.0	4.4842283
			249 16 14.48	69 26 59.36	Laguna	31555.1	4.4990691
Conejo	34 11 57.106	1759.6	47 10 17.15	227 06 20.34	Laguna	14741.2	4.1685338
1857	118 56 49.932	1278.3	104 05 45.17	283 54 59.80	San Buenaventura	30260.5	4.4808759
Santa Clara (old)	34 19 33.224	1023.7	329 03 00.64	149 06 05.91	Conejo	16382.9	4.2143897
1857	119 02 19.014	486.0	5 38 11.02	185 37 18.88	Laguna	24198.1	4.3837815
			72 13 58.84	252 06 17.85	San Buenaventura	21978.7	4.3420021
Saddle Mountain	34 05 01.717	52.9	315 21 06.60	135 29 17.46	West Beach	32117.5	4.5067418
1860	118 38 18.352	470.5	114 17 10.32	294 06 46.46	Conejo	31222.9	4.4944733
San Fernando (old)	34 19 08.898	274.2	13 31 04.62	193 28 47.04	Saddle Mountain	26844.8	4.4288606
1856	118 34 13 597	347.7	69 07 46.23	248 55 02.71	Conejo	37164.6	4.5701295
			91 07 42.97	270 51 52.65	Santa Clara (old)	43095.3	4.6344295
Cowango	34 08 10.179	313.6	343 40 56.90	163 44 08.12	Dominguez Hill	31282.4	4.4953004
1856	118 19 53.581	1372.8	11 28 26.52	191 26 19.82	West Beach	29266.3	4.4663681
			78 29 48.03	258 19 28.50	Saddle Mountain	28904.4	4.4609643
			132 44 44.45	312 36 40.72	San Fernando	29940.8	4.4762635
Catalina Peak	33 23 13.168	405.7	188 36 00.44	8 38 09.91	San Pedro	40303.5	4.6053433
1876	118 24 01.556	40.2	228 07 40.65	48 20 47.26	Las Bolsas	49253.4	4.6924365
Santa Barbara Island	33 28 20.378	627.6	151 56 47.07	331 45 20.44	Anacapa	67448.6	4.8289727
1871	119 02 27.046	698.3	178 14 19.15	358 13 32.04	Laguna	70627.8	4.8489754
			244 54 36.36	65 18 02.12	San Pedro	72178.2	4.8584062
			278 51 10.78	99 12 20.90	Catalina Peak	60305.5	4.7803570
Harbor	32 59 54.779	1687.5	139 44 50.66	319 29 04.54	Santa Barbara Id.	68980.9	4.8387288
1860	118 33 40.818	1059.6	199 09 33.22	19 14 50.34	Catalina Peak	45618.2	4.6591378
West Peak	33 27 36.014	1109.5	359 17 24.35	179 17 37.72	Harbor	51181.5	4.7091133
1877	118 34 05.246	135.5	91 54 42.47	271 39 04.02	Santa Barbara Id.	43965.9	4.6431156
			214 09 51.46	34 17 35.15	San Pedro	38401.9	4.5843532
			244 33 16.21	64 51 57.40	Las Bolsas	57836.0	4.7621981
			297 23 33.06	117 29 05.59	Catalina Peak	17573.3	4.2448521
Saddle Peak	35 13 21.638	666.9	153 51 47.90	333 42 31.63	Rocky Butte	54769.2	4.7385362
1872	120 47 32.816	829.9	253 39 22.07	73 47 22.68	San Luis	21931.2	4.3410626
			257 39 17.78	77 57 25.98	San Jose	48732.7	4.6878206
			301 53 01.39	122 13 55.70	Tepusquet	65269.5	4.8147102
			334 52 59.16	154 59 25.67	Lospe	40250.6	4.6047722

Primaries—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Cahto	39 41 13.079	403.4	294 23 02.45	114 41 31.35	Mt. Sanhedrin	45624.48	4.6591980
1880	123 34 43.123	1027.6	356 13 06.11	176 15 14.62	Cold Spring	73917.17	4.8687453
			17 37 17.83	197 31 54.25	Great Caspar	40229.91	4.6045490
King Peak	40 09 26.187	807.7	308 38 02.37	129 17 33.19	Mt. Sanhedrin	113170.88	5.0537347
1881	124 07 24.332	575.9	318 05 40.32	138 26 38.93	Cahto	69971.27	4.8449198
			338 58 17.57	159 13 46.46	Great Caspar	96948.52	4.9865412
Mount Lassic	40 20 03.791	116.9	336 31 32.60	156 49 11.23	Mt. Sanhedrin	98917.89	4.9952748
1881	123 33 12.978	306.4	1 42 41.94	181 41 43.98	Cahto	71916.70	4.8568297
			68 06 22.97	247 44 17.66	King Peak	52321.96	4.7186840
Chemise Mountain	40 00.51.848	1599.3	147 15 44.02	327 11 06.40	King Peak	18867.57	4.2757160
1872	124 00 13.198	313.0	227 01 49.15	47 19 14.39	Mt. Lassic	52268.19	4.7182375
			305 06 24.01	125 41 15.49	Mt. Sanhedrin	95472.54	4.9798785
			314 50 55.43	135 07 15.89	Cahto	51427.17	4.7111926
			341 51 35.71	162 02 27.92	Great Caspar	78573.34	4.8952752
Bear Ridge*	40 29 52.68	1624.9	285 53 05.9	106 21 53.6	Mt. Lassic	65400.3	4.8155796
1869	124 17 37.81	890.3	338 59 46.7	159 06 23.7	King Peak	40507.7	4.6075371
Mad River*	40 42 11.45	353.2	335 16 36.1	155 25 14.8	Mt. Lassic	45058.3	4.6537747
1881	123 46 31.32	735.3	26 05 24.7	205 51 52.1	King Peak	67430.4	4.8288560
Point Conception Lighthouse†	34 26 59.388	1830.0	150 28 50.42	330 25 44.35	Arguello	16985.9	4.2300895
1873	120 28 10.630	271.4	256 50 28.30	76 59 41.46	Gaviota	25601.7	4.4082695
			273 53 45.24	94 19 21.76	Santa Barbara	69571.1	4.8424291
			309 14 07.20	129 32 46.43	Santa Cruz West	65806.9	4.8182714
			327 19 42.58	147 31 00.41	Brockway	57260.7	4.7578560
			333 11 15.92	153 21 13.61	Farrell	60500.5	4.7817589
			350 21 24.13	170 24 13.71	New San Miguel	46115.9	4.6638505
La Mesa	34 01 27.173	837.3	112 59 45.94	292 54 05.07	Saddle Mountain	16953.5	4.2292600
1856	118 28 09.630	247.1	225 38 51.25	45 43 29.21	Cowango	17774.6	4.2497995
			336 55 51.52	156 58 22.04	West Beach	17677.2	4.2474124
			338 03 50.99	158 08 19.85	San Pedro	33225.8	4.5214754
Point Dume	34 00 06.409	197.5	265 19 57.44	85 31 15.66	La Mesa	31209.6	4.4942877
1856	118 48 22.074	566.5	289 47 09.32	110 00 56.73	West Beach	40475.6	4.6071930
			302 55 11.66	123 10 56.23	San Pedro	51962.8	4.7156925
			20 23 23.02	200 15 33.77	Santa Barbara Id.	62622.8	4.7967322
Gavilan	36 45 20.910	644.5	17 24 32.52	197 21 21.08	Mount Toro	26685.85	4.4262810
1852	121 31 11.350	281.6	143 56 25.47	323 44 45.39	Loma Prieta	48869.24	4.6890356
			236 58 11.66	57 08 31.26	Santa Ana	30521.54	4.4846064
Pajaro Mouth	36 51 09.484	292.3	174 00 43.7	353 59 30.3	Loma Prieta	28870.5	4.460455
1852	121 48 34.442	853.7	292 28 41.3	112 39 06.2	Gavilan	28001.2	4.447176
Santa Cruz Azimuth Station	36 58 42.023	1295.3	231 51 01.0	51 58 40.2	Loma Prieta	23932.4	4.378987
1852	122 03 18.594	462.4	297 11 29.5	117 30 45.8	Gavilan	53747.3	4.730357
			302 26 11.9	122 35 03.0	Pajaro Mouth	25955.7	4.414232
Point Pinos Latitude Station	36 37 59.186	1824.2	95 33 47.9	275 33 31.6	Point Pinos L. H.	680.3	2.832717
1851	121 55 31.632	785.8	163 13 25.0	343 08 45.2	Santa Cruz	40022.1	4.602300
			249 17 33.2	69 32 05.8	Gavilan	38723.7	4.587977

Mexican boundary to Point La Jolla.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Old Town	32 45 03.439	105.9	346 03 18.5	150 05 21.7	Boundary Mon. 258	24724.2	4.393123
1852	117 11 08.630	224.7	30 25 42.3	210 23 55.8	Pt. Loma L. H. (old)	10140.8	4.006073
			147 51 21.1	327 49 11.3	Soledad	11662.4	4.066789
Middle Loma	32 42 09.239	284.6	227 54 33.0	47 56 36.4	Old Town	8008.1	3.903531
1887	117 14 56.910	1482.4	327 23 23.5	147 27 29.7	Boundary Mon. 258	22109.6	4.344580
			346 29 18.8	166 29 35.6	Pt. Loma L. H. (old)	3475.4	3.541003

* No check on this position.

† This light was abandoned and a new light erected in 1882. Approximate position of the new light, latitude 34° 26′ 56″.2 and longitude 120° 28′ 12″.6.

Mexican boundary to Point La Jolla—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Chula	32 39 19.639	604.9	9 33 15.7	189 32 29.2	Boundary Mon. 258	13595.2	4.133384
1892	117 05 53.828	1402.8	97 54 49.7	277 50 13.4	Pt. Loma L. H. (old)	13466.5	4.129253
			110 18 24.7	290 13 31.5	Middle Loma	15082.8	4.178483
			142 16 32.9	322 13 42.8	Old Town	13393 7	4.126899
Observatory, S. W. corner, pole	32 43 29.893	920.8	324 01 04.4	144 03 00.4	Chula	9524.6	3.978847
1891	117 09 28.563	743.8	350 59 34.6	171 00 43.9	Boundary Mon. 258	21378.8	4.329983
			52 52 42.7	232 50 02.2	Pt. Loma L. H. (old)	9711.1	3.987268
			73 49 25.9	253 46 28.5	Middle Loma	8904.9	3.949627
San Diego Longitude Sta.	32 43 29.962	922.9			Meridian Stake	395.465	2.597108
1892	117 09 28.461	741.2					
San Diego Latitude Sta.	32 43 29.962	922.9					
1892	117 09 28.510	742.4					
San Diego Latitude Sta.	32 42 03.945	121.5	223 37 57.0	43 39 46.5	Old Town	7641.3	3.883168
1851	117 14 31.174	812.0	357 28 55.0	177 28 57.9	Pt. Loma L. H. (old)	3219.3	3.507756
Middle	32 41 25.000	770.1	57 49 11.8	237 48 05.5	Pt. Loma L. H. (old)	3785.3	3.578098
1898	117 12 22.785	593.6	109 44 35.8	289 43 26.6	S. Diego Lat. S. 1851	3553.0	3.550595
			196 00 26.0	16 01 06.1	Old Town	7000.5	3.845130
New South	32 39 54.933	1692.1	346 27 43.5	166 28 55.4	Boundary Mon. 258	14907.6	4.173407
1899	117 09 34.033	886.9	95 43 01.1	275 40 23.6	Pt. Loma L. H. (old)	7638.7	3.883019
			117 11 50.5	297 09 10.1	S. Diego Lat. S. 1851	8701.7	3.939605
			122 16 00.0	302 14 28.9	Middle	5198.9	3.715910
			165 28 22.8	345 27 31.7	Old Town	9817.6	3.992005
Mud	32 41 39.819	1226.6	114 50 05.7	294 49 32.4	S. Diego Lat. S. 1851	1769.8	3.247922
1887	117 13 29.511	768.8	210 18 44.2	30 20 00.3	Old Town	7266.5	3.861327
			284 42 34.1	104 43 10.1	Middle	1797.1	3.254579
Ballast Point Lighthouse	32 41 10.884	335.2	152 18 08.0	332 17 50.2	S. Diego Lat. S. 1851	1846.1	3.266250
1899	117 13 58.230	1517.0	220 00 24.8	40 00 40.3	Mud	1163.7	3.065833
			260 04 22.8	80 05 14.4	Middle	2524.2	3.402117
San Diego 2	32 43 12.313	379.3	55 33 44.5	235 31 03.7	Pt. Loma L. H. (old)	9405.9	3.973402
1871	117 09 28.014	729.5	75 05 15.4	255 02 31.5	S. Diego Lat. S. 1851	8171.6	3.912306
			77 14 41.1	257 11 43.4	Middle Loma	8783.3	3.943659
			142 34 53.9	322 33 59.5	Old Town	4310.6	3.634536
San Diego Longitude Station	32 43 12.313	379.3	90 00	270 00	San Diego 2	4.8	0.68144
1871	117 09 27.834	724.7					
Indian Point	32 41 31.377	966.5	76 54 49.3	256 51 32.4	Pt. Loma L. H. (old)	9753.4	3.989158
1851	117 08 21.131	550.4	146 16 51.7	326 15 21.1	Old Town	7854.8	3.895138
			150 44 40.6	330 44 04.5	San Diego 2	3564.0	3.551939
Blackfish Point 2	32 40 49.439	1522.9	81 13 24.6	261 11 21.2	Pt. Loma L. H. (old)	6024.7	3.779935
1871	117 10 37.226	970.0	174 02 07.1	354 01 50.1	Old Town	7867.0	3.895807
			202 16 09.9	22 16 47.3	San Diego 2	4756.0	3.677246
			249 58 09.9	69 59 23.5	Indian Point	3773.5	3.576741
Peninsula Point	32 44 11.573	356.5	230 57 27.5	50 58 08.4	Old Town	2536.8	3.404287
1887	117 12 24.315	633.2	19 57 58.9	199 57 23.7	Mud	4973.5	3.696662
			40 02 59.2	220 01 50.6	S. Diego Lat. S. 1851	5135.3	3.710562
San Diego, Sherman School	32 42 35.141	1082.5	17 38 14.8	197 37 42.2	New South	5178.4	3.714200
1899	117 08 33.818	880.8	77 32 43.5	257 30 03.8	Mud	7888.1	3.896973
			84 07 55.5	264 04 42.4	S. Diego Lat. S. 1851	9357.1	3.971140
			116 20 53.3	296 18 48.7	Peninsula Point	6697.1	3.825888
Old Adobe	32 44 33.891	1044.0	166 21 32.1	346 20 36.3	Soledad	11096.4	4.045182
1887	117 13 26.595	692.5	255 46 08.9	75 47 23.5	Old Town	3705.3	3.568820
			292 00 24.5	112 02 33.4	San Diego 2	6701.2	3.826152
			11 07 42.1	191 07 10.1	Pt. Loma L. H. (old)	7985.2	3.902285
New False Bay	32 44 08.776	270.4	176 44 27.0	356 44 12.0	Soledad	11575.4	4.063537
1887	117 14 41.917	1091.4	248 27 54.2	68 28 35.0	Old Adobe	2108.2	3.323904
			253 06 52.0	73 08 47.4	Old Town	5802.6	3.763619
			281 59 22.9	102 02 12.5	San Diego 2	8356.7	3.922037
			356 35 07.1	176 35 15.9	Pt. Loma L. H. (old)	7074.1	3.849669
Bay Point	32 46 48.051	1480.1	9 22 36.5	189 22 19.7	New False Bay	4972.8	3.696602
1887	117 14 10.800	281.1	167 33 27.2	347 32 55.3	Soledad	6810.3	3.833169
			304 11 16.1	124 12 54.7	Old Town	5733.0	3.758380
			344 26 19.3	164 26 33.2	Old Adobe	4289.9	3.632451

Mexican boundary to Point La Jolla—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Back Bay	32 47 58.353	1797.5	340 42 23.6	160 43 02.8	Old Town	5708.6	3.756530
1887	117 12 21.084	548.6	15 09 08.6	195 08 33.0	Old Adobe	6525.1	3.814588
			27 24 32.5	207 23 16.2	New False Bay	7965.6	3.901217
			52 49 31.9	232 48 32.5	Bay Point	3583.4	3.554295
Hill	32 48 30.560	941.4	285 42 41.2	105 43 54.6	Back Bay	3661.5	3.563654
1887	117 14 36.552	951.0	319 41 02.4	139 42 55.0	Old Town	8365.8	3.922509
			345 58 23.4	165 59 01.2	Old Adobe	7514.4	3.875896
			348 01 03.5	168 01 17.5	Bay Point	3228.1	3.508946
			0 59 32.4	180 59 29.5	New False Bay	8065.4	3.906626
Beach	32 47 43.337	1334.9	218 33 46.4	38 34 10.5	Hill	1860.5	3.269627
1887	117 15 21.130	549.9	264 20 50.3	84 22 27.8	Back Bay	4707.4	3.672785
			312 56 05.7	132 56 43.8	Bay Point	2500.0	3.397944
			351 13 05.6	171 13 26.8	New False Bay	6687.8	3.825286
Knoll	32 48 47.663	1468.2	290 24 36.3	110 25 05.8	Hill	1510.5	3.179120
1887	117 15 30.966	805.6	352 38 26.2	172 38 31.6	Beach	1998.0	3.300599
False Point	32 48 28.704	884.2	233 38 38.5	53 38 55.0	Knoll	985.2	2.993545
1887	117 16 01.467	38.2	268 30 42.0	88 31 27.9	Hill	2209.9	3.344378
			323 05 31.9	143 05 53.8	Beach	1747.7	3.242473
Wash	32 49 17.391	535.7	339 12 13.3	159 12 20.5	Knoll	979.6	2.991039
1887	117 15 44.335	1153.3	16 33 02.7	196 32 53.4	False Point	1564.6	3.194403
Island Point	32 48 53.746	1655.6	228 49 59.4	48 50 16.8	Wash	1106.6	3.043988
1887	117 16 16.360	425.7	279 00 46.0	99 01 10.6	Knoll	1195.7	3.077613
			333 19 47.7	153 19 55.8	False Point	863.2	2.936130
Moss	32 49 32.658	1006.0	228 24 52.3	48 25 29.4	Soledad	2380.1	3.376595
1887	117 16 15.680	407.9	299 58 27.9	119 58 44.9	Wash	941.2	2.973701
			350 27 25.1	170 27 24.6	Pt. Loma L. H. (old)	17277.3	4.237476
			0 50 44.5	180 50 44.1	Island Point	1198.8	3.078748
Sandstone Point	32 49 19.319	595.1	231 48 10.1	51 49 02.8	Soledad	3219.5	3.507794
1887	117 16 44.518	1157.9	241 16 53.1	61 17 08.7	Moss	855.3	2.932116
			272 09 58.9	92 10 31.6	Wash	1566.6	3.194955
			296 59 59.1	117 00 39.0	Knoll	2147.5	3.331926
			317 04 48.8	137 05 04.1	Island Point	1075.6	3.031667
			324 18 25.8	144 18 49.2	False Point	1919.7	3.283224
Boulder	32 50 15.441	475.6	261 04 57.2	81 05 31.9	Soledad	1689.0	3.227623
1887	117 16 11.386	296.1	4 50 39.0	184 50 36.7	Moss	1322.7	3.121447
			26 29 45.1	206 29 27.1	Sandstone Point	1931.7	3.285949
Sand Ridge	32 50 08.263	254.5	256 35 08.2	76 35 27.5	Boulder	953.4	2.979268
1887	117 16 47.044	1223.5	259 27 24.8	79 28 18.8	Soledad	2640.5	3.421684
			323 21 25.6	143 21 42.6	Moss	1366.9	3.135738
			357 30 14.5	177 30 15.8	Sandstone Point	1509.2	3.178740
Pentagon	32 50 38.758	1193.9	314 29 07.1	134 29 22.3	Boulder	1025.0	3.010718
1887	117 16 39.503	1027.5	343 04 25.5	163 04 38.3	Moss	2128.4	3.328048
			11 47 33.6	191 47 29.5	Sand Ridge	959.6	2.982112
Bench	32 50 33.635	1036.1	30 06 09.8	210 05 47.2	Moss	2171.2	3.336691
1887	117 15 33.814	879.5	38 46 41.8	218 46 03.5	Sandstone Point	2936.4	3.467819
			60 09 52.6	240 09 32.2	Boulder	1126.4	3.051702
			67 41 32.4	247 40 52.8	Sand Ridge	2058.6	3.313574
			95 16 58.1	275 16 22.5	Pentagon	1715.5	3.234402
La Jolla Park	32 50 54.774	1687.2	296 42 01.0	116 42 28.0	Bench	1449.1	3.161090
1887	117 16 23.594	613.6	345 18 57.7	165 19 04.3	Boulder	1252.6	3.097795
			355 20 51.3	175 20 55.6	Moss	2537.9	3.404481
			39 58 53.7	219 58 45.1	Pentagon	643.9	2.808806
Barranca	32 51 46.207	1423.3	354 54 48.5	174 54 53.2	Soledad	2544.4	3.405590
1887	117 15 15.901	413.4	11 46 15.1	191 46 05.4	Bench	2283.6	3.358618
			48 00 47.5	228 00 10.8	La Jolla Park	2368.2	3.374420
Bush	32 51 39.774	1225.2	28 55 43.6	208 55 20.1	Bench	2327.8	3.366947
1887	117 14 50.515	1313.5	60 12 16.4	240 11 25.8	La Jolla Park	2789.1	3.445467
			106 42 52.2	286 42 38.4	Barranca	689.1	2.838298
Center	32 52 20.333	626.3	351 36 40.2	171 36 44.0	Bush	1263.0	3.101387
1887	117 14 57.602	1497.5	24 20 59.1	204 20 49.2	Barranca	1153.9	3.062169
			40 18 51 6	220 18 04.9	La Jolla Park	3456.2	3.538605

Mexican boundary to Point La Jolla—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Ball 1887	32 53 14.746	454.2	355 52 18.4	175 52 20.9	Center	1680.6	3.225453
	117 15 02.256	58.6	1 24 26.3	181 24 23.5	Soledad	5263.5	3.721271
			7 24 39.5	187 24 32.1	Barranca	2750.4	3.439102
			26 07 50.5	206 07 06.3	La Jolla Park	4802.5	3.681466
Round Top 1887	32 53 06.280	193.4	12 17 30.4	192 17 07.6	Soledad	5118.4	3.709130
	117 14 25.328	658.4	13 48 26.5	193 48 12.8	Bush	2744.1	3.438402
			20 44 44.2	200 44 07.1	Bench	5028.1	3.701404
			30 39 36.8	210 39 19.3	Center	1645.4	3.216266
			105 12 10.2	285 11 50.2	Ball	994.7	2.997685
La Jolla Park, Botsford's house, spire 1887	32 50 54.862	1689.9	298 21 38.7	118 22 04.0	Bench	1376.5	3.138772
	117 16 20.392	530.4	349 05 01.1	169 05 06.0	Boulder	1236.8	3.092288
			357 13 45.4	177 13 48.0	Moss	2535.3	3.404027
			25 46 30.4	205 46 16.0	Sand Ridge	1594.1	3.202516
			45 03 05.1	225 02 54.7	Pentagon	702.2	2.846488
Ocean Beach, Cliff Hotel, north gable 1887	32 44 48.507	1494.2	203 05 21.5	23 05 54.1	Bay Point	4003.3	3.602418
	117 15 11.126	289.7	265 48 52.5	85 51 03.7	Old Town	6329.7	3.801380
			328 08 36.5	148 08 51.7	New False Bay	1440.9	3.158641
Ocean Beach Windmill 1887	32 45 03.897	120.0	203 11 03.1	23 11 31.7	Bay Point	3490.4	3.542874
	117 15 03.603	93.8	290 05 44.3	110 06 36.8	Old Adobe	2689.3	3.429636
			341 36 26.1	161 36 37.8	New False Bay	1789.4	3.252700
Point Meganos 1887	32 45 37.648	1159.7	169 52 03.8	349 51 49.4	Beach	3933.2	3.594744
	117 14 54.539	1419.7	207 41 33.9	27 41 57.6	Bay Point	2449.4	3.389051
			280 08 33.5	100 10 35.7	Old Town	5974.3	3.776290
			310 37 09.2	130 37 46.8	Old Adobe	3016.4	3.479491
Coronado Hotel, highest tower 1887–88	32 40 49.725	1531.7	81 02 36.2	261 00 34.2	Pt. Loma L. H. (old)	5961.3	3.775338
	117 10 39.744	1035.5	109 14 51.3	289 13 19.7	Mud	4684.1	3.670623
			110 47 09.3	290 45 04.5	S. Diego Lat. S. 1851	6447.7	3.809406
			112 02 46.3	292 01 50.7	Middle	2896.0	3.461797
			158 32 03.9	338 29 39.3	Soledad	19009.2	4.278968
			174 30 14.9	354 29 59.5	Old Town	7851.7	3.894962
			314 35 08.2	134 35 43.9	New South	2404.2	3.380967
			342 10 10.5	162 11 58.0	Boundary Mon. 258	16996.9	4.230370
Standpipe 1898–99	32 45 23.025	709.2	346 15 05.2	166 15 56.5	New South	10404.5	4.017222
	117 11 08.929	232.4	4 02 39.5	184 02 32.6	Channel Point	4883.7	3.688745
			14 42 11.9	194 41 32.0	Middle	7580.3	3.879684
			28 02 31.5	208 01 15.5	Mud	7789.6	3.891514
			28 44 59.6	208 43 13.4	Pt. Loma L. H. (old)	10661.7	4.027825
			40 40 08.7	220 38 19.4	S. Diego Lat. S. 1851	8083.4	3.907595
			41 43 40.4	221 42 59.7	Peninsula Point	2949.0	3.469669
			45 07 33.7	225 06 11.2	Fisherman Point	5606.2	3.748665
Channel Point 1887	32 42 44.878	1382.4	46 54 08.8	226 52 29.6	Pt. Loma L. H. (old)	6551.0	3.816306
	117 11 22.158	577.1	148 47 07.2	328 46 33.6	Peninsula Point	3122.8	3.494545
			184 42 59.6	4 43 06.9	Old Town	4282.8	3.631731
			254 07 14.6	74 08 16.3	San Diego 2	3090.4	3.490008
Meridian Mark 1871	32 39 59.973	1847.4	94 27 44.5	274 25 03.6	Pt. Loma L. H. (old)	7785.4	3.891281
	117 09 27.851	725.8	114 56 21.9	294 53 24.2	Middle Loma	9452.3	3.975536
			130 08 04.7	310 07 27.2	Blackfish Point 2	2364.2	3.373678
			164 19 25.3	344 18 30.8	Old Town	9709.6	3.987201
			211 41 02.9	31 41 38.9	Indian Point	3308.9	3.519689
Glorieta Bight 1887	32 40 56.548	1741.9	79 29 21.8	259 27 14.6	Pt. Loma L. H. (old)	6239.2	3.795128
	117 10 30.305	789.6	172 31 35.4	352 31 14.7	Old Town	7670.6	3.884827
			201 11 56.2	21 12 29.9	San Diego 2	4485.8	3.651842
			316 57 28.8	136 58 02.5	Meridian Mark	2384.3	3.377369
Indian Point 2 1887	32 41 31.613	973.8	31 55 34.8	211 54 58.4	Meridian Mark	3325.8	3.521902
	117 08 20.352	530.2	72 18 49.9	252 17 39.7	Glorieta Bight	3553.6	3.550665
Made Point 1887	32 41 50.557	1557.3	162 24 52.2	342 24 13.1	Old Town	6233.1	3.794705
	117 09 56.290	1466.3	196 17 48.1	16 18 03.4	San Diego 2	2623.9	3.418945
			283 08 10.5	103 09 02.3	Indian Point 2	2566.3	3.409308
			347 43 36.4	167 43 51.8	Meridian Mark	3486.1	3.542339
National City 1887	32 39 54.376	1675.0	92 29 19.6	272 27 57.0	Meridian Mark	3989.2	3.600882
	117 06 54.901	1430.6	143 23 04.2	323 22 18.1	Indian Point 2	3732.1	3.571950
Sand Hill 1887	32 39 10.526	324.2	104 12 21.7	284 09 27.4	Pt. Loma L. H. (old)	8677.0	3.938372
	117 09 02.907	75.8	156 53 31.9	336 53 18.4	Meridian Mark	1656.1	3.219075
			194 18 32.9	14 18 55.9	Indian Point 2	4485.3	3.651789
			247 56 45.4	67 57 54.5	National City	3598.8	3.556163

Mexican boundary to Point La Jolla—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Sweetwater	32 38 25.423	783.1	112 17 11.9	292 16 01.7	Sand Hill	3665.1	3.564085
1887	117 06 52.777	1375.8	125 47 29.7	305 46 06.0	Meridian Mark	4981.5	3.697358
			158 18 38.4	338 17 51.2	Indian Point 2	6172.7	3.790477
			178 50 35.9	358 50 34.8	National City	2740.7	3.437857
Shell Hill	32 37 46.988	1447.4	156 45 51.1	336 45 28.2	Sand Hill	2800.5	3.447241
1887	117 08 20.512	534.7	209 36 59.3	29 37 45.5	National City	4514.1	3.654567
			242 37 21.1	62 38 08.4	Sweetwater	2575.2	3.410811
Brush Hill	32 36 30.307	933.6	160 37 29.8	340 36 53.9	Sand Hill	5231.9	3.718657
1887	117 07 56.306	1468.3	165 02 38.8	345 02 25.8	Shell Hill	2444.9	3.388269
			194 16 49.9	14 17 23.1	National City	6486.7	3.812026
			205 01 47.4	25 02 21.7	Sweetwater	3913.7	3.592591
Marsh Point	32 36 34.224	1054.2	87 51 30.5	267 50 24.1	Brush Hill	3214.9	3.507162
1887	117 05 53.094	1384.4	120 15 44.9	300 14 25.5	Shell Hill	4449.1	3.648275
			134 13 58.9	314 12 16.6	Sand Hill	6903.9	3.839093
			155 34 33.6	335 34 01.4	Sweetwater	3762.2	3.575441
Fisherman Point	32 43 14.596	449.6	228 51 34.3	48 52 16.1	Peninsula Point	2668.1	3.426201
1887	117 13 41.488	1080.4	229 52 35.3	49 53 58.0	Old Town	5204.0	3.716335
			270 35 29.0	90 37 46.1	San Diego 2	6601.2	3.819620
			353 54 01.3	173 54 07.8	Mud	2936.2	3.467781
			30 44 18.8	210 43 52.0	S. Diego Lat. S. 1851	2532.0	3.403462
Cemetery Bluff	32 41 24.144	743.7	167 35 33.9	347 35 27.5	Middle Loma	1422.4	3.153013
1887	117 14 45.177	1177.0	219 50 17.6	39 52 14.6	Old Town	8799.7	3.944466
			248 00 31.9	68 03 23.2	San Diego 2	8907.4	3.949753
			287 23 18.2	107 26 09.5	Meridian Mark	8664.6	3.937746
			345 43 35.6	165 43 46.1	Pt. Loma L. H. (old)	2053.5	3.312490
San Diego, Russ Schoolhouse, flagstaff	32 43 11.942	367.9	338 42 42.8	158 43 07.8	Indian Point 2	3316.8	3.520721
1887–99	117 09 06.579	171.3	27 19 02.1	207 18 35.2	Made Point	2821.6	3.450495
			27 36 38.7	207 35 53.5	Glorieta Bight	4706.5	3.672695
			76 43 29.9	256 42 16.7	Channel Point	3627.9	3.559658
			91 10 24.9	271 10 13.4	San Diego 2	558.4	2.746928
San Diego, G. Hazard's house, tower	32 43 50.536	1556.7	335 05 37.7	155 06 18.6	Indian Point 2	4718.0	3.673759
1887	117 09 36.626	953.7	349 13 05.0	169 13 09.4	San Diego 2	1198.6	3.078674
			7 53 24.9	187 53 14.0	Made Point	3731.2	3.571847
			53 39 21.8	233 38 24.7	Channel Point	3412.2	3.533033
			98 27 17.6	278 25 46.9	Peninsula Point	4414.0	3.644837
			133 09 39.5	313 08 49.6	Old Town	3283.5	3.516334
San Diego, electric light mast, 21st and J sts.	32 42 34.044	1048.7	330 58 06.2	150 59 01.1	National City	5624.9	3.750112
1887	117 08 39.659	1033.0	345 20 38.9	165 20 49.3	Indian Point 2	1987.8	3.298376
			56 08 16.4	236 07 35.0	Made Point	2403.8	3.380901
Entrance	32 41 28.798	887.1	131 55 54.4	311 55 29.4	S. Diego Lat. S. 1851	1620.3	3.209586
1887	117 13 44.897	1169.7	181 33 35.9	1 33 37.7	Fisherman Point	3260.2	3.513247
			202 42 17.9	22 43 01.5	Peninsula Point	5435.6	3.735251
			211 35 56.5	31 37 21.1	Old Town	7763.8	3.890076
			229 44 00.5	49 44 08.9	Mud	525.2	2.720347
Ballast Point 2	32 41 10.685	329.1	151 55 47.2	331 55 29.2	S. Diego Lat. S. 1851	1859.4	3.269367
1887	117 13 57.583	1500.2	186 15 58.8	6 16 07.4	Fisherman Point	3839.9	3.584322
			203 32 49.1	23 33 39.5	Peninsula Point	6078.0	3.783802
			211 31 23.8	31 32 55.0	Old Town	8412.2	3.924912
			219 10 23.2	39 10 38.3	Mud	1157.6	3.063576
South	32 39 59.016	1817.9	142 57 32.8	322 57 05.1	Glorieta Bight	2220.4	3.346423
1887	117 09 38.966	1015.5	215 40 29.0	35 41 11.5	Indian Point 2	3511.6	3.545500
			271 54 09.8	91 55 38.4	National City	4277.5	3.631189
Black Flag	32 42 20.068	618.2	79 23 23.3	259 22 28.3	S. Diego Lat. S. 1851	2695.4	3.430630
1887	117 12 49.459	1288.1	141 06 37.4	321 06 09.2	Fisherman Point	2158.1	3.334074
			190 47 27.1	10 47 40.7	Peninsula Point	3496.7	3.543658
			207 32 37.3	27 33 31.8	Old Town	5676.3	3.754064
Blackfish Point	32 40 47.761	1471.2	174 19 13.2	354 18 56.9	Old Town	7914.9	3.898447
1851	117 10 38.540	1004.2	249 25 00.8	69 26 15.0	Indian Point	3823.5	3.582462
Point Loma	32 40 19.551	602.2	210 24 14.4	30 26 00.9	Old Town	10140.9	4.006078
1851	117 14 25.779	671.7	261 37 59.1	81 40 01.8	Blackfish Point	5984.0	3.776989
Fitchs Hill	32 43 02.826	87.1	305 35 05.6	125 37 06.1	Blackfish Point	7147.0	3.854123
1851	117 14 21.635	563.4	1 13 46.8	181 13 44.6	Point Loma	5030.7	3.701631
San Diego East Base	32 41 24.108	742.6	54 03 01.5	234 02 04.7	Point Loma	3386.7	3.529777
1851	117 12 40.555	1056.6	139 07 21.0	319 06 26.4	Fitchs Hill	4022.3	3.604473

Mexican boundary to Point La Jolla—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Playa	32 42 16.01	493.2	301 34 34	121 35 28	San Diego E. Base	3052.8	3.484705
1851	117 14 20.40	531.3	2 14 21	182 14 18	Point Loma	3590.3	3.555126
Ballast Point	32 41 11.12	342.5	163 35 57	343 35 45	Playa	2083.7	3.31883
1851	117 13 57.81	1506.1	258 45 13	78 45 55	San Diego E. Base	2051.9	3.31215
San Diego West Base	32 41 47.12	1451.5	301 05 48	121 06 12	San Diego E. Base	1372.2	3.13742
1851	117 13 25.66	668.5	37 03 58	217 03 41	Ballast Point	1389.5	3.14285
San Diego Azimuth Station	32 42 03.954	121.8	187 53 35.0	7 53 40.2	Fitchs Hill	1830.9	3.262658
	117 14 31.290	815.0	293 02 33.6	113 03 33.4	San Diego E. Base	3134.8	3.496207
1851							
Roseville Hotel, west gable, or	32 43 21.377	658.5	233 25 28.5	53 26 56.5	Old Town	5277.7	3.722446
	117 13 51.441	1339.7	235 42 57.5	55 43 44.6	Peninsula Point	2745.5	3.438620
Yellow Gable, U. S. E.			23 27 20.5	203 26 59.0	S. Diego Lat. S. 1851	2600.0	3.414981
1887							
Slaughter House, south gable	32 44 38.395	1182.7	354 00 52.8	174 01 00.4	Channel Point	3516.0	3.546049
	117 11 36.235	943.4	56 34 38.0	236 34 12.0	Peninsula Point	1499.9	3.176062
1887			51 38 50.6	231 37 42.8	Fisherman Point	4159.3	3.619023
San Diego, W. H. Pringle's house, spire	32 43 57.799	1780.4	347 51 25.5	167 51 31.5	San Diego 2	1433.3	3.156323
	117 09 39.593	1030.9	6 19 53.4	186 19 44.2	Made Point	3943.7	3.595901
1887			49 56 33.3	229 55 37.8	Channel Point	3489.9	3.542812
			95 39 43.5	275 38 14.4	Peninsula Point	4309.8	3.634462
			131 06 15.9	311 05 27.6	Old Town	3076.0	3.487992
Stone's house, pipe	32 44 51.607	1589.7	260 59 52.2	81 00 40.0	Old Town	2331.1	3.367565
1887	117 12 37.073	965.3	333 26 36.8	153 27 17.3	Channel Point	4364.1	3.639892
			344 55 29.5	164 55 35.4	Peninsula Point	1277.2	3.106254
San Diego, Florence Hotel, flagstaff	32 43 32.130	989.7	61 13 47.6	241 12 52.6	Channel Point	3023.6	3.480520
	117 09 40.392	1051.9	105 54 06.4	285 52 37.8	Peninsula Point	4437.8	3.647170
1887			140 45 56.6	320 45 03.8	Old Town	3631.7	3.560111
San Diego, electric light mast, 4th & Cedar Sts.	32 43 19.754	608.5	68 23 40.5	248 22 44.2	Channel Point	2916.7	3.464889
	117 09 38.034	990.5	110 15 00.2	290 13 30.3	Peninsula Point	4614.6	3.664138
1887			143 33 37.3	323 32 48.2	Old Town	3970.6	3.598855
			311 18 06.5	131 18 11.7	San Diego 2	347.3	2.540687
San Diego, electric light mast, D & Front Sts.	32 42 56.494	1740.2	81 22 48.0	261 21 59.1	Channel Point	2385.6	3.377590
	117 09 51.594	1343.7	120 11 31.4	300 10 08.8	Peninsula Point	4600.4	3.662799
1887			152 51 03.2	332 50 21.3	Old Town	4394.9	3.642950
			231 33 49.1	51 34 01.6	San Diego 2	783.9	2.894252
San Diego, southeast electric light mast	32 42 49.139	1513.6	119 58 27.1	299 56 55.7	Peninsula Point	5084.6	3.706256
	117 09 35.149	915.5	149 32 11.3	329 31 20.8	Old Town	4800.0	3.681241
1887			194 35 09.3	14 35 13.2	San Diego 2	737.6	2.867840
San Diego, Baptist Church, spire	32 42 48.259	1486.5	87 59 11.9	267 58 10.7	Channel Point	2951.5	3.470044
	117 09 28.898	752.7	148 03 34.8	328 02 40.9	Old Town	4907.5	3.690863
1887			181 46 38.1	1 46 38.6	San Diego 2	741.3	2.870015
Coronado Beach, artesian well tower, or	32 41 45.166	1391.3	95 19 42.3	275 17 33.2	S. Diego Lat. S. 1851	6250.0	3.7[illegible]5883
	117 10 32.258	840.4	144 45 11.7	324 44 27.8	Channel Point	2252.5	3.352672
Water, U. S. E.			147 06 10.5	327 05 09.9	Peninsula Point	5371.8	3.730118
1887			171 11 16.5	351 10 39.8	Old Town	6178.4	3.791045
Coronado Beach, mill stack	32 41 45.890	1413.6	94 37 05.4	274 34 42.0	S. Diego Lat. S. 1851	6937.4	3.841199
	117 10 05.695	148.4	132 22 59.5	312 22 18.3	Channel Point	2695.9	3.430705
1887			141 11 46.7	321 10 31.8	Peninsula Point	5759.5	3.760382
			164 55 56.2	344 55 22.3	Old Town	6302.2	3.799493
San Diego, Pierce & Morse building, flagstaff	32 42 49.966	1539.1	86 52 29.0	266 51 29.6	Channel Point	2867.6	3.457514
	117 09 32.214	839.1	119 18 09.8	299 16 36.8	Peninsula Point	5138.4	3.710829
			148 35 59.4	328 35 07.3	Old Town	4817.4	3.682813
1887			189 01 39.5	9 01 41.6	San Diego 2	697.0	2.843228
San Diego, Episcopal Church, spire	32 43 00.199	6.1	81 09 12.3	261 08 09.4	Channel Point	3065.8	3.486546
	117 09 25.839	672.9	115 19 54.0	295 18 17.5	Peninsula Point	5141.3	3.711070
1887			144 49 27.8	324 48 32.2	Old Town	4644.9	3.666980
			171 20 46.7	351 20 45.3	San Diego 2	377.4	2.576841
San Diego, mill stack	32 42 21.844	672.9	313 16 13.3	133 16 47.4	Indian Point 2	2257.2	3.353574
1887	117 09 23.445	610.6	319 33 43.7	139 35 02.3	National City	5967.5	3.775792
			33 32 39.3	213 32 01.6	Glorieta Bight	3152.3	3.498627
			41 35 48.3	221 35 30.6	Made Point	1288.7	3.110155

Mexican boundary to Point La Jolla—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms.
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Coronado Hotel, northeast corner 1887	32 40 53.674	1653.3	213 51 13.5	33 51 37.9	Made Point	2110.0	3.324288
	117 10 41.416	1079.2	252 20 52.2	72 22 08.4	Indian Point 2	3856.2	3.586164
			287 10 50.4	107 12 51.1	National City	6178.1	3.790852
West Twin Windmill 1887	32 34 59.343	1828.0	138 37 38.3	318 36 47.3	Brush Hill	3734.4	3.572217
	117 06 21.642	564.5	172 42 54.7	352 42 37.9	Sweetwater	6399.8	3.806166
			194 17 17.9	14 17 33.3	Marsh Point	3016.0	3.479436
East Twin Windmill 1887	32 34 59.242	1824.9	137 57 12.9	317 56 20.6	Brush Hill	3777.9	3.577251
	117 06 19.267	592.6	172 10 10.7	352 09 52.7	Sweetwater	6411.0	3.806925
			193 07 43.7	13 07 57.8	Marsh Point	3004.4	3.477752
La Punta house, chimney 1887	32 35 47.705	1469.5	107 56 42.4	287 55 18.6	Brush Hill	4262.0	3.629612
	117 05 20.800	542.5	128 07 01.9	308 05 25.1	Shell Hill	5954.5	3.774842
			149 33 42.4	329 33 25.0	Marsh Point	1662.1	3.220651
			153 44 14.7	333 43 25.1	Sweetwater	5417.9	3.733832
National City, W. Kimball's house, flagstaff 1887	32 39 52.482	1616.6	1 31 23.2	181 31 19.7	Marsh Point	6109.4	3.785995
	117 05 46.866	1221.4	32 38 41.5	212 38 05.9	Sweetwater	3184.7	3.503074
			46 01 15.4	225 59 52.5	Shell Hill	5565.9	3.745534
National City Railway Tank 1887	32 39 32.585	1003.7	0 18 05.0	180 18 04.2	Marsh Point	5494.3	3.739914
	117 05 51.986	1354.9	30 00 01.8	209 58 54.5	Brush Hill	6483.0	3.811773
			37 26 58.8	217 26 25.8	Sweetwater	2605.8	3.415945
			49 58 17.6	229 56 57.3	Shell Hill	5056.3	3.703834
			82 14 15.5	262 12 32.5	Sand Hill	5021.6	3.700842
			133 29 52.1	313 28 32.0	Indian Point 2	5327.9	3.726555
Spit Windmill 1887	32 37 35.853	1104.4	146 17 43.4	326 17 38.7	Shell Hill	412.3	2.615256
	117 08 11.734	305.9	205 08 04.6	25 08 46.1	National City	4713.6	3.673354
			233 25 17.9	53 26 00.5	Sweetwater	2562.7	3.408702
			297 41 57.1	117 43 11.8	Marsh Point	4082.7	3.610949
			348 43 56.5	168 44 04.8	Brush Hill	2058.7	3.313602
National City, Episcopal Church, spire 1887	32 40 40.117	1235.8	17 41 47.3	197 41 19.9	Sweetwater	4355.1	3.639002
	117 06 01.986	51.8	21 10 30.9	201 09 29.2	Brush Hill	8251.9	3.916554
			34 06 18.9	214 05 04.2	Shell Hill	6440.1	3.808890
			44 22 51.2	224 22 22.6	National City	1971.4	3.294764
			94 09 40.4	274 07 15.6	Glorieta Bight	7008.9	3.845647
			113 45 47.2	293 44 32.6	Indian Point 2	3938.2	3.595303
National City Schoolhouse, tower 1887	32 40 34.248	1054.9	21 40 38.9	201 39 37.1	Brush Hill	8085.8	3.907724
	117 06 01.756	45.8	35 04 22.9	215 03 08.1	Shell Hill	6294.6	3.798969
			61 21 47.8	241 20 10.0	Sand Hill	5378.9	3.730695
National City, New Methodist Church 1587	32 40 17.096	526.6	33 48 17.2	213 47 13.1	Shell Hill	5551.3	3.744396
	117 06 21.757	566.9	50 58 55.1	230 58 37.2	National City	1111.6	3.045945
			126 37 08.4	306 36 04.4	Indian Point 2	3849.1	3.585357
National City, Congregational Church 1887	32 40 35.458	1092.2	31 35 26.6	211 34 20.6	Shell Hill	6091.8	3.784745
	117 06 18.094	471.5	37 09 31.9	217 09 12.0	National City	1587.8	3.200806
			118 30 57.3	298 29 51.3	Indian Point 2	3624.5	3.559245
Windmill (a) 1887	32 38 47.990	1478.3	4 46 22.1	184 46 15.0	Marsh Point	4134.9	3.616460
	117 05 39.899	1040.0	39 59 14.9	219 58 01.3	Brush Hill	5534.6	3.743087
			65 50 20.6	245 48 54.0	Shell Hill	4588.8	3.661696
			69 54 17.7	249 53 38.3	Sweetwater	2022.7	3.305924
Coronado Beach, hotel electric light mast 1887	32 40 52.663	1622.2	109 36 24.5	289 34 16.6	S. Diego Lat. S. 1851	6549.3	3.816193
	117 10 34.313	894.1	154 56 54.6	334 55 55.2	Peninsula Point	6764.0	3.830204
			160 10 38.4	340 10 12.6	Channel Point	3674.5	3.565199
			173 24 12.0	353 23 53.5	Old Town	7776.5	3.890786
			201 52 00.0	21 52 36.0	San Diego 2	4635.5	3.666094
Coronado Beach, middle electric light mast 1887	32 41 07.924	244.1	106 29 39.5	286 27 38.5	S. Diego Lat. S. 1851	6084.1	3.784198
	117 10 47.203	1229.8	155 55 09.1	335 54 16.6	Peninsula Point	6196.8	3.792169
			163 02 56.4	343 02 37.4	Channel Point	3122.3	3.494473
			175 36 13.0	355 36 02.1	Old Town	7276.3	3.861912
			208 17 14.6	28 17 57.4	San Diego 2	4351.6	3.638647
Coronado Beach, north electric light mast 1887	32 41 40.971	1262.0	96 23 47.1	276 21 35.8	S. Diego Lat. S. 1851	6370.4	3.804164
	117 10 28.125	732.7	144 26 36.6	324 26 07.3	Channel Point	2419.9	3.383804
			146 53 39.7	326 52 36.9	Peninsula Point	5538.8	3.743416
			170 24 15.1	350 23 53.1	Old Town	6325.5	3.801094
National City, International Hotel, flagstaff 1887	32 39 42.548	1310.6	351 26 03.0	171 26 21.0	Marsh Point	5866.5	3.768382
	117 06 26.607	693.3	16 01 11.1	196 00 57.0	Sweetwater	2471.7	3.392998
			109 45 58.6	289 43 47.1	Glorieta Bight	6746.4	3.829074
			116 18 02.1	296 17 46.9	National City	822.4	2.915075
			138 35 37.4	318 34 36.1	Indian Point 2	4479.9	3.651270

Mexican boundary to Point La Jolla—Continued.

Station.	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
National City, Two Tower House	32 41 02.846	87.7	30 05 26.4	210 03 45.7	Brush Hill	9701.6	3.986843
1887	117 04 49.756	1296.3	33 28 36.2	213 27 29.8	Sweetwater	5813.1	3.764408
			42 19 42.4	222 17 48.7	Shell Hill	8158.7	3.911623
			62 20 26.2	242 18 09.6	Sand Hill	7448.5	3.872071
			88 46 22.1	268 43 18.4	Glorieta Bight	8874.2	3.948127
			99 11 28.5	279 09 35.0	Indian Point 2	5557.3	3.744861
National City, San Diego Land and Town Company's office, flagstaff	32 39 37.961	1169.3	349 01 33.6	169 01 56.3	Marsh Point	5765.2	3.760817
1887	117 06 35.186	917.0	11 35 45.0	191 35 35.5	Sweetwater	2281.0	3.358129
			141 57 34.9	321 56 38.2	Indian Point 2	4445.7	3.647941
North Coronado Island, south rock, Mex.	32 26 03.952	121.7	188 02 20.5	8 03 47.3	Middle Loma	30030.5	4.477562
1887	117 17 38.148	996.6	189 01 55.7	9 03 28.9	Cemetery Bluff	28702.4	4.457918
			196 06 40.1	16 10 09.9	Old Town	36541.1	4.562781
			201 56 27.3	22 00 51.2	San Diego 2	34159 8	4.533515
South Coronado Island, north rock, Mex.	32 25 14.858	457.7	180 18 27.3	0 18 30.8	Middle Loma	31247.8	4.494819
1887	117 15 03.348	87.5	180 54 30.1	0 54 39.9	Cemetery Bluff	29862.0	4.475119
			189 28 27.6	9 30 33.9	Old Town	37121.4	4.569624
			194 44 21.7	14 47 22.2	San Diego 2	34323.0	4.535585
Middle Coronado Island, Mex.	32 25 05.038	155.2	181 52 51.5	1 53 12.9	Middle Loma	31566.2	4.499223
1887	117 15 36.690	958.7	182 32 51.0	2 33 18.8	Cemetery Bluff	30189.8	4.479860
			190 42 14.0	10 44 38.4	Old Town	37571.4	4.574858
			195 59 36.1	16 02 54.6	San Diego 2	34845.5	4.542147
Middle Hydrographic Signal	32 41 25.281	778.7	55 22 41.7	235 21 40.9	Pt. Loma L. H. (old)	3563.7	3.551896
1887	117 12 33.192	864.6	111 11 31.9	291 10 28.2	S. Diego Lat. S. 1851	3296.0	3.517982
			198 08 12.4	18 08 58.1	Old Town	7071.8	3.849533
Bar Buoy Station	32 41 23.608	727.2	50 02 25.9	230 01 37.1	Pt. Loma L. H. (old)	3072.3	3.487465
1887	117 12 55.309	1440.8	116 27 42.4	296 26 50.6	S. Diego Lat. S. 1851	2789.2	3.445482
			264 53 04.2	84 53 16.1	Middle Hydrog. Sig.	578.4	2.762257
Hotel Bight Hydrographic Signal	32 41 11.609	357.6	71 37 09.5	251 35 29.6	Pt. Loma L. H. (old)	5083.4	3.706151
1887	117 11 20.601	536.7	108 00 20.8	287 58 37.9	S. Diego Lat. S. 1851	5219.5	3.717627
			182 29 55.3	2 30 01.8	Old Town	7148.2	3.854197
Beacon 3	32 42 23.19	714.3	193 07 48.1	13 07 55.8	Fisherman Point	1626.0	3.21112
1887	117 13 55.67	1450.0	215 27 57.7	35 28 47.1	Peninsula Point	4099.6	3.61274
Beacon 4	32 42 38.57	1188.1	62 58 05.1	242 57 21.7	S. Diego Lat. S. 1851	2346.5	3.37042
1887	117 13 10.93	284.6	202 57 31.7	22 57 56.9	Peninsula Point	3111.4	3.49295
Beacon 5	32 43 14.80	455.9	89 46 27.9	269 45 55.7	Fisherman Point	1549.4	3.19017
1887	117 12 42.00	1093.7	194 45 44.3	14 45 53.9	Peninsula Point	1808.6	3.25735
Beacon 6	32 42 53.98	1662.8	189 46 50.5	9 46 59.1	Peninsula Point	2425.6	3.38482
1887	117 12 40.14	1045.3	210 51 01.2	30 51 50.7	Old Town	4645.7	3.66705
Beacon 7	32 42 55.49	1709.3	132 47 27.0	312 46 34.4	Peninsula Point	3450.6	3.53790
1887	117 10 47.06	1225.6	171 53 33.8	351 53 22.1	Old Town	3981.3	3.60003
Beacon 8	32 41 48.74	1501.4	137 54 54.6	317 53 32.1	Peninsula Point	5929.4	3.77301
1887	117 09 51.68	1346.2	161 31 53.3	341 31 11.7	Old Town	6323.4	3.80095
West Point Beacon	32 42 54.09	1666.2	151 56 52.5	331 56 26.1	Peninsula Point	2704.5	3.43209
1887	117 11 35.47	923.8	189 56 42.2	9 56 56.7	Old Town	4045.3	3.60695
Indian Point Beacon	32 41 25.29	779.0	10 01 08.4	190 00 58.8	Meridian Mark	2668.9	3.42633
1887	117 09 10.03	261.3	67 03 59.3	247 03 15.9	Glorieta Bight	2271.1	3.35624
Indian Point Beacon S.	32 41 22.29	686.6	26 25 16.6	206 24 50.5	Meridian Mark	2831.3	3.45199
1887	117 08 39.50	1028.9	74 38 52.5	254 37 52.7	Glorieta Bight	2993.6	3.47619
Bight Beacon	32 40 37.19	1145.6	67 29 52.4	247 28 55.1	Meridian Mark	2994.7	3.47635
1887	117 07 41.67	1085.7	148 59 31.7	328 59 10.8	Indian Point 2	1955.9	3.29135
Middle Beacon	32 40 18.64	574.2	77 06 24.6	257 05 32.6	Meridian Mark	2575.1	3.41080
1887	117 07 51.52	1342.4	161 31 22.6	341 31 07.0	Indian Point 2	2370.2	3.37479
National City Beacon	32 40 07.64	235.3	85 07 59.3	265 07 01.9	Meridian Mark	2779.2	3.44392
1887	117 07 41.58	1083.5	158 40 12.3	338 39 51.2	Indian Point 2	2777.0	3.44357
San Diego, southwest corner block 119*	32 44 06.03	185.7	27 41 19.2	207 40 51.9	Channel Point	2823.0	3.45071
1887	117 10 31.79	827.7	93 20 40.0	273 19 39.1	Peninsula Point	2934.8	3.46758

* No check on this position.

Mexican boundary to Point La Jolla—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Big Tank Windmill*	32 36 45.16	1391.1	70 23 55.4	250 23 35.8	Marsh Point	1004.4	3.00189
1887	117 05 16.81	438.2	140 59 50.2	320 58 58.5	Sweetwater	3974.6	3.59929
Beacon 2	32 42 10.99	338.5	183 03 28.1	3 03 30.3	Fisherman Point	1962.0	3.29270
1887	117 13 45.51	1185.4	209 38 38.5	29 39 22.4	Peninsula Point	4274.0	3.63083
Boathouse, flagstaff	32 40 48.000	1478.6	170 20 32.1	350 20 31.2	Glorieta Bight	267.1	2.426659
1887	117 10 28.585	744.7	172 27 11.7	352 26 50.1	Old Town	7937.5	3.899682
			199 32 06.0	19 32 38.9	San Diego 2	4717.1	3.673675
			248 04 57.4	68 06 06.7	Indian Point 2	3600.7	3.556386
Barracks, flagstaff	32 42 43.051	1326.1	91 41 17.5	271 40 37.8	Channel Point	1915.9	3.282378
1887	117 10 08.624	224.6	127 40 06.4	307 38 53.2	Peninsula Point	4463.3	3.649655
			160 08 24.0	340 07 51.6	Old Town	4598.2	3.662586
			229 25 56.8	49 26 18.7	San Diego 2	1386.3	3.141846
			308 00 01.2	128 00 59.6	Indian Point 2	3573.6	3.553103
			315 50 44.5	135 52 27.4	National City	7240.2	3.859750
			348 54 51.5	168 54 54.9	Made Point	1647.7	3.216871
Tank	32 41 45.207	1392.5	349 06 44.3	169 06 57.7	New South	3459.2	3.538976
1899	117 09 59.108	1539.7	94 40 36.9	274 38 09.9	S. Diego Lat. S. 1851	7110.2	3.851880
			140 01 25.2	320 00 06.7	Peninsula Point	5884.6	3.769719
			163 29 30.5	343 28 52.8	Old Town	6369.2	3.804082
San Diego Court-House	32 42 58.576	1804.3	355 01 13.8	175 01 29.0	New South	5678.3	3.754219
1899	117 09 52.947	1378.9	55 26 15.4	235 23 48.0	Pt. Loma L. H. (old)	8631.2	3.936072
			79 42 43.7	259 41 55.5	Channel Point	2361.3	3.373155
			119 42 55.6	299 41 33.8	Peninsula Point	4537.9	3.656851
		(164.6)	152 52 41.9	332 52 01.0	Old Town	4321.8	3.635560
Point Loma Light-house (new)	32 39 54.660	1683.7	269 54 57.8	89 57 38.5	New South	7760.4	3.889886
	117 14 31.853	830.0	274 31 48.8	94 36 28.4	Chula	13542.2	4.131688
1892			322 07 32.3	142 11 24.8	Boundary Mon. 258	18343.1	4.263473
Loma Southeast Tangent	32 39 57.89	1783.2	228 29 28.2	48 30 31.0	Middle	4049.8	3.60743
1899	117 14 19.20	500.3	270 40 51.2	90 43 25.1	New South	7431.4	3.87107
Loma East Tangent	32 40 17.83	549.2	201 56 23.7	21 56 44.8	Mud	2722.7	3.43500
1899	117 14 08.57	223.3	233 05 40.1	53 06 37.2	Middle	3446.1	3.53733
Bluff	32 40 17.97	553.5	202 21 34.1	22 21 55.6	Mud	2726.2	3.43555
1899	117 14 09.33	243.1	233 20 34.3	53 21 31.8	Middle	3459.9	3.53906
Pole	32 41 33.21	1023.0	211 53 58.1	31 55 01.1	Peninsula Point	5746.6	3.75941
1899	117 14 20.95	545.7	261 21 25.1	81 21 52.9	Mud	1355.2	3.13200
Jetty	32 40 35.236	1085.4	146 46 20.4	326 45 43.4	S. Diego Lat. S. 1851	3266.9	3.514136
1899	117 13 22.445	584.7	174 42 51.5	354 42 47.7	Mud	1997.9	3.300576
			202 51 39.5	22 52 51.8	Old Town	8966.8	3.952637
			225 23 30.3	45 24 02.5	Middle	2183.1	3.339064
			281 45 59.8	101 48 03.2	New South	6079.6	3.783876
Chimney	32 41 14.726	453.6	133 17 17.8	313 16 44.4	S. Diego Lat. S. 1851	2211.4	3.344663
1899	117 13 29.374	765.1	179 44 01.8	359 44 01.6	Mud	773.0	2.888163
			207 28 27.6	27 29 43.7	Old Town	7941.7	3.899916
			259 39 18.7	79 39 54.5	Middle	1763.3	3.246326
			291 49 37.5	111 51 44.5	New South	6606.0	3.819937
Phone	32 41 22.818	702.9	116 33 24.4	296 32 31.8	S. Diego Lat. S. 1851	2834.3	3.45244
1899	117 12 53.844	1402.7	201 56 57.1	21 57 54.0	Old Town	7327.7	3.86497
Quarantine	32 42 13.561	417.7	58 40 44.9	238 40 34.9	S. Diego Lat. S. 1851	569.8	2.755734
1899	117 14 12.485	325.2	203 14 06.5	23 14 23.2	Fisherman Point	2046.1	3.310933
			217 45 47.8	37 46 46.3	Peninsula Point	4599.0	3.662659
			222 26 25.6	42 28 05.0	Old Town	7092.6	3.850804
			297 37 24.9	117 38 24.1	Middle	3225.4	3.508579
			300 27 48.5	120 30 18.9	New South	8417.8	3.925200
			312 52 31.5	132 52 54.7	Mud	1527.5	3.183992
Cupola	32 42 34.107	1050.6	229 47 59.7	49 49 13.5	Peninsula Point	4652.6	3.667694
1899	117 14 40.800	1062.6	230 12 04.4	50 13 59.0	Old Town	7189.1	3.856672
			231 04 32.2	51 05 04.1	Fisherman Point	1985.3	3.297837
			266 18 54.8	86 20 42.1	Channel Point	5184.1	3.714674
			300 37 19.0	120 38 33.4	Middle	4177.9	3.620962
			301 30 30.1	121 33 15.8	New South	9375.9	3.972014
			312 00 04.5	132 00 43.0	Mud	2498.9	3.397746

*No check on this position.

Mexican boundary to Point La Jolla—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Tell (top)	32 41 23.348	719.2	96 33 29.8	276 33 20.6	Middle	445.7	2.649008
1899	117 12 05.790	150.8	192 22 43.0	12 23 13.9	Old Town	6941.3	3.841439
			204 20 38.9	24 21 02.5	Channel Point	2756.6	3.440380
			304 32 58.8	124 34 20.8	New South	4801.1	3.681345
Theosophical Hotel,	32 43 08.084	249.0	239 10 31.7	59 12 35.5	Old Town	6938.3	3.841252
south tower	117 14 57.505	1497.6	243 52 12.8	63 53 35.6	Peninsula Point	4442.6	3.647634
1899			277 14 52.5	97 16 48.9	Channel Point	5653.6	3.752326
			305 12 07.9	125 15 02.7	New South	10315.3	4.013481
			308 13 33.4	128 14 57.0	Middle	5130.6	3.710166
Bight	32 41 11.548	355.7	104 10 43.9	284 10 09.9	Middle	1692.3	3.228472
1899	117 11 19.801	515.9	107 57 18.7	287 55 35.3	S. Diego Lat. S. 1851	5239.9	3.719321
			182 19 53.1	2 19 59.1	Old Town	7149.2	3.854259
			310 34 11.9	130 35 09.0	New South	3628.3	3.559699
Red Roof House	32 43 49.860	1535.8	248 00 53.5	68 02 50.2	Old Town	6058.7	3.782378
1899	117 14 44.441	1157.2	290 47 31.0	110 49 20.3	Channel Point	5635.2	3.750908
			311 48 22.5	131 51 11.6	New South	10851.2	4.035477
			320 24 22.7	140 25 40.7	Middle	5790.0	3.762677
Ferry Tower	32 42 00.078	2.4	91 02 33.6	271 00 15.2	S. Diego Lat. S. 1851	6668.3	3.824018
1899	117 10 15.205	396.1	128 21 44.3	308 21 08.1	Channel Point	2223.8	3.347100
			140 18 52.6	320 17 42.8	Peninsula Point	5264.3	3.721339
			166 10 02.9	346 09 34.0	Old Town	5817.1	3.764710
			344 26 53.8	164 27 16.0	New South	4001.5	3.602225
Ballast Point Fog Bell	32 41 10.735	330.7	151 56 40.9	331 56 22.7	S. Diego Lat. S. 1851	1857.4	3.268908
1899	117 13 57.635	1501.5	203 33 51.7	23 34 42.1	Peninsula Point	6077.7	3.783742
			211 32 11.3	31 33 42.6	Old Town	8411.7	3.924882
			219 16 19.6	39 16 34.7	Mud	1157.3	3.063458
			259 54 30.6	79 55 21.6	Middle	2509.7	3.399619
Beacon 3½	32 42 54.01	1663.7	4 05 18.1	184 05 14.7	Mud	2291.3	3.36008
1899	117 13 23.24	605.2	48 55 36.1	228 54 59.4	S. Diego Lat. S. 1851	2347.1	3.37054
Beacon 5	32 43 14.77	455.0	22 55 15.5	202 54 49.8	Mud	3175.7	3.50184
1899	117 12 42.03	1094.5	89 48 04.5	269 47 32.4	Fisherman Point	1548.4	3.18987
Beacon 3	32 42 21.52	662.9	330 28 14.6	150 28 29.7	Mud	1476.3	3.16917
1899	117 13 57.44	1496.1	58 21 33.6	238 21 15.4	S. Diego Lat. S. 1851	1031.9	3.01365
Beacon 5½	32 43 14.38	443.0	90 07 20.8	270 06 09.4	Fisherman Point	3438.8	3.53641
1899	117 11 29.43	766.4	140 57 31.8	320 57 02.1	Peninsula Point	2268.6	3.35575
Beacon 6	32 42 53.95	1661.8	111 41 03.6	291 40 30.4	Fisherman Point	1721.2	3.23582
1899	117 12 40.07	1043.5	189 44 08.6	9 44 17.1	Peninsula Point	2425.9	3.38488
Beacon 4	32 42 38.57	1188.1	14 57 48.7	194 57 38.7	Mud	1873.2	3.27258
1899	117 13 10.94	284.9	62 58 04.7	242 57 21.4	S. Diego Lat. S. 1851	2346.1	3.37034
Beacon 6½	32 42 57.51	1771.5	102 41 39.9	282 40 51.4	Fisherman Point	2396.8	3.37963
1899	117 12 11.70	304.7	171 48 24.9	351 48 18.1	Peninsula Point	2305.1	3.36269
La Playa Wharf, flagstaff	32 42 12.710	391.5	69 20 19.9	249 20 05.0	S. Diego Lat. S. 1851	765.1	2.88374
1871	117 14 03.689	96.1	220 54 13.9	40 55 48.5	Old Town	6959.9	3.84260
			255 38 03.9	75 40 32.9	San Diego 2	7410.7	3.86986
Diamond Beacon	32 42 53.88	1659.7	101 04 22.1	281 03 14.4	Fisherman Point	3326.1	3.52193
1899	117 11 36.14	941.2	152 20 39.1	332 20 13.1	Peninsula Point	2702.2	3.43172
Beacon 7	32 42 55.42	1707.1	97 25 07.7	277 23 33.4	Fisherman Point	4582.9	3.66114
1899	117 10 46.98	1223.5	132 47 28.7	312 46 36.1	Peninsula Point	3453.7	3.53828
Beacon 2	32 42 11.03	339.8	336 30 48.0	156 30 56.7	Mud	1048.2	3.02045
1899	117 13 45.55	1186.4	79 35 58.0	259 35 33.4	S. Diego Lat. S. 1851	1208.2	3.08215
Stone	32 43 58.659	1806.9	240 11 33.4	60 12 45.8	Old Town	4015.7	3.603759
1899	117 13 22.479	585.4	255 16 40.1	75 17 11.6	Peninsula Point	1565.8	3.194727
			305 56 51.0	125 57 56.0	Channel Point	3870.7	3.587795
			20 02 18.3	200 02 08.0	Fisherman Point	1444.8	3.159811
			26 51 24.7	206 50 47.6	S. Diego Lat. S. 1851	3960.8	3.597780
Ways Smokestack	32 42 43.117	1328.1	76 05 14.5	256 03 33.5	S. Diego Lat. S. 1851	5013.6	3.700150
1899	117 11 24.337	633.8	105 11 57.0	285 10 42.9	Fisherman Point	3701.1	3.568325
			150 11 01.8	330 10 29.4	Peninsula Point	3140.7	3.497028
			185 24 14.8	5 24 23.3	Old Town	4341.9	3.637678

Mexican boundary to Point La Jolla—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Nail	32 43 08.464	260.7	230 45 02.1	50 45 51.4	Peninsula Point	3073.1	3.487578
1899	117 13 55.717	1451.1	230 50 16.7	50 51 46.9	Old Town	5609.9	3.748955
			345 57 51.5	165 58 05.7	Mud	2814.6	3.449424
			24 55 27.3	204 55 08.1	S. Diego Lat. S. 1851	2191.5	3.340745
Electric	32 42 53.782	1656.7	347 34 30.1	167 36 00.7	Boundary Mon. 258	20482.1	4.311375
1899	117 10 09.184	239.2	54 36 31.6	234 34 13.0	Pt. Loma L. H. (old)	8200.1	3.913817
			66 25 32.6	246 23 44.4	Mud	5693.6	3.755388
			81 47 33.6	261 46 54.2	Channel Point	1920.2	3.283339
			96 37 50.0	276 35 55.3	Fisherman Point	5565.9	3.745537
			124 15 53.6	304 14 40.7	Peninsula Point	4257.3	3.629130
			158 49 16.4	338 48 44.3	Old Town	4283.5	3.631794
La Playa Light-house	32 42 12.597	388.0	201 28 22.2	21 28 37.7	Fisherman Point	2052.3	3.312250
	117 14 10.338	269.3	216 59 02.9	37 00 00.2	Peninsula Point	4588.6	3.661682
			221 56 39.0	41 58 17.2	Old Town	7077.0	3.849851
			313 30 42.6	133 31 04.7	Mud	1466.4	3.166257
House, flagpole	32 47 24.592	757.5	199 54 23.5	19 54 38.8	Hill	2161.3	3.334714
	117 15 04.838	125.9	256 16 15.5	76 17 44.2	Back Bay	4385.9	3.642063
			308 40 20.4	128 40 49.7	Bay Point	1801.3	3.255582
House, west window on south side	32 47 33.318	1026.3	307 34 56.5	127 37 01.2	Old Town	7567.1	3.878929
	117 14 58.987	1534.9	318 02 01.0	138 02 27.1	Bay Point	1875.3	3.273078
			336 28 49.9	156 29 39.9	•Old Adobe	6027.7	3.780149
Sandstone Rock*	32 48 52.54	1618.4	149 22 47	329 22 37	Sandstone Point	958.5	2.98160
1887	117 16 25.75	669.9	191 57 53	11 57 59	Moss	1263.3	3.10149
New Windmill*	32 47 11.76	362.2	151 03 45	331 03 18	False Point	2708.7	3.43276
1887	117 15 11.09	288.6	200 18 45	20 19 04	Hill	2588.6	3.41306
Soledad Lat. and Az. Sta.	32 50 24.52	755.3	178 32 48.37		Soledad Az. mark		
1899	117 15 07.24	188.4	358 33	178 33	Soledad	18.02	1.25575

Point La Jolla to San Mateo Point.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Shell Mound	32 54 29.005	893.5	337 14 34.2	157 14 56.5	Round Top	2763.4	3.441450
1887	117 15 06.452	167.9	357 16 12.9	177 16 15.2	Ball	2290.2	3.359869
			0 09 10.1	180 09 09.6	Soledad	7549.5	3.877917
Deer	32 54 38.572	1188.2	353 00 44.3	173 00 51.6	Round Top	2864.4	3.457028
1887	117 14 38.734	1006.5	13 19 14.7	193 19 02.0	Ball	2653.7	3.423849
			67 44 57.8	247 44 42.8	Shell Mound	778.3	2.891130
Red Bluff	32 54 53.842	1658.6	350 16 59.7	170 17 01.5	Deer	477.3	2.678749
1887	117 14 41.833	1087.0	39 54 05.2	219 53 51.9	Shell Mound	997.3	2.998845
Pine	32 55 17.964	553.3	311 59 28.6	131 59 45.9	Red Bluff	1110.7	3.045581
1887	117 15 13.602	353.4	323 15 04.7	143 15 23.8	Deer	1514.4	3.180245
			342 48 41.0	162 49 07.4	Round Top	4246.2	3.627996
			352 58 38.1	172 58 42.1	Shell Mound	1519.6	3.181734
White Bluff	32 56 22.619	696.8	357 25 37.2	177 25 39.8	Red Bluff	2737.6	3.437367
1887	117 14 46.563	1209.7	19 25 46.2	199 25 31.5	Pine	2112.0	3.324691
Railroad	32 56 29.553	910.4	279 48 40.0	99 49 05.8	White Bluff	1253.0	3.097951
1887	117 15 34.092	885.5	335 16 14.0	155 16 42.4	Red Bluff	3246.0	3.511348
			346 25 41.3	166 25 52.4	Pine	2268.7	3.355770
Del Mar	32 57 22.740	700.5	331 02 40.2	151 03 01.6	White Bluff	2116.6	3.325635
1887	117 15 26.009	675.5	7 18 09.6	187 18 05.2	Railroad	1651.9	3.217974
Wave Crest Point	32 57 38.011	1171.0	297 53 03.4	117 53 22.0	Del Mar	1005.8	3.002512
1887	117 16 00.238	6.2	342 08 52.9	162 09 07.1	Railroad	2215.6	3.345483

*No check on this position.

Point La Jolla to San Mateo Point—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Red Cliff	32 58 56.934	1753.9	334 36 07.2	154 36 36.1	Del Mar	3212.1	3.506785
1887	117 16 19.052	494.6	348 38 11.0	168 38 21.3	Wave Crest Point	2479.9	3.394431
San Dieguito	32 57 31.479	969.7	68 39 55.5	248 39 41.1	Del Mar	739.9	2.869194
1887	117 14 59.472	1544.5	141 52 24.1	321 51 40.8	Red Cliff	3346.7	3.524622
Town	32 57 05.234	161.2	349 10 45.3	169 10 50.5	White Bluff	1336.5	3.125979
1887	117 14 56.222	1460.3	7 46 53.7	187 46 44.2	Pine	3335.2	3.523123
			124 52 50.9	304 52 34.7	Del Mar	943.1	2.974542
			174 02 23.9	354 02 22.1	San Dieguito	812.9	2.910036
Pebble	32 59 49.991	1540.0	342 15 33.4	162 16 02.0	San Dieguito	4479.9	3.651270
1887	117 15 52.032	1350.8	351 31 31.2	171 31 45.4	Del Mar	4586.2	3.661457
			3 00 02.3	182 59 57.9	Wave Crest Point	4071.3	3.609736
			23 13 51.5	203 13 36.8	Red Cliff	1778.7	3.250093
Ledge	33 00 02.244	69.1	287 08 38.2	107 09 03.9	Pebble	1280.3	3.107301
1887	117 16 39.156	1016.5	330 51 40.3	150 52 34.6	San Dieguito	5317.0	3.725666
			338 51 38.2	158 52 18.1	Del Mar	5268.0	3.721644
			345 27 17.4	165 27 28.4	Red Cliff	2078.5	3.317759
			347 11 02.6	167 11 23.9	Wave Crest Point	4556.7	3.658647
Search	33 01 14.797	455.8	353 22 18.0	173 22 24.4	Pebble	2630.1	3.419973
1887	117 16 03.726	96.7	22 22 05.5	202 21 46.2	Ledge	2416.9	3.383254
San Elijo	33 01 05.057	155.8	257 41 37.2	77 42 06.1	Search	1408.2	3.148653
1887	117 16 56.736	1472.6	324 00 15.0	144 00 50.3	Pebble	2858.1	3.456072
			346 43 46.7	166 43 56.3	Ledge	1988.1	3.298439
Rancheria	33 01 39.218	1208.1	298 02 30.1	118 02 59.8	Search	1600.0	3.204125
1887	117 16 58.138	1508.7	332 58 34.2	152 59 10.3	Pebble	3777.1	3.577153
			350 38 01.3	170 38 11.7	Ledge	3027.7	3.481114
			358 01 12.6	178 01 13.4	San Elijo	1053.0	3.022411
Flint	33 02 21.420	659.9	336 35 24.9	156 35 43.6	Search	2236.4	3.349553
1887	117 16 37.962	985.1	21 56 14.4	201 56 03.4	Rancheria	1401.5	3.146608
Encinitas	33 02 19.042	586.6	267 29 27.7	87 30 02.9	Flint	1676.6	3.224417
1887	117 17 42.511	1103.1	307 39 40.5	127 40 44.4	Search	3238.6	3.510364
			316 48 39.8	136 49 04.0	Rancheria	1682.6	3.225973
			332 28 03.0	152 28 28.0	San Elijo	2570.2	3.409960
			338 40 49.0	158 41 23.6	Ledge	4523.6	3.655486
Kincaid	33 03 18.908	582.5	342 27 33.0	162 27 58.4	Search	4009.7	3.603114
1887	117 16 50.289	1304.7	349 45 42.7	169 45 49.4	Flint	1799.6	3.255181
			3 47 41.3	183 47 37.0	Rancheria	3077.8	3.488241
			36 18 32.2	216 18 03.7	Encinitas	2288.5	3.359544
Leucadia	33 03 29.325	903.4	279 18 47.0	99 19 28.1	Kincaid	1981.7	3.297043
1887	117 18 05.668	147.0	312 35 04.9	132 35 52.7	Flint	3091.0	3.490097
			344 29 20.5	164 29 33.1	Encinitas	2246.9	3.351590
White Rock	33 04 48.529	1495.0	345 46 43.2	165 46 57.9	Kincaid	2848.1	3.454554
1887	117 17 17.259	447.7	8 05 54.6	188 05 40.8	Encinitas	4651.4	3.667585
			27 14 10.9	207 13 44.5	Leucadia	2744.1	3.438401
Scott	33 04 38.749	1193.7	261 19 01.5	81 19 43.0	White Rock	1997.0	3.300377
1887	117 18 33.372	865.7	312 35 59.8	132 36 56.0	Kincaid	3633.1	3.560283
			341 25 27.1	161 25 42.2	Leucadia	2256.2	3.353372
			342 57 04.9	162 57 32.6	Encinitas	4501.5	3.653361
Rock	33 06 40.637	1251.9	345 19 57.8	165 20 16.8	White Rock	3569.9	3.552661
1887	117 17 52.110	1351.2	15 54 30.9	195 54 08.4	Scott	3904.4	3.591555
Post	33 06 37.374	1151.3	267 26 26.9	87 27 14.4	Rock	2257.9	3.353703
1887	117 19 19.109	495.5	316 41 25.7	136 42 32.2	White Rock	4607.4	3.663452
			342 00 54.1	162 01 19.1	Scott	3842.0	3.584561
Escondido	33 08 04.824	148.6	321 49 34.1	141 50 17.0	Rock	3298.7	3.518346
1887	117 19 10.745	278.5	4 36 08.5	184 36 03.9	Post	2702.7	3.431804
Mull	33 08 56.367	1736.5	302 34 59.3	122 35 51.7	Escondido	2948.0	3.469522
1887	117 20 46.577	1207.1	312 44 32.3	132 46 07.6	Rock	6159.3	3.789528
			332 05 30.0	152 06 17.8	Post	4845.1	3.685305
Kelly	33 09 48.740	1501.5	338 51 56.1	158 52 43.2	Rock	6212.4	3.793258
1887	117 19 18.503	479.5	356 24 20.5	176 24 24.7	Escondido	3207.6	3.506182
			0 09 10.1	180 09 09.7	Post	5895.4	3.770511
			54 44 57.0	234 44 08.8	Mull	2795.0	3.446388

Point La Jolla to San Mateo Point—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Fire	33 11 26.318	810.8	333 13 28.9	153 14 00.9	Kelly	3367.0	3.527237
1887	117 20 17.040	441.5	9 24 31.9	189 24 15.7	Mull	4682.5	3.670475
Trestle	33 10 45.393	1398.4	247 12 45.8	67 13 49.2	Fire	3256.4	3.512732
1887	117 22 12.938	335.2	291 06 06.8	111 07 42.2	Kelly	4844.8	3.685275
			326 19 12.5	146 19 59.7	Mull	4035.9	3.605943
San Luis	33 12 08.398	258.7	289 22 14.8	109 23 32.7	Fire	3906.4	3.591775
1887	117 22 39.307	1018.0	309 34 40.0	129 36 29.9	Kelly	6750.7	3.829349
			345 02 32.8	165 02 47.3	Trestle	2646.8	3.422718
Wire	33 13 37.820	1165.1	326 38 22.6	146 39 19.0	Fire	4850.0	3.685738
1887	117 21 59.998	1553.6	329 19 51.0	149 21 19.4	Kelly	8203.9	3.914018
			20 16 59.9	200 16 38.4	San Luis	2936.9	3.467886
Oceanside	33 11 58.326	1796.8	211 55 12.4	31 55 52.8	Wire	3611.4	3.557673
1887	117 23 13.742	355.9	250 48 55.7	70 49 14.6	San Luis	944.3	2.975130
			324 57 50.1	144 58 23.5	Trestle	2743.9	3.438375
Spade	33 15 26.305	810.4	297 20 49.9	117 23 06.6	Wire	7270.5	3.861566
1887	117 26 09.407	243.5	324 36 57.0	144 38 33.3	Oceanside	7857.5	3.895284
Rabbit	33 16 05.609	172.8	328 47 00.8	148 47 59.2	Wire	5323.3	3.726177
1887	117 23 46.548	1204.7	353 38 08.3	173 38 26.3	Oceanside	7665.2	3.884525
			71 52 44.1	251 51 25.8	Spade	3890.8	3.590036
Quartz	33 18 35.509	1093.9	331 15 30.4	151 16 24.0	Rabbit	5266.5	3.721525
1886	117 25 24.398	631.2	11 18 10.7	191 17 46.0	Spade	5944.1	3.774084
Mound	33 17 06.358	195.9	230 48 09.1	50 49 20.6	Quartz	4346.7	3.638162.
1886	117 27 34.617	895.9	287 34 33.5	107 36 38.6	Rabbit	6191.7	3.791810
			324 24 42.6	144 25 29.4	Spade	3790.0	3.578635
Flores Hill	33 19 13.790	424.8	289 16 05.1	109 17 16.7	Quartz	3572.0	3.552915
1886	117 27 34.746	898.9	359 57 04.1	179 57 04.2	Mound	3925.8	3.593933
Barranca Bluff	33 18 01.193	36.8	208 35 12.8	28 35 38.7	Flores Hill	2547.1	3.406046
1886	117 28 21.865	565.6	257 01 08.3	77 02 45.8	Quartz	4711.2	3.673136
			324 06 16.6	144 06 42.6	Mound	2085.3	3.319162
Horno Bluff	33 19 51.560	1588.5	286 14 47.0	106 16 11.8	Flores Hill	4156.2	3.618699
1886	117 30 09.015	233.2	320 48 22.3	140 49 21.2	Barranca Bluff	4386.7	3.642134
Horno Hill	33 21 16.538	509.5	307 48 49.2	127 51 04.9	Quartz	8088.1	3.907845
1886	117 29 31.400	812.0	321 24 35.3	141 25 39.4	Flores Hill	4837.4	3.684616
			343 21 23.4	163 22 01.6	Barranca Bluff	6281.1	3.798032
			20 23 05.6	200 22 44.9	Horno Bluff	2792.8	3.446040
Cuate Hill	33 21 50.849	1566.6	294 19 15.7	114 20 05.4	Horno Hill	2565.9	3.409234
1886	117 31 01.833	47.4	339 36 34.4	159 37 03.4	Horno Bluff	3920.5	3.593346
Cuate Bluff	33 21 16.649	512.9	233 35 31.0	53 36 01.4	Cuate Hill	1775.3	3.249283
1886	117 31 57.101	1476.4	270 02 26.7	90 03 46.8	Horno Hill	3767.1	3.576010
			313 09 21.4	133 10 20.8	Horno Bluff	3831.9	3.583412
Onofre Hill	33 22 34.696	1068.9	303 57 53.8	123 58 36.5	Cuate Hill	2417.5	3.383362
1886	117 32 19.388	501.2	346 31 21.2	166 31 33.5	Cuate Bluff	2472.5	3.393138
Onofre Bluff	33 22 05.293	163.1	238 50 37.3	58 51 09.2	Onofre Hill	1751.1	3.243307
1886	117 33 17.360	448.8	277 13 38.8	97 14 54.4	Cuate Hill	3531.8	3.547993
			305 49 53.5	125 50 37.7	Cuate Bluff	2559.5	3.408162
Cuchillo	33 23 45.880	1413.5	314 37 01.3	134 37 48.6	Onofre Hill	3121.9	3.494425
1886	117 33 45.359	1172.1	346 51 09.8	166 51 25.2	Onofre Bluff	3182.2	3.502731
			76 49 16.8	256 48 10.7	San Mateo Point	3192.1	3.504081
			116 13 18.9	296 12 27.1	County Boundary	2718.2	3.434284
Medio	33 22 59.831	1843.3	121 42 39.7	301 42 16.0	San Mateo Point	1313.6	3.118466
1886	117 35 02.378	61.5	170 17 16.4	350 17 07.0	County Boundary	2657.5	3.424476
			234 30 59.3	54 31 41.7	Cuchillo	2444.4	3.388169
			280 24 06.7	100 25 36.4	Onofre Hill	4283.5	3.631800
			301 44 47.4	121 45 45.2	Onofre Bluff	3192.5	3.504133
Mesa Point	33 22 37.490	1155.0	115 57 14.8	295 56 44.7	Medio	1572.9	3.196703
1886	117 34 07.661	198.0	195 17 55.2	15 18 07.5	Cuchillo	2184.4	3.339330
			271 45 08.4	91 46 08.0	Onofre Hill	2800.0	3.447165

Point La Jolla to San Mateo Point—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Ridge	33 22 26.393	813.1	320 13 49.0	140 14 27.1	Horno Hill	2799.7	3.447110
1886	117 30 40.670	1051.3	26 32 55.5	206 32 43.9	Cuate Hill	1224.1	3.087815
			42 36 28.6	222 35 46.6	Cuate Bluff	2919.1	3.465246
			95 43 53.5	275 42 59.2	Onofre Hill	2564.6	3.409018
			117 10 17.3	297 08 35.7	Cuchillo	5365.0	3.729570
Road Knoll	33 17 00.324	10.0	37 12 16.2	217 11 29.6	Spade	3636.5	3.560679
1886	117 24 44.458	1150.6	92 25 40.9	272 24 07.5	Mound	4407.0	3.644141
			160 35 24.5	340 35 02.6	Quartz	3109.0	3.492618
			318 21 31.2	138 22 02.9	Rabbit	2255.6	3.353268
Shingle Bluff	33 15 40.976	1262.3	144 16 56.4	324 16 16.2	Mound	3239.8	3.510518
1886	117 26 21.524	557.0	195 22 03.4	15 22 34.7	Quartz	5576.2	3.746340
			259 16 36.8	79 18 01.7	Rabbit	4082.2	3.610895
			325 15 04.4	145 15 11.0	Spade	550.2	2.740552
Vailetta Point	33 05 30.892	951.7	160 29 40.8	340 29 25.5	Post	2172.8	3.337020
1887	117 18 51.128	1326.0	215 27 19.0	35 27 51.2	Rock	2637.9	3.421259
			298 11 12.4	118 12 03.6	White Rock	2762.2	3.441254
			344 00 06.8	164 00 16.5	Scott	1671.0	3.222977
San Marcos	33 06 01.406	43.3	113 52 22.1	293 51 29.3	Post	2738.7	3.437550
1887	117 17 42.515	1102.4	168 22 10.6	348 22 05.3	Rock	1234.0	3.091302
			343 43 59.0	163 44 12.7	White Rock	2338.6	3.368962
			27 23 11.1	207 22 43.3	Scott	2867.6	3.457520
			62 09 23.6	242 08 46.1	Vailetta Point	2012.3	3.303689
Stewarts Point	33 07 46.764	1440.7	152 13 55.4	332 13 31.6	Mull	2423.4	3.384424
1887	117 20 03.012	78.1	197 03 42.1	17 04 06.5	Kelly	3930.8	3.594478
			247 40 07.3	67 40 35.9	Escondido	1464.6	3.165720
			300 57 55.9	120 59 07.4	Rock	3958.0	3.597476
			331 57 51.7	151 58 15.7	Post	2421.7	3.384127
Santa Margarita River	33 14 12.735	392.3	211 21 41.2	31 22 26.0	Rabbit	4072.5	3.609866
1887	117 25 08.442	218.6	282 25 03.7	102 26 47.0	Wire	4996.3	3.698646
			314 45 15.0	134 46 36.7	San Luis	5439.3	3.735546
			324 20 18.6	144 21 21.4	Oceanside	5095.8	3.707216
North Mission	33 13 18.617	573.5	31 08 14.7	211 07 47.1	San Luis	2527.3	3.402650
1887	117 21 48.851	1265.1	153 59 31.1	333 59 25.0	Wire	658.2	2.818386
South Mission	33 12 35.177	1083.7	64 41 56.5	244 41 19.6	San Luis	1930.0	3.285554
1887	117 21 31.939	827.2	161 52 48.5	341 52 39.2	North Mission	1408.1	3.148635
Mission Knoll	33 13 11.545	355.7	67 21 21.9	247 20 25.1	South Mission	2909.1	3.463760
1887	117 19 48.269	1250.2	94 00 02.4	273 58 56.3	North Mission	3130.0	3.495551
San Luis Rey Mission, tower	33 13 56.668	1745.8	37 04 42.2	217 04 20.0	Mission Knoll	1742.3	3.241129
1887	117 19 07.703	199.4	74 19 13.5	254 17 45.2	North Mission	4334.2	3.636904
San Luis Rey Hotel, windmill	33 13 46.305	1426.5	1 29 21.6	181 29 21.0	Mission Knoll	1071.2	3.029882
1887	117 19 47.194	1222.2	74 51 29.1	254 50 22.4	North Mission	3263.6	3.513693
Del Mar, S. E. Biery's office, tower	32 57 11.668	359.4	175 20 53.1	355 20 51.7	Wave Crest Point	814.2	2.910732
1887	117 15 57.696	1498.5	247 29 12.5	67 29 29.7	Del Mar	890.9	2.949817
			334 42 14.5	154 42 27.3	Railroad	1435.0	3.156840
Del Mar Schoolhouse, spire	32 57 16.746	515.9	141 18 35.9	321 18 24.9	Wave Crest Point	839.3	2.923922
1887	117 15 40.037	1039.8	243 07 19.2	63 07 26.8	Del Mar	408.5	2.611157
			353 56 11.4	173 56 14.6	Railroad	1462.0	3.164943
Del Mar Pavilion, south gable	32 56 53.838	1658.4	23 31 55.7	203 31 48.9	Railroad	816.0	2.911677
1887	117 15 21.550	559.7	143 33 34.8	323 33 13.8	Wave Crest Point	1691.6	3.228292
			172 35 22.4	352 35 20.0	Del Mar	897.8	2.953201
			316 36 59.4	136 37 18.4	White Bluff	1323.2	3.121627
Oceanside House, west chimney	33 12 09.828	302.7	344 41 08.8	164 41 24.0	Trestle	2696.9	3.430869
1887	117 22 40.432	1047.3	67 40 25.5	247 40 07.3	Oceanside	932.7	2.969743
			201 07 02.5	21 07 24.7	Wire	2906.0	3.463290
			289 50 00.7	109 51 19.3	Fire	3948.6	3.596446
Oceanside, R. L. Couts' house, flagstaff	33 12 00.996	30.7	79 39 01.3	259 38 51.8	Oceanside	457.7	2.660580
1887	117 22 56.359	1459.8	206 04 09.2	26 04 40.1	Wire	3320.8	3.521245
			242 41 25.0	62 41 34.3	San Luis	497.1	2.696413
			334 13 09.6	154 13 33.4	Trestle	2586.5	3.412706

Point La Jolla to San Mateo Point—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Oceanside Windmill	33 11 57.238	1763.2	91 45 53.4	271 45 30.4	Oceanside	1090.4	3.037602
1887	117 22 31.663	820.2	150 03 48.0	330 03 43.8	San Luis	396.7	2.598505
			194 49 13.8	14 49 31.1	Wire	3205.3	3.505868
			285 16 06.6	105 17 20.3	Fire	3614.8	3.558088
			347 38 15.7	167 38 26.0	Trestle	2265.8	3.355230
Oceanside, South Pacific	33 11 43.354	1335.7	171 14 18.8	351 13 52.4	Rabbit	8174.8	3.912475
Hotel, flagstaff	117 22 58.436	1513.7	203 13 22.5	23 13 54.5	Wire	3837.4	3.584038
1887			212 42 21.8	32 42 32.3	San Luis	916.9	2.962340
			234 31 05.3	54 31 52.7	South Mission	2751.0	3.439486
			277 08 34.4	97 10 02.8	Fire	4213.5	3.624639
			326 34 07.4	146 34 32.3	Trestle	2139.5	3.330310
Oceanside Schoolhouse,	33 11 48.243	1486.2	148 31 03.9	328 30 55.8	San Luis	728.1	2.862190
spire	117 22 24.626	637.9	190 41 50.2	10 42 03.6	Wire	3435.5	3.535985
1887			198 24 13.5	18 24 33.0	North Mission	2934.3	3.467502
			223 20 20.9	43 20 49.7	South Mission	1988.1	3.298449
			281 32 29.1	101 33 38.9	Fire	3373.2	3.528038
			351 06 41.2	171 06 47.6	Trestle	1959.7	3.292198
Oceanside, J. C. Hay's	33 11 09.518	293.2	48 23 19.4	228 23 01.8	Trestle	1119.1	3.048883
house, cupola	117 21 40.640	1052.8	173 44 20.9	353 44 10.3	Wire	4596.2	3.662395
1887			256 33 11.6	76 33 57.4	Fire	2226.6	3.347643
			304 02 18.7	124 03 36.5	Kelly	4444.5	3.647827
Carlsbad, J. Shutte's	33 09 31.575	972.8	140 44 56.9	320 44 17.7	Trestle	2936.9	3.467887
house, weather vane	117 21 01.212	31.4	197 56 10.5	17 56 34.7	Fire	3715.5	3.570017
1887			258 45 16.7	78 46 12.9	Kelly	2713.5	3.433523
Carlsbad, J. Mull's house,	33 09 01.838	56.6	186 03 38.6	6 03 48.6	Fire	4476.0	3.650892
front door	117 20 35.284	914.4	234 00 30.5	54 01 12.5	Kelly	2458.9	3.390743
1887			308 42 41.0	128 43 27.2	Escondido	2808.2	3.448429
Carlsbad, tank house	33 09 36.381	1120.8	140 52 32.4	320 51 55.9	Trestle	2740.7	3.437868
1887	117 21 06.183	160.2	200 35 57.1	20 36 24.0	Fire	3618.2	3.558496
			262 13 16.6	82 14 15.5	Kelly	2816.1	3.449646
Vail's (Dr. A. H.) house,	33 06 03.069	94.6	152 19 03.5	332 18 51.8	Post	1193.4	3.076796
pipe	117 18 57.725	1496.8	235 46 06.3	55 46 42.1	Rock	2057.7	3.313374
1887			271 29 59.0	91 30 40.1	San Marcos	1950.9	3.290232
			350 12 27.2	170 12 30.8	Vailetta Point	1005.9	3.002564
Leucadia Windmill	33 03 53.533	1649.2	32 57 20.1	212 57 09.9	Leucadia	888.8	2.948781
1887	117 17 47.032	1219.9	204 30 11.9	24 30 28.1	White Rock	1861.9	3.269956
			305 55 23.6	125 55 54.5	Kincaid	1817.9	3.259562
			357 41 32.4	177 41 34.8	Encinitas	2913.2	3.464376
Encinitas Cottage, chimney	33 02 47.977	1478.0	24 26 21.9	204 26 13.4	Encinitas	979.1	2.990819
1887	117 17 26.901	697.9	141 42 25.4	321 42 04.3	Leucadia	1623.0	3.210314
			183 51 08.7	3 51 14.0	White Rock	3722.1	3.570789
			224 54 27.3	44 54 47.3	Kincaid	1345.4	3.128864
			302 47 20.8	122 47 47.5	Flint	1510.5	3.179134
Encinitas Schoolhouse,	33 02 38.503	1186.2	160 36 07.3	340 35 55.7	Leucadia	1659.8	3.220067
chimney	117 17 44.418	1152.3	228 26 43.3	48 27 12.8	Kincaid	1876.6	3.273372
1887			355 16 54.9	175 16 55.9	Encinitas	601.5	2.779270
House near Encinitas,	33 02 15.939	491.1	350 50 08.3	170 50 14.7	Search	1907.9	3.280548
front door	117 16 15.434	400.4	44 24 48.5	224 24 25.2	Rancheria	1583.6	3.199640
1887			92 25 46.0	272 24 58.5	Encinitas	2261.6	3.354407
			106 06 48.3	286 06 36.0	Flint	608.5	2.784230
Stewarts R. R. Station,	33 07 51.628	1590.5	142 03 42.7	322 03 09.9	Mull	2529.0	3.402942
warehouse, west gable	117 19 46.582	1207.6	191 24 05.2	11 24 20.6	Kelly	3680.5	3.565908
1887			246 21 37.6	66 21 57.2	Escondido	1014.0	3.006032
			306 22 44.9	126 23 47.4	Rock	3686.4	3.566598
Leucadia, club house,	33 03 51.707	1593.0	159 52 22.3	339 52 10.2	Scott	1543.4	3.188492
tower	117 18 12.896	334.5	219 29 58.2	39 30 28.6	White Rock	2268.6	3.355766
1887			295 14 12.3	115 14 57.4	Kincaid	2369.2	3.374610
			344 33 35.8	164 33 52.4	Encinitas	2961.5	3.471505
			344 47 11.5	164 47 15.5	Leucadia	714.5	2.854020
Encinitas Hotel, chimney	33 02 42.471	1308.5	15 16 09.0	195 16 04.8	Encinitas	748.1	2.873957
1887	117 17 34.919	906.0	151 04 23.0	331 04 06.2	Leucadia	1649.2	3.217280
			186 43 36.9	6 43 46.5	White Rock	3910.3	3.592209

Point La Jolla to San Mateo Point—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Starges' (J. A.) house, chimney 1887	33 02 11.949	368.1	103 18 37.0	283 18 19.5	Encinitas	949.3	2.977391
	117 17 06.911	179.3	191 48 27.9	11 48 38.9	Kincaid	2107.3	3.323734
			248 46 16.7	68 46 34.5	Flint	805.9	2.906261
			317 01 52.5	137 02 26.9	Search	2405.9	3.381282
Schoolhouse, pipe 1887	33 06 09.653	297.3	31 55 31.2	211 55 15.6	Vailetta Point	1406.9	3.148260
	117 18 22.439	581.8	219 28 51.4	39 29 08.0	Rock	1236.7	3.092276
			283 47 16.3	103 47 38.1	San Marcos	1065.9	3.027736
Oceanside, bank building, tower 1887	33 11 45.853	1412.7	117 33 14.9	297 32 59.2	Oceanside	830.7	2.919467
	117 22 45.307	1173.5	192 36 44.2	12 36 47.4	San Luis	711.7	2.852311
			278 53 40.4	98 55 01.6	Fire	3887.4	3.589662
			335 45 39.0	155 45 56.7	Trestle	2042.6	3.310187
Bank 1887	33 14 20.029	617.1	120 10 42.9	300 09 28.5	Spade	4062.9	3.608836
	117 23 53.717	1390.7	183 15 54.4	3 15 58.3	Rabbit	3257.9	3.512937
			346 39 24.8	166 39 46.7	Oceanside	4486.5	3.651904
Soledad Canyon R. R. Crossing, post* 1887	32 55 11.35	349.6	44 57 11	224 56 59	Red Bluff	761.9	2.88192
	117 14 21.12	548.8	141 48 17	321 47 37	Railroad	3065.7	3.48653
San Luis Rey, Goldbaum's barn, south gable* 1887	33 13 46.72	1439.4	355 57 02	175 57 04	Mission Knoll	1086.5	3.03602
	117 19 51.23	1326.5	49 48 12	229 47 17	South Mission	3414.6	3.53334

San Mateo Point to Newport Bay

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Westminster 1873	33 46 09.680	298.2	359 00 31.1	179 00 34.7	Las Bolsas	9604.7	3.9824856
	118 00 24.145	621.4	103 14 06.2	283 08 53.4	Los Cerritos	14866.1	4.1721962
Santa Ana 1873	33 44 42.509	1309.6	58 39 03.1	238 34 58.6	Las Bolsas	13283.7	4.1233203
	117 52 57.268	1474.2	103 10 43.8	283 06 35.5	Westminster	11810.2	4.0722555
La Mesa 1873	33 37 56.156	1730.1	131 42 05.7	311 39 50.4	Las Bolsas	8423.7	3.9255049
	117 56 13.524	348.6	201 58 17.7	22 00 06.6	Santa Ana	13501.4	4.1303787
French Hill 1875	33 38 59.490	1832.8	80 42 12.4	260 37 57.1	La Mesa	12033.4	4.0803878
	117 48 32.759	844.1	147 12 54.6	327 10 27.8	Santa Ana	12573.4	4.0994533
San Joaquin 1874	33 36 08.773	270.3	106 24 54.0	286 20 52.3	La Mesa	11730.4	4.0693146
	117 48 56.932	1467.8	116 58 42.0	296 52 24.8	Las Bolsas	19676.3	4.2939427
			158 39 17.8	338 37 04.6	Santa Ana	16995.6	4.2303366
			186 45 14.4	6 45 27.8	French Hill	5296.4	3.7239808
			322 31 23.7	142 34 07.2	Niguel	12547.1	4.0985444
Newport 1875	33 38 17.621	542.9	83 40 43.0	263 38 35.0	La Mesa	5989.5	3.777391
	117 52 22.544	581.1	175 41 22.2	355 41 03.0	Santa Ana	11891.8	4.075248
			257 41 34.0	77 43 41.3	French Hill	6060.3	3.782496
			306 49 02.6	126 50 56.4	San Joaquin	6621.8	3.820975
Spur 1875	33 37 09.816	302.4	103 36 56.1	283 34 49.2	La Mesa	6072.5	3.783365
	117 52 24.534	632.5	181 24 22.3	1 24 23.4	Newport	2089.6	3.320071
			240 29 11.9	60 31 20.3	French Hill	6862.8	3.836504
			289 20 44.9	109 22 39.8	San Joaquin	5672.7	3.753787
Brush 1875	33 35 54.170	1668.9	123 42 54.9	303 40 53.7	La Mesa	6773.8	3.830831
	117 52 34.906	900.1	186 32 40.9	6 32 46.6	Spur	2345.8	3.370299
			265 24 23.0	85 26 23.6	San Joaquin	5637.9	3.751118
Pond 1875	33 35 38.706	1192.5	127 47 59.7	307 47 46.5	Brush	777.4	2.890642
	117 52 11.082	285.8	172 57 29.3	352 57 21.8	Spur	2828.3	3.451532
			259 30 03.6	79 31 51.0	San Joaquin	5090.8	3.706787
Abalone Knoll 1884	33 33 23.144	713.0	130 49 15.2	310 47 31.5	Pond	6390.9	3.805562
	117 49 03.514	90.6	181 54 16.6	1 54 20.2	San Joaquin	5105.7	3.708051
			301 53 00.3	121 55 47.5	Niguel	9190.7	3.963348

* No check on this position.

San Mateo Point to Newport Bay—Continued.

Station.	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Reef Hill	33 34 34.241	1054.9	116 02 45.5	296 01 18.3	Pond	4525.1	3.655630
1884	117 49 33.407	861.7	117 45 55.5	297 44 15.1	Brush	5288.5	3.723334
			197 53 41.3	17 54 01.5	San Joaquin	3060.5	3.485797
			340 36 18.7	160 36 35.2	Abalone Knoll	2322.1	3.365890
Aliso Peak	33 30 33.786	1040.9	147 05 30.6	327 03 07.4	San Joaquin	12295.8	4.089755
1884	117 44 37.829	976.5	249 10 53.4	69 11 13.7	Niguel	1013.2	3.005694
South Niguel	33 29 51.876	1598.2	142 26 39.8	322 26 18.6	Aliso Peak	1628.8	3.211859
1884	117 43 59.362	1532.3	178 24 52.5	358 24 51.5	Niguel	1651.9	3.217973
Dana	33 27 51.747	1594.2	135 17 24.0	315 13 47.4	Abalone Knoll	14373.8	4.157572
1884	117 42 31.501	813.6	148 30 05.6	328 29 17.1	South Niguel	4340.8	3.637572
			156 37 35.1	336 36 45.6	Niguel	5831.0	3.765741
Egan	33 29 52.084	1604.6	27 37 50.1	207 37 08.6	Dana	4184.4	3.621631
1884	117 41 16.351	422.0	89 55 30.6	269 54 00.6	South Niguel	4207.8	3.624057
			111 09 20.0	291 07 49.0	Niguel	4560.1	3.658977
Widows Hill	33 28 20.797	640.7	77 14 40.4	257 13 16.0	Dana	4049.9	3.607440
1884	117 39 58.540	1511.6	144 28 05.6	324 27 22.7	Egan	3456.2	3.538594
Ring Cliff	33 27 13.345	411.1	105 41 43.9	285 40 13.9	Dana	4376.7	3.641144
1884	117 39 48.333	1248.3	155 04 56.7	335 04 08.2	Egan	5392.7	3.731806
			172 46 21.1	352 46 15.5	Widows Hill	2094.7	3.321123
Forster	33 28 00.298	9.2	43 13 40.7	223 13 11.7	Ring Cliff	1985.1	3.297786
1884	117 38 55.688	1438.0	87 18 36.3	267 16 37.2	Dana	5579.1	3.746562
			111 16 04.4	291 15 29.7	Widows Hill	1741.5	3.240912
			133 29 29.5	313 28 11.9	Egan	5004.9	3.699396
Martin	33 26 35.602	1096.8	112 08 32.4	292 06 29.2	Dana	6228.6	3.794392
1884	117 38 48.085	1242.0	126 46 28.6	306 45 55.4	Ring Cliff	1942.5	3.288372
			175 41 49.0	355 41 44.8	Forster	2616.7	3.417756
Flat Top	33 26 53.868	1659.6	76 37 45.3	256 36 54.8	Martin	2432.2	3.386000
1884	117 37 16.473	425.5	98 42 37.2	278 41 13.5	Ring Cliff	3967.7	3.598543
			102 23 11.4	282 20 17.7	Dana	8328.8	3.920584
			128 37 25.4	308 36 30.7	Forster	3279.3	3.515778
No Brace	33 25 23.276	717.1	131 01 17.4	310 59 54.2	Ring Cliff	5167.8	3.713304
1884	117 37 17.365	448.7	133 33 46.3	313 32 56.4	Martin	3233.7	3.509703
			152 18 34.7	332 17 40.5	Forster	5463.6	3.737482
			180 28 24.0	0 28 24.5	Flat Top	2791.1	3.445771
Green Ridge	33 25 37.389	1151.9	75 51 57.7	255 51 20.9	No Brace	1779.9	3.250405
1884	117 36 10.555	272.7	113 47 47.7	293 46 21.0	Martin	4446.9	3.648061
			117 44 24.6	297.42 24.5	Ring Cliff	6354.7	3.803098
			135 55 21.8	315.53 50.7	Forster	6129.9	3.787451
			144 09 03.8	324 08 27.5	Flat Top	2907.0	3.463449
County Boundary	33 24 24.855	765.7	120 38 26.4	300 37 21.6	No Brace	3532.4	3.548069
1884	117 35 19.728	509.8	149 33 42.8	329 33 14.8	Green Ridge	2591.9	3.413624
San Mateo Point	33 23 22.241	685.2	141 39 19.6	321 37 39.2	Martin	7596.9	3.880636
1884	117 35 45.616	1179.1	147 33 30.3	327 32 39.8	No Brace	4418.7	3.645294
			150 11 35.3	330 09 50.6	Forster	9873.8	3.994485
			160 12 21.0	340 11 31.0	Flat Top	6929.5	3.840703
			171 12 13.7	351 11 59.9	Green Ridge	4213.2	3.624612
			199 07 33.2	19 07 47.5	County Boundary	2041.7	3.309998
Mendelson	33 28 56.405	1737.7	61 05 12.3	241 04 29.9	Widows Hill	2268.5	3.355739
1884	117 38 41.634	1074.9	71 27 53.8	251 25 46.9	Dana	6260.6	3.796615
			113 15 17.1	293 13 51.7	Egan	4346.9	3.638176
Sheehan	33 30 47.258	1455.9	349 49 58.6	169 50 11.7	Mendelson	3469.6	3.540285
1884	117 39 05.356	138.2	16 55 37.9	196 55 08.5	Widows Hill	4716.4	3.673611
			63 19 11.6	243 17 59.3	Egan	3784.3	3.577985
Argens	33 28 30.342	934.8	152 25 30.6	332 25 02.5	South Niguel	2833.9	3.452388
1884	117 43 08.541	220.5	228 59 06.2	49 00 08.1	Egan	3838.1	3.584114
			321 11 04.1	141 11 24.5	Dana	1526.0	3.183548
Black Flag	33 29 19.339	595.8	140 00 30.6	320 00 12.6	South Niguel	1308.4	3.116746
1884	117 43 26.786	691.5	253 18 41.4	73 19 53.4	Egan	3515.0	3.545923
			342 40 05.8	162 40 15.9	Argens	1581.3	3.199017

San Mateo Point to Newport Bay—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Mussel Cove	33 29 19.988	615.8	164 08 43.4	344 08 29.6	Aliso Peak	2363.5	3.373558
1884	117 44 12.810	330.7	199 27 37.4	19 27 44.8	South Niguel	1041.9	3.017841
			270 57 36.8	90 58 02.3	Black Flag	1188.3	3.074927
			312 39 53.5	132 40 29.1	Argens	2256.7	3.353469
			316 05 46.9	136 06 42.9	Dana	3772.6	3.576643
Abalone Hill	33 33 40.061	1234.2	55 08 28.7	235 08 12.6	Abalone Knoll	911.8	2.959912
1884	117 48 34.508	890.2	137 41 58.8	317 41 26.2	Reef Hill	2257.0	3.353531
			172 48 29.8	352 48 17.4	San Joaquin	4618.0	3.664453
Two Rock Hill	33 33 15.006	462.3	97 35 57.8	277 35 17.4	Abalone Knoll	1897.2	3.278108
1884	117 47 50.613	1305.6	124 17 10.6	304 16 46.3	Abalone Hill	1370.4	3.136835
			162 17 16.5	342 16 39.8	San Joaquin	5620.1	3.749744
			307 52 00.5	127 54 07.2	Niguel	7502.2	3.875191
East Bluff	33 27 45.333	1396.6	93 43 01.7	273 41 56.5	Dana	3055.6	3.485092
1884	117 40 33.423	863.1	164 09 27.8	344 09 04.1	Egan	4059.2	3.608444
			219 29 59.9	39 30 19.1	Widows Hill	1416.0	3.151068
			232 48 30.0	52 49 31.7	Mendelson	3623.0	3.559063
			259 38 22.9	79 39 16.7	Forster	2565.5	3.409179
			310 14 18.0	130 14 42.8	Ring Cliff	1525.5	3.183400
West Knoll	33 28 09.803	302.0	74 56 49.7	254 56 05.5	Dana	2141.0	3.330610
1884	117 41 11.435	295.2	259 47 34.7	79 48 14.9	Widows Hill	1912.5	3.281592
			274 45 54.0	94 47 08.9	Forster	3517.4	3.546225
			307 31 20.7	127 31 41.7	East Bluff	1237.7	3.092603
			309 01 07.0	129 01 52.8	Ring Cliff	2762.4	3.441282
East Knoll	33 27 51.727	1593.6	66 09 42.8	246 09 33.3	East Bluff	487.4	2.687854
1884	117 40 16.160	417.3	90 01 06.1	270 00 01.3	Dana	3494.9	3.543439
			111 19 05.9	291 18 35.4	West Knoll	1532.1	3.185293
			157 15 57.2	337 15 23.9	Egan	4020.5	3.604278
			206 55 46.9	26 55 56.5	Widows Hill	1004.5	3.001971
			262 45 05.4	82 45 49.7	Forster	2094.7	3.321119
Capistrano North Base	33 28 11.990	369.4	320 46 08.2	140 46 19.1	East Knoll	805.9	2.906274
1884	117 40 35.897	926.9	355 33 01.5	175 33 02.9	East Bluff	823.7	2.915779
			85 48 15.9	265 47 56.3	West Knoll	920.1	2.963834
Capistrano South Base	33 27 48.026	1479.6	92 26 32.0	272 25 34.2	Dana	2699.7	3.431319
1884	117 40 47.048	1215.0	136 49 00.8	316 48 47.3	West Knoll	920.2	2.963859
			201 18 22.9	21 18 29.0	Capistrano N. Base	792.5	2.898974
			231 07 33.8	51 08 00.4	Widows Hill	1608.8	3.206512
			261 51 42.2	81 51 59.2	East Knoll	805.8	2.906204
			262 30 03.3	82 31 04.6	Forster	2900.4	3.462453
Capistrano Middle Base	33 28 00.008	0.2	21 18 26.0	201 18 23.0	Capistrano S. Base	396.2	2.597944
1884	117 40 41.473	1070.9	111 18 41.3	291 18 24.8	West Knoll	830.4	2.919309
			201 18 25.9	21 18 29.0	Capistrano N. Base	396.2	2.597944
			291 19 04.6	111 19 18.6	East Knoll	701.7	2.846138
			335 18 17.4	155 18 21.9	East Bluff	497.6	2.696880
Aliso Point	33 30 26.994	831.6	249 24 12.4	69 24 24.4	Aliso Peak	594.8	2.774389
1884	117 44 59.398	1533.1	304 54 59.2	124 55 32.4	South Niguel	1890.0	3.276468
			329 46 18.3	149 46 44.1	Mussel Cove	2389.1	3.378239
Goff Ridge	33 31 17.808	548.6	295 51 30.6	115 52 14.6	Niguel	2283.6	3.358617
1884	117 45 20.756	535.5	320 45 11.4	140 45 35.1	Aliso Peak	1751.2	3.243340
			321 33 43.6	141 34 28.6	South Niguel	3379.6	3.528868
			340 36 17.8	160 36 29.5	Aliso Point	1659.7	3.220018
Goff Island	33 30 51.721	1593.4	206 13 41.8	26 13 50.3	Goff Ridge	896.0	2.952292
1884	117 45 36.100	931.7	290 10 08.6	110 10 40.8	Aliso Peak	1602.2	3.204718
			306 26 07.9	126 27 01.4	South Niguel	3103.8	3.491891
			308 48 24.3	128 48 44.5	Aliso Point	1215.5	3.084745
			322 43 58.9	142 44 44.9	Mussel Cove	3550.9	3.550337
West Bluff	33 27 44.424	1368.6	97 05 35.1	277 04 56.3	Dana	1828.4	3.262070
1884	117 41 21.235	548.3	197 56 21.6	17 56 27.0	West Knoll	821.8	2.914780
			234 02 34.3	54 02 49.4	Capistrano N. Base	1446.4	3.160290
			242 18 19.1	62 19 04.7	Widows Hill	2411.6	3.382306
			262 50 07.1	82 50 26.0	Capistrano S. Base	889.8	2.949305
			268 41 52.0	88 42 18.4	East Bluff	1235.1	3.091697
			291 44 54.5	111 45 45.7	Ring Cliff	2583.3	3.412168
South Sierra	33 29 59.358	1828.9	169 51 06.5	349 51 01.1	Niguel	1443.3	3.159353
1884	117 43 51.280	1323.6	273 11 44.3	93 13 00.8	Egan	4005.4	3.602646
			332 20 37.6	152 21 21.7	Dana	4438.3	3.647221

San Mateo Point to Newport Bay—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
North Sierra	33 30 44.030	1356.5	293 23 34.6	113 24 53.7	Egan	4029.0	3.605202
1884	117 43 39.608	1022.2	341 40 01.3	161 40 38.8	Dana	5591.4	3.747519
			12 20 53.9	192 20 47.5	South Sierra	1408.9	3.148866
			94 34 29.0	274 34 17.1	Niguel	557.3	2.746107
Rags	33 29 07.912	243.7	138 05 26.5	318 05 19.4	Mussel Cove	499.9	2.698911
1884	117 43 59.875	1545.8	180 33 34.6	0 33 34.9	South Niguel	1354.5	3.131784
			247 35 56.0	67 36 14.4	Black Flag	923.9	2.965637
			311 07 40.1	131 08 08.6	Argens	1759.6	3.245417
Abalone Point	33 33 14.705	453.0	165 10 09.3	345 09 55.4	Reef Hill	2534.9	3.403954
1884	117 49 08.250	212.8	205 09 54.6	25 09 57.2	Abalone Knoll	287.3	2.458262
			228 05 17.1	48 05 35.8	Abalone Hill	1169.5	3.068001
			269 43 43.2	89 44 26.1	Two Rock Hill	2002.7	3.301623
Extra	33 33 04.764	146.8	123 19 49.3	303 19 39.3	Abalone Point	557.4	2.746189
1884	117 48 50.195	1294.9	148 45 10.6	328 45 03.2	Abalone Knoll	662.4	2.821088
			200 24 31.1	20 24 39.8	Abalone Hill	1160.3	3.064567
			258 23 36.8	78 24 09.8	Two Rock Hill	1569.1	3.195638
Two Rock Point	33 32 47.923	1476.5	118 01 41.6	298 01 20.7	Extra	1104.2	3.043067
1884	117 48 12.410	320.2	129 27 40.7	309 27 12.4	Abalone Knoll	1707.5	3.232354
			160 27 43.9	340 27 31.7	Abalone Hill	1704.5	3.231585
			213 58 26.2	33 58 38.3	Two Rock Hill	1006.2	3.002674
Recreation Point	33 32 36.392	1121.2	108 11 47.9	288 11 24.7	Two Rock Point	1137.8	3.056074
1884	117 47 30.511	787.2	120 59 07.1	300 58 15.6	Abalone Knoll	2798.4	3.446908
			156 26 54.2	336 26 43.1	Two Rock Hill	1297.8	3.113198
Recreation Hill	33 33 15.077	464.5	14 48 57.1	194 48 50.4	Recreation Point	1232.8	3.090903
1884	117 47 17.292	446.1	59 04 21.7	239 03 51.8	Two Rock Point	1627.6	3.211539
			89 51 06.5	269 50 48.7	Two Rock Hill	833.8	2.921048
			154 34 58.1	334 34 03.6	San Joaquin	5925.2	3.772703
Laguna Hill	33 32 51.720	1593.4	75 31 19.5	255 30 40.3	Recreation Point	1888.1	3.276035
1884	117 46 19.650	507.0	87 42 22.2	267 41 19.9	Two Rock Point	2911.4	3.464097
			107 00 25.4	286 59 35.2	Two Rock Hill	2453.8	3.389844
			115 26 40.1	295 26 07.7	Recreation Hill	1675.2	3.224077
Corn Patch	33 32 10.443	321.7	123 08 12.2	303 07 46.0	Recreation Point	1462.7	3.165144
1884	117 46 43.038	1110.4	138 46 19.4	318 45 42.1	Two Rock Hill	2645.0	3.422424
			155 27 16.4	335 26 56.9	Recreation Hill	2189.2	3.340284
			205 22 55.7	25 23 08.6	Laguna Hill	1407.6	3.148475
			312 39 17.0	132 40 26.2	Aliso Peak	4394.0	3.642864
			324 32 09.8	144 32 46.8	Goff Island	2977.5	3.473858
Winston	33 31 36.382	1120.8	318 45 26.0	138 45 36.8	Goff Ridge	761.0	2.881393
1884	117 45 40.195	1037.3	355 36 20.3	175 36 22.6	Goff Island	1380.0	3.139880
			122 54 51.1	302 54 16.4	Corn Patch	1931.4	3.285876
			156 19 20.4	336 18 58.6	Laguna Hill	2534.5	3.403885
Cactus Point	33 31 38.439	1184.2	132 59 29.5	312 58 48.5	Recreation Point	2618.6	3.418073
1884	117 46 16.268	419.8	144 59 20.2	324 59 05.4	Corn Patch	1203.8	3.080561
			177 47 15.8	357 47 13.9	Laguna Hill	2259.3	3.353979
			273 53 39.2	93 53 59.1	Winston	933.0	2.969872
			293 55 25.0	113 55 55.7	Goff Ridge	1567.2	3.195131
			308 05 29.3	128 06 23.7	Aliso Peak	3228.2	3.508966
			324 14 08.4	144 14 30.6	Goff Island	1773.8	3.248902
Mustard	33 34 50.388	1552 4	112 08 42.2	292 07 23.7	Pond	3951.0	3.596702
1884	117 49 49.156	1267.8	114 42 15.8	294 40 44.1	Brush	4704.1	3.672480
			209 08 25.1	29 08 54.0	San Joaquin	2765.0	3.441700
			320 46 13.0	140 46 21.7	Reef Hill	642.2	2.807665
Pelican Hill	33 35 35.398	1090.6	92 03 10.2	272 02 08.9	Pond	2858.1	3.456078
1884	117 50 20.308	523.7	99 28 21.1	279 27 06.6	Brush	3518.4	3.546341
			244 25 47.8	64 26 33.9	San Joaquin	2383.0	3.377122
			329 54 49.6	149 55 06.8	Mustard	1602.6	3.204812
Reef Point	33 33 59.101	1820.8	131 24 57.6	311 23 43.0	Pond	4639.8	3.666497
1884	117 49 56.137	1447.9	168 08 10.3	348 07 57.0	Pelican Hill	3031.5	3.481659
			186 30 01.5	6 30 05.4	Mustard	1590.3	3.201475
			208 26 01 1	28 26 13.7	Reef Hill	1231.1	3.090302
			285 33 44.5	105 34 29.7	Abalone Hill	2185.7	3.339586
			309 12 54.8	129 13 23.9	Abalone Knoll	1752.1	3.243548
			317 54 40.4	137 55 06.9	Abalone Point	1843.0	3.265528

San Mateo Point to Newport Bay—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Rocky Bight	33 34 20.325	626.2	177 19 54.4	357 19 52.1	Pelican Hill	2315.4	3.364620
1884	117 50 16.129	415.9	216 51 20.3	36 54 35.2	Mustard	1158.3	3.063823
			248 44 03.9	68 44 27.5	Reef Hill	1182.2	3.072706
			313 14 27.3	133 15 07.4	Abalone Knoll	2571.3	3.410148
			319 06 03.7	139 06 41.2	Abalone Point	2674.4	3.427231
			321 44 30.1	141 44 41.2	Reef Point	832.7	2.920486
Pelican Point	33 34 48.363	1489.9	133 19 12.0	313 18 36.7	Pond	2260.9	3.354277
1884	117 51 07.291	188.0	219 53 41.1	39 54 07.1	Pelican Hill	1888.8	3.276178
			268 13 17.4	88 14 00.6	Mustard	2015.9	3.304474
			280 10 50.4	100 11 42.3	Reef Hill	2459.9	3.390924
			303 12 29.5	123 12 57.8	Rocky Bight	1577.1	3.197854
			309 35 13.5	129 35 52.8	Reef Point	2381.4	3.376826
Arch Rock	33 35 06.530	201.2	149 14 11.1	329 13 58.4	Pond	1153.6	3.062070
1884	117 51 48.198	1242.9	248 34 03.4	68 34 52.0	Pelican Hill	2434.6	3.386422
			279 11 36.3	99 12 42.1	Mustard	3109.8	3.492739
			285 57 36.9	105 58 51.4	Reef Hill	3615.6	3.558176
			297 56 43.3	117 57 05.9	Pelican Point	1194.2	3.077078
			305 42 02.2	125 43 04.1	Reef Point	3559.2	3.551351
Pond Point	33 35 28.153	867.3	142 55 26.7	322 55 13.7	Brush	1004.7	3.002040
1884	117 52 11.414	294.3	181 30 24.9	1 30 25.1	Pond	325.2	2.512200
			265 32 14.0	85 33 15.5	Pelican Hill	2873.6	3.458422
			287 35 11.3	107 36 30.0	Mustard	3848.5	3.585293
			306 32 45.5	126 33 21.0	Pelican Point	2058.4	3.313532
			318 03 08.6	138 03 21.5	Arch Rock	895.6	2.952138
Table Ridge	33 35 45.157	1391.2	77 48 30.2	257 47 36.6	Pond Point	2479.2	3.394316
1884	117 50 37.434	965.3	254 18 29.6	74 19 25.2	San Joaquin	2691 5	3.429988
			304 15 05.0	124 15 14.5	Pelican Hill	534.3	2.727750
			23 45 03.8	203 44 47.3	Pelican Point	1911.6	3.281399
			56 53 36.1	236 52 57.0	Arch Rock	2178.4	3.338146
Clam Point	33 39 00.887	27.3	270 09 06.6	90 13 44.9	French Hill	12945.8	4.112129
1874	117 56 55.159	1421.3	280 43 22.5	100 45 53.5	Newport	7150.5	3.854337
			293 14 25.3	113 18 49.9	San Joaquin	13418.4	4.127701
			331 43 00.3	151 43 23.3	La Mesa	2264.6	3.354994
Black Knob	33 37 37.570	1157.5	181 06 38.6	1 06 39.7	Clam Point	2567.4	3.409496
1874	117 56 57.090	1471.4	242 58 35.7	62 58 59.8	La Mesa	1260.4	3.100520
Turning Point	33 37 01.187	36.6	124 06 58.5	304 06 04.8	La Mesa	3020.0	3.480012
1875	117 54 36.513	941.2	235 41 47.9	55 43 02.1	Newport	4179.5	3.621128
			265 31 17.8	85 32 31.0	Spur	3412.4	3.533066
Prickly Point	33 37 19.208	591.7	159 39 22.3	339 39 13.2	La Mesa	1214.0	3.084224
1875	117 55 57.148	1473.1	284 57 01.0	104 57 45.6	Turning Point	2151.4	3.332726
Bitter Point	33 37 33.368	1028.0	107 52 17.4	287 50 08.9	Black Knob	421.7	2.625038
1875	117 56 41.516	1070.2	225 46 50.9	45 47 06.4	La Mesa	1006.7	3.002889
			290 52 34.7	110 52 59.3	Prickly Point	1224.0	3.087783
Promontory	33 36 49.435	1523.0	107 08 27.7	287 08 02.5	Turning Point	1228.7	3.089444
1875	117 53 50.966	1313.8	119 14 01.6	299 12 42.7	La Mesa	4210.5	3.624330
			219 59 04.0	39 59 53.0	Newport	3546.2	3.549766
			254 15 15.6	74 16 03.6	Spur	2314.8	3.364513
			310 57 44.8	130 58 27.1	Brush	2596.9	3.414459
Sand Point	33 36 28.558	879.8	141 14 17.6	321 13 43.2	Bitter Point	2560.9	3.408397
1875	117 55 39.313	1013.5	163 35 00.9	343 34 51.1	Prickly Point	1626.9	3.211348
			238 09 23.0	58 09 57.8	Turning Point	1905.6	3.280033
			257 01 24.4	77 02 24.4	Promontory	2866.2	3.457309
Chalk Rock	33 37 42.267	1302.2	235 09 41.4	55 10 15.0	Newport	1906.9	3.280322
1875	117 53 23.275	599.9	303 26 01.3	123 26 33.8	Spur	1814.4	3.258731
			23 40 49.6	203 40 34.1	Promontory	1777.3	3.249768
Dune	33 36 04.901	151.0	134 02 44.2	314 01 27.9	La Mesa	4931.2	3.692952
1875	117 53 55.999	1443.8	210 29 48.1	30 30 39.8	Newport	4745.8	3.676312
			229 41 19.3	49 42 09.9	Spur	3091.9	3.490224
			278 58 43.1	98 59 28.0	Brush	2116.8	3.325672
First Bend*	33 37 19.93	614.0	232 36 09	52 36 49	Newport	2926.8	3.466393
1875	117 53 52.76	1360.0	357 10 27	177 10 28	Promontory	940.7	2.973432
Camp*	33 38 44.00	1355.6	315 44 59	135 45 16	Newport	1134.7	3.054888
1875	117 52 53.27	1372.7	345 40 52	165 41 08	Spur	2994.8	3.476374

*No check on this position.

San Mateo Point to Newport Bay—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Rock *	33 35 38.21	1177.2	140 09 41	320 09 02	Promontory	2858.1	3.456074
1875	117 52 39.94	1029.8	194 46 52	14 46 55	Brush	508.6	2.706362
Sand Cone	33 38 19.620	604.5	238 15 56.9	58 16 41.1	Clam Point	2417.6	3.383392
1874	117 58 14.956	385.4	302 50 18.7	122 51 01.8	Black Knob	2388.7	3.378156
Scallop Point	33 39 24.447	753.2	159 54 10.6	339 53 47.9	Las Bolsas	3068.6	3.486936
1874	117 59 36.760	947.1	279 52 33.0	99 54 02.6	Clam Point	4226.7	3.626003
			313 26 57.4	133 27 42.8	Sand Cone	2903.9	3.462976
Cactus Knoll	33 40 43.463	1339.0	313 28 22.3	133 29 34.0	Clam Point	4592.5	3.662045
:874	117 59 04.497	115.8	343 55 42.6	163 56 10.1	Sand Cone	4611.8	3.663871
			18 51 12.7	198 50 54.8	Scallop Point	2572.4	3.410334
			103 21 03.3	283 20 22.7	Las Bolsas	1937.8	3.287304
Anaheim *	33 50 15.85	488.3	340 40 52	160 44 09	San Joaquin	27650.3	4.441700
1874	117 54 51.73	1330.1	26 02 26	205 59 25	Las Bolsas	19125.4	4.281610
Las Bolsas Chica	33 42 38.632	1190.2	133 18 58.0	313 15 11.0	Los Cerritos	14432.0	4.159326
1873	118 02 58.513	1506.5	211 25 02.1	31 26 27.8	Westminster	7620.3	3.881974
			306 48 37.6	126 50 06.8	Las Bolsas	5174.0	3.713823
Landing Hill	33 44 57.630	1775.6	131 14 35.7	311 12 17.3	Los Cerritos	8516.4	3.930258
1873	118 05 37.775	972.3	254 35 53.4	74 38 47.7	Westminster	8371.1	3.922780
			316 14 03.9	136 15 32.3	Las Bolsas Chica	5928.8	3.772965
Bolsas Bluff	33 40 56.814	1750.4	153 10 13.0	333 09 38.9	Las Bolsas Chica	3515.5	3.545985
1873	118 01 56.894	1465.6	269 11 11.6	89 12 06.6	Las Bolsas	2555.5	3.407468
Sand Knoll	33 41 35.420	1091.2	167 35 48.1	347 35 38.8	Las Bolsas Chica	1994.0	3.299736
1873	118 02 41.880	1078.6	287 14 37.0	107 15 57.0	Las Bolsas	3888.7	3.589808
			315 44 47.2	135 45 12.1	Bolsas Bluff	1660.5	3.220238
Ice Plant	33 40 16.351	503.7	141 33 22.1	321 33 00.8	Bolsas Bluff	1591.8	3.201879
1874	118 01 18.472	475.8	230 40 13.8	50 40 47.5	Las Bolsas	2023.9	3.306192
			301 23 05.0	121 24 01.3	Scallop Point	3069.9	3.487119
Bitter Lake	33 39 19.78	609.4	130 08 15	310 07 30	Ice Plant	2704.4	3.432065
1874	117 59 58.22	1500.1	170 35 08	350 34 57	Las Bolsas	3067.0	3.486711
Laguna, Dyer Cottage, flagstaff	33 32 26.882	828.2	107 49 34.7	287 49 15.1	Recreation Point	957.3	2.981041
1884	117 46 55.187	1423.8	136 02 32.9	316 02 02.3	Two Rock Hill	2059.8	3.313830
			230 08 51.8	50 09 11.4	Laguna Hill	1194.2	3.077090
			328 14 34.6	148 14 41.3	Corn Patch	595.6	2.774972
Inner Two Rock	33 32 44.512	1371.3	125 53 14.1	305 52 55.6	Extra	1064.5	3.027131
1884	117 48 16.764	432.5	165 01 38.6	345 01 28.8	Abalone Hill	1771.5	3.248352
			215 40 46.2	35 41 00.7	Two Rock Hill	1156.6	3.063192
			238 01 1[illegible].5	58 01 43.8	Recreation Hill	1778.3	3.249993
			265 47 14.9	85 48 19.6	Laguna Hill	3029.5	3.481374
			281 50 10.9	101 50 36.4	Recreation Point	1219.2	3.086085
			293 27 23.7	113 28 15.5	Corn Patch	2636.1	3.420968
Sheep Herders Hut	33 28 29.270	901.8	49 28 56.6	229 28 27.7	Dana	1779.2	3.250234
1884	117 41 39.122	1010.1	125 06 53.6	305 05 36.2	South Niguel	4425.5	3.645960
			143 10 14.3	323 09 07.8	North Sierra	5187.5	3.714961
			192 58 23.7	12 58 36.3	Egan	2618.2	3.418001
			223 01 29.5	43 02 54.4	Sheehan	5816.1	3.764635
			259 38 53.4	79 40 31.4	Mendelson	4658.1	3.668212
			281 55 49.3	101 57 19.4	Forster	4313.4	3.634820
			293 24 32.5	113 26 57.3	Flat Top	7392.1	3.868766
			298 21 37.5	118 22 13.4	East Knoll	2434.6	3.386421
			308 34 54.8	128 35 31.1	East Bluff	2170.4	3.336531
			309 15 41.5	129 16 42.6	Ring Cliff	3695.4	3.567665
Boathouse, flagstaff	33 27 45.144	1390.8	170 40 34.7	350 40 21.0	Egan	3963.2	3.598043
1884	117 40 51.477	1329.3	209 25 46.5	29 25 52.0	Capistrano M. Base	525.7	2.720777
			232 11 02.9	52 11 05.4	Capistrano S. Base	144.8	2.160660
			300 59 28.1	121 00 02.9	Ring Cliff	1902.3	3.279285
Congdon's house, chimney	33 29 17.285	532.5	125 59 14.4	305 58 42.8	Egan	1824.7	3.261191
1884	117 40 19.154	494.5	214 29 30.1	34 30 10.8	Sheehan	3363.3	3.526765
			284 19 34.3	104 20 28.1	Mendelson	2598.5	3.414728
San Mateo Rock	33 24 18.033	555.6	127 37 41.0	307 34 38.6	Dana	10790.4	4.033039
1884	117 37 00.558	14.4	146 45 55.6	326 44 56.4	Martin	5067.5	3.704795
			156 31 58.7	336 30 55.3	Forster	7465.5	3.873060
			175 06 23.5	355 06 14.8	Flat Top	4818.6	3.682917

* No check on this position.

San Mateo Point to Newport Bay—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
San Juan Rock	33 27 26.267	809.2	260 02 54.7	80 05 02.5	Forster	6077.6	3.783729
1884	117 42 47.508	1226.9	274 54 11.9	94 55 50.7	Ring Cliff	4644.4	3.666928
			276 38 02.0	96 41 04.5	Flat Top	8607.5	3.934878
			284 08 55.0	104 11 07.0	Martin	6377.6	3.804657
			288 05 06.9	108 08 45.8	Green Ridge	10787.9	4.032936
			304 33 47.4	124 37 40.9	San Mateo Pt.	13240.9	4.121916
Widow's house, west gable	33 28 21.086	649.6	2 14 01.1	182 14 00.2	East Bluff	1102.3	3.042314
1884	117 40 31.759	820.0	21 07 11.8	201 07 06.4	Capistrano M. Base	696.2	2.842713
			21 11 18.3	201 11 09.9	Capistrano S. Base	1094.0	3.039019
San Juan Capistrano Mission, pole	33 30 09.336	287.6	77 44 21.4	257 43 29.1	Egan	2501.3	3.398168
	117 39 41.660	1075.3	218 43 41.1	38 44 01.1	Sheehan	1497.6	3.175401
			325 24 12.9	145 24 46.0	Mendelson	2729.4	3.436068
San Juan Capistrano Schoolhouse, chimney.	33 30 11.550	355.8	76 37 48.9	256 36 55.0	Egan	2592.1	3.413653
	117 39 38.654	997.8	217 59 45.4	38 00 03.8	Sheehan	1396.0	3.144877
			327 32 50.7	147 33 22.2	Mendelson	2743.4	3.438294
Old Hydrographic Signal	33 35 39.61	1220.3	272 10 49	92 11 05	Pond	733.4	2.86537
1884	117 52 39.51	1018.7	307 36 16	127 36 45	Arch Rock	1670.1	3.22275
Sand Spit	33 27 45.282	1395.1	261 56 35.8	81 57 45.7	Forster	3304.5	3.51911
1884	117 41 02.398	61.9	297 13 00.2	117 13 41.0	Ring Cliff	2150.9	3.33263

Newport Bay to Point Dume.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Centinela	34 00 18.422	567.6	11 51 14.1	191 50 09.5	West Beach	14455.6	4.1600370
1875	118 21 44.567	1143.6	102 07 50.7	282 04 15.3	La Mesa	10104.7	4.0045238
Sand Hill 3	33 57 23.790	732.9	163 21 07.7	343 20 18.6	La Mesa	7827.2	3.8936058
1875	118 26 42.226	1084.2	234 49 24.0	54 52 10.4	Centinela	9345.0	3.9705776
			331 54 05.8	151 55 47.4	West Beach	9937.3	3.9972699
Ridge	34 00 00.50	15.4	266 58 38	87 02 28	Centinela	10583.6	4.024634
1875	118 28 36.42	934.8	328 43 41	148 44 45	Sand Hill 3	5648.6	3.751938
High Table	34 00 44.367	1367.1	276 40 37	96 43 01	Centinela	6855.5	3.836038
1875	118 26 09.901	254.1	7 38 57	187 38 39	Sand Hill 3	6235.4	3.794864
			70 14 22	250 13 00	Ridge	3995.5	3.601572
Reef	34 01 59.088	1820.7	301 01 34.0	121 11 55.7	West Beach	33382.5	4.523519
1862	118 42 13.217	339.0	69 53 02.2	249 49 35.8	Pt. Dume	10080.7	4.003492
Linn	34 02 19.346	596.1	309 29 33.4	129 37 24.1	West Beach	28065.3	4.448169
1862	118 37 42.844	1099.0	76 01 39.2	255 55 41.6	Pt. Dume	16905.4	4.228000
			84 52 43.2	264 50 11.9	Reef	6963.7	3.842843
Malaga	34 02 40.615	1251.5	279 39 23.3	99 40 47.2	Linn	3902.2	3.591307
1862	118 40 12.811	328.6	67 30 24.4	247 29 17.2	Reef	3343.1	3.524154
			69 18 21.8	249 13 48.0	Pt. Dume	13421.7	4.127807
Buck	34 01 32.558	1003.2	264 03 56.4	84 06 48 6	Reef	7938.2	3.899723
1862	118 47 21.004	538.9	30 33 38.0	210 33 03.8	Pt. Dume	3082.3	3.488879
Corral	34 01 31.638	974.9	36 46 17.5	216 45 34.7	Pt. Dume	3278.0	3.515606
1862	118 47 05.609	143.9	94 06 21.0	274 06 12.4	Buck	396.0	2.597672
Point	34 01 37.050	1141.6	58 32 50.2	238 31 10.7	Pt. Dume	5350.0	3.728356
1862	118 45 24.228	621.6	86 20 21.3	266 19 24.6	Corral	2606.3	3.416021
			87 21 49.2	267 20 43.9	Buck	2999.1	3.476990
Deadmans Island	33 43 33.318	1026.5	110 21 26.4	290 19 15.0	San Pedro	6494.5	3.812548
1859	118 16 10.842	279.1	230 15 31.2	50 19 04.7	Los Cerritos	12849.7	4.108894
Drum	33 46 58.966	1816.8	257 28 19.5	77 31 22.2	Los Cerritos	8656.7	3.937354
1872	118 15 15.249	392.3	12 43 45.5	192 43 14.6	Deadmans Island	6495.5	3.812612
			61 32 33.9	241 29 51.4	San Pedro	8553.3	3.932133

Newport Bay to Point Dume—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Point Fermin 1855	33 42 33.691 118 17 36.059	1036.0 928.5	136 25 54.3	316 24 30.3	San Pedro	5652.0	3.752205
			230 03 19.8	50 04 07.1	Deadmans Island	2861.7	3.456618
			230 12 39.3	50 17 00.2	Los Cerritos	15711.0	4.196205
Cactus 1870	33 43 57.019 118 19 13.212	1756.8 340.1	278 49 35.1	98 51 16.4	Deadmans Island	4751.4	3.676822
			315 44 16.3	135 45 10.2	Point Fermin	3584.4	3.554412
Outpost 1874	33 44 57.195 118 18 36.947	1762.2 950.9	304 28 55.3	124 30 16.4	Deadmans Island	4563.2	3.659273
			26 43 40.3	206 43 20.2	Cactus	2075.7	3.317171
Solitary 1870	33 43 16.905 118 17 36.683	520.8 944.4	116 26 56.7	296 26 03.1	Cactus	2775.5	3.443334
			153 20 41.1	333 20 07.6	Outpost	3457.4	3.538754
			257 06 22.1	77 07 09.7	Deadmans Island	2267.2	3.355483
R. R. Flagstaff 1899	33 42 47.460 118 17 33.903	1462.2 873.0	175 29 19.7	355 29 18.2	Solitary	910.0	2.959055
			236 32 33.7	56 33 19.8	Deadmans Island	2563.1	3.408773
Timm 1899	33 43 48.051 118 16 40.321	1480.5 1038.0	300 52 55.9	120 53 12.2	Deadmans Island	884.3	2.946612
			36 28 05.4	216 28 35.7	R. R. Flagstaff	2321.2	3.365715
			56 31 39.2	236 31 08.0	Solitary	1739.6	3.240460
Old 1899	33 43 13.965 118 16 58.014	430.3 1493.6	203 26 44.1	23 26 53.9	Timm	1144.7	3.058694
			243 50 49.8	63 51 16.0	Deadmans Island	1352.9	3.131277
			48 32 10.5	228 32 50.5	R. R. Flagstaff	1233.2	3.091036
			95 12 09.1	275 11 47.6	Solitary	999.7	2.999888
San Pedro, Clarence Hotel, cupola 1899	33 44 37.854 118 16 39.638	1166.3 1020.4	339 33 04.7	159 33 20.7	Deadmans Island	2122.0	3.326748
			0 39 24.1	180 39 23.7	Timm	1534.5	3.185964
			22 20 03.6	202 20 33.5	R. R. Flagstaff	3676.9	3.565483
			30 29 42.6	210 29 10.9	Solitary	2894.2	3.461530
San Pedro, Episcopal Church, white spire 1899	33 44 31.359 118 16 47.162	966.2 1214.0	332 23 37.9	152 23 58.1	Deadmans Island	2017.9	3.304900
			352 28 50.8	172 28 54.6	Timm	1345.9	3.128998
			20 36 19.7	200 35 53.8	R. R. Flagstaff	3419.8	3.533999
			29 04 02.3	209 03 34.8	Solitary	2624.3	3.419016
San Pedro, Methodist Church, gray spire 1899	33 44 16.375 118 16 51.528	504.5 1326.4	321 42 13.3	141 42 35.9	Deadmans Island	1690.2	3.227942
			341 41 18.2	161 42 24.4	Timm	919.1	2.963355
			4 57 45.3	184 57 41.7	Old	1930.1	3.285569
			32 23 49.8	212 23 24.7	Solitary	2169.9	3.336436
San Pedro Pavilion, cupola 1899	33 44 11.924 118 16 46.700	367.4 1202.1	322 10 56.3	142 11 16.2	Deadmans Island	1505.6	3.177719
			347 24 49.1	167 24 52.7	Timm	753.6	2.877153
			25 02 08.8	205 01 42.7	R. R. Flagstaff	2872.1	3.458197
			37 12 23.4	217 11 55.7	Solitary	2128.2	3.328006
San Pedro Schoolhouse, cupola, flagstaff 1899	33 44 21.754 118 17 00.163	670.3 4.2	319 36 15.5	139 36 42.9	Deadmans Island	1959.3	3.292111
			16 39 57.1	196 38 38.3	R. R. Flagstaff	3032.2	3.481763
			25 12 10.4	205 11 50.1	Solitary	2208.1	3.344019
San Pedro, Catholic Church, spire 1899	33 44 09.807 118 17 02.869	302.2 73.9	310 00 16.6	130 00 45.5	Deadmans Island	1748.6	3.242702
			355 50 35.3	175 50 38.1	Old	1725.0	3.236790
			17 28 57.9	197 28 40.7	R. R. Flagstaff	2659.9	3.424867
			28 06 33.8	208 06 15.0	Solitary	1847.8	3.266649
San Pedro Latitude Station 1852	33 43 21.04 118 17 02.18	648.2 56.1	118 56 49.7	298 55 06.8	San Pedro	5448.2	3.736253
			232 30 00.0	52 34 02.0	Los Cerritos	14118.8	4.149798
Terminal Island Planing Mill, iron stack 1899	33 44 48.306 118 16 09.786	1488.3 251.9	0 40 27.9	180 40 27.3	Deadmans Island	2310.5	3.363707
			22 57 03.3	202 56 46.4	Timm	2016.0	3.304483
			38 28 11.2	218 27 23.0	Solitary	3596.4	3.555866
Black Beacon* 1899	33 44 03.52 118 16 33.85	108.3 871.3	327 31 04	147 31 17	Deadmans Island	1102.9	3.042531
			19 16 52	199 16 48	Timm	504.7	2.703059
Terminal Wharf, flagstaff on extreme end	33 44 46.306 118 15 54.139	1426.7 1393.5	10 49 33.4	190 49 24.1	Deadmans Island	2289.5	3.359732
			33 31 21.7	213 30 56.1	Timm	2152.8	3.333001
			35 03 16.3	215 02 21.0	R. R. Flagstaff	4472.5	3.650553
			43 47 27.4	223 46 30.5	Solitary	3815.1	3.581505
Red Beacon 1899	33 43 52.740 118 16 22.155	1624.9 570.3	334 02 49.7	154 02 56.0	Deadmans Island	665.5	2.823150
			42 34 18.0	222 33 38.2	R. R. Flagstaff	2730.8	3.436297
			60 05 22.6	240 04 41.2	Solitary	2213.7	3.345120
			72 50 10.0	252 49 59.9	Timm	489.5	2.689738

* No check on this position.

Newport Bay to Point Dume—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Curve	33 43 53.080	1635.4	348 40 17.5	168 40 20.1	Deadmans Island	621.0	2.793071
1899	118 16 15.580	401.1	42 11 43.8	222 11 20.3	Old	1626.6	3.211275
			44 55 55.7	224 55 12.3	R. R. Flagstaff	2855.5	3.455680
			61 54 50.5	241 54 05.5	Solitary	2366.8	3.374168
Jetty	33 43 43.010	1325.2	340 06 15.7	160 06 18.0	Deadmans Island	317.5	2.501811
1899	118 16 15.039	387.2	49 52 44.6	229 52 00.9	R. R. Flagstaff	2655.5	3.424154
			51 02 13.2	231 01 49.4	Old	1423.0	3.153194
			69 04 06.5	249 03 21.2	Solitary	2250.6	3.352291
			103 25 30.7	283 25 16.7	Timm	669.1	2.825518
Post	33 42 36.525	1125.3	188 08 38.9	8 08 42.5	Old	1165.2	3.066417
1899	118 17 04.425	113.9	195 43 33.3	15 43 46.7	Timm	2289.4	3.359720
			218 15 01.6	38 15 31.2	Deadmans Island	2228.2	3.347956
Hotel	33 42 36.970	1139.0	202 05 56.3	22 06 06.4	Old	1230.2	3.089982
1899	118 17 15.989	411.7	202 44 48.1	22 45 07.9	Timm	2374.8	3.375620
			224 00 34.2	44 01 10.4	Deadmans Island	2414.0	3.382743
San Pedro, Presbyterian Church, spire*	33 44 01.01	31.2	359 43 42	179 43 42	Old	1449.4	3.161190
1899	118 16 58.28	1500.3	36 02 36	216 02 15	Solitary	1680.4	3.225417
Point Fermin Lighthouse	33 42 20.134	620.3	15 46 43.2	195 43 08.8	Catalina Peak	36714.6	4.5648388
1878	118 17 35.298	909.0	139 03 25.1	319 02 00.7	San Pedro	5974.5	3.7763014
			229 00 50.6	49 05 11.0	Los Cerritos	15967.1	4.2032254
			275 19 50.4	95 29 26.1	Las Bolsas	26842.8	4.4288276
Sepulveda	33 45 37.541	1156.6	70 52 08.6	250 50 30.9	San Pedro	4787.1	3.680074
1859	118 17 11.689	300.8	230 03 07.0	50 04 11.7	Drum	3907.8	3.591928
			337 44 23.2	157 44 57.0	Deadmans Island	4135.3	3.616512
Rattlesnake Island 2	33 45 08.878	273.5	18 29 45.6	198 29 24.4	Deadmans Island	3104.5	3.491986
1872	118 15 32.588	838.7	109 06 23.4	289 05 28.4	Sepulveda	2699.0	3.431211
			187 29 33.6	7 29 43.3	Drum	3421.0	3.534156
San Gabriel River 2	33 45 44.896	1383.2	43 15 25.5	223 14 03.2	Deadmans Island	5565.3	3.745485
1872	118 13 42.709	1099.1	68 34 56.4	248 33 55.3	Rattlesnake Id. 2	3037.8	3.482554
			87 36 13.3	267 34 17.2	Sepulveda	5382.8	3.731008
			133 47 24.5	313 46 33.1	Drum	3298.2	3.518274
Station I	33 46 02.411	74.3	54 46 46.7	234 44 26.4	Deadmans Island	7961.0	3.900967
1872	118 11 58.226	1498.4	108 59 02.0	288 57 12.5	Drum	5360.6	3.729213
			223 04 51.3	43 06 04.5	Los Cerritos	4952.3	3.694806
Station II	33 45 49.787	1533.9	66 09 54.1	246 06 29.0	Deadmans Island	10392.9	4.016738
1872	118 10 01.586	40.8	97 23 32.2	277 22 27.4	Station I	3026.6	3.480957
			104 49 03.3	284 46 09.1	Drum	8347.5	3.921557
			185 27 06.4	5 27 14.7	Los Cerritos	4023.6	3.604620
Station III	33 45 34.426	1060.7	71 39 40.3	251 35 37.8	Deadmans Island	11838.1	4.073282
1872	118 08 54.376	1399.4	100 20 32.3	280 18 50.1	Station I	4809.1	3.682063
			105 18 28.1	285 17 50.7	Station II	1793.2	3.253633
			163 15 58.0	343 15 29.0	Los Cerritos	4676.8	3.669953
Los Alamitos	33 46 20.380	627.9	313 32 50.2	133 33 48.1	Landing Hill	3699.9	3.568195
1872	118 07 21.971	565.4	59 14 13.1	239 13 21.6	Station III	2767.4	3.442074
			129 26 49.5	309 25 29.0	Los Cerritos	4821.8	3.683213
New River	33 45 00.769	23.7	116 23 52.6	296 23 07.3	Station III	2332.9	3.367893
1872	118 07 33.177	853.9	148 05 15.7	328 04 01.4	Los Cerritos	6498.5	3.812812
			186 42 16.8	6 42 23.0	Los Alamitos	2469.7	3.392639
Landing	33 44 12.920	398.0	122 20 02.0	302 19 11.7	New River	2756.8	3.440408
1872	118 06 02.674	68.8	152 32 43.1	332 31 59.0	Los Alamitos	4425.6	3.645975
			204 56 44.2	24 56 58.0	Landing Hill	1519.3	3.181638
Slough	33 44 13.041	401.8	89 56 02.7	269 55 00.5	Landing	2883.1	3.459864
1872	118 04 10.670	274.6	121 30 11.2	301 29 22.8	Landing Hill	2629.5	3.419874
Sand Beach	33 43 35.402	1090.8	120 58 42.6	300 58 01.1	"	2246.0	3.351417
1872	118 04 47.866	1232.3	153 06 44.9	333 06 17.2	Landing Hill	2840.6	3.453404
			219 32 39.1	39 32 59.8	Slough	1503.9	3.177208
Little Hill	33 43 26.869	827.8	100 16 26.9	280 15 55.6	Sand Beach	1474.7	3.168695
1872	118 03 51.504	1326.0	160 52 19.3	340 52 08.7	Slough	1505.7	3.177733

*No check on this position.

Newport Bay to Point Dume—Continued.

Station.	Latitude and longitude.	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Bolsas Creek 1872	33 42 36.782	1133.3	137 42 53.7	317 42 18.3	Sand Beach	2441.5	3.387650
	118 03 44.061	1134.6	172 55 14.7	352 55 10.6	Little Hill	1555.0	3.191737
			267 12 55.1	87 13 24.0	Las Bolsas Chica	1174.2	3.069746
			319 43 46.1	139 44 24.3	Sand Knoll	2477.6	3.394024
Grass Edge 1873	33 42 11.949	368.1	8 37 19.0	188 37 11.4	Bolsas Bluff	2341.3	3.369461
	118 01 43.267	1114.2	53 17 47.5	233 17 15.0	Sand Knoll	1882.9	3.274818
			112 59 41.7	292 59 00.0	Las Bolsas Chica	2104.8	3.323212
Mustard Point 1873	33 41 40.933	1261.1	320 58 23.3	140 58 46.4	Las Bolsas	1703.4	3.231315
	118 00 59.335	1528.2	47 29 13.6	227 28 41.7	Bolsas Bluff	2011.3	3.303483
			86 19 39.7	266 18 42.9	Sand Knoll	2646.5	3.422667
			120 05 19.3	300 04 13.2	Las Bolsas Chica	3546.7	3.549828
			130 11 17.8	310 10 53.5	Grass Edge	1480.9	3.170537
Los Angeles Normal School 1883	34 03 02.249	69.3	343 07 10.0	163 10 13.0	Los Cerritos	29053.2	4.4631945
	118 15 14.695	376.9	355 29 16.9	175 29 52.1	Dominguez Hill	20602.4	4.3139182
			34 05 51.1	214 01 08.7	West Beach	23169.9	4.3649235
De Camp 1883	34 00 16.629	512.4	242 55 48.2	62 59 26.3	Normal School	11225.0	4.0501865
	118 21 44.409	1139.6	320 51 37.3	140 58 17.6	Los Cerritos	29247.0	4.4660810
			322 58 22.4	143 02 35.2	Dominguez Hill	19325.6	4.2861332
			11 54 53.7	191 53 49.1	West Beach	14402.4	4.1584338
Los Angeles Magnetic Observatory 1883	34 03 03.584	110.4	296 20 18.2	116 20 20.0	Normal School	92.6	1.966794
	118 15 17.931	459.9	342 59 09.9	163 02 14.7	Los Cerritos	29116.8	4.4641434
			355 16 00.5	175 16 37.5	Dominguez Hill	20650.1	4.3149223
			33 52 11.5	213 47 30.9	West Beach	23157.6	4.3646926
			62 36 31.6	242 32 55.3	De Camp	11170.0	4.0480512
Compton Schoolhouse, spire 1883	33 53 50.778	1564.4	332 21 40.0	152 23 42.6	Los Cerritos	12204.9	4.086536
	118 13 26.832	689.6	17 59 10.0	197 58 45.0	Dominguez Hill	3729.7	3.571672
			132 58 32.7	312 53 54.9	De Camp	17452.0	4.241846
Tajanta Schoolhouse, tower 1883	33 56 36.780	1133.1	336 23 22.8	156 25 53.6	Los Cerritos	17380.9	4.240072
	118 14 17.349	445.5	359 01 45.1	179 01 48.3	Dominguez Hill	8663.3	3.937684
			120 35 05.5	300 30 55.7	De Camp	13326.3	4.124709
Downey City Church, spire 1883	33 55 52.230	1609.1	5 55 24.0	185 54 51.3	Los Cerritos	14633.9	4.165359
	118 08 48.014	1233.4	48 47 07.6	228 44 07.1	Dominguez Hill	11057.9	4.043671
			112 17 24.5	292 10 10.8	De Camp	21532.5	4.333095
			143 11 41.2	323 08 05.1	Normal School	16554.0	4.218904
Los Angeles (Boyle Heights), Davis tank house, flagstaff 1883	34 02 13.935	429.4	348 38 30.2	168 40 24.9	Los Cerritos	26840.7	4.428794
	118 13 12.224	313.6	4 35 00.0	184 34 26.8	Dominguez Hill	19111.1	4.281285
			42 21 55.9	222 16 05.2	West Beach	23946.5	4.379242
			115 21 53.8	295 20 45.2	Normal School	3476.2	3.541104
Los Angeles (Boyle Heights), electric light mast 1883	34 02 50.986	1571.0	349 15 57.2	169 17 50.1	Los Cerritos	27945.6	4.446314
	118 13 09.068	232.6	4 33 14.6	184 32 39.6	Dominguez Hill	20255.5	4.306543
			40 43 48.9	220 37 56.3	West Beach	24854.7	4.395409
			70 15 18.3	250 10 29.9	De Camp	14050.6	4.147694
			96 08 28.1	276 08 17.7	Normal School	3240.7	3.510636
Los Angeles, Baptist Church, spire 1883	34 02 48.490	1494.1	343 22 52.8	163 25 50.1	Los Cerritos	28571.0	4.455926
	118 15 04.388	112.6	35 14 16.6	215 09 28.6	West Beach	22971.5	4.361190
			65 31 17.9	245 27 34.2	De Camp	11279.0	4.052269
Los Angeles, Catholic Cathedral, spire 1883	34 03 01.786	55.0	344 57 02.7	164 59 44.8	Los Cerritos	28774.8	4.459012
	118 14 37.178	953.5	358 10 05.1	178 10 19.4	Dominguez Hill	20534.9	4.312492
			36 02 54.0	215 57 50.7	West Beach	23711.2	4.374953
			65 07 45.6	245 03 46.6	De Camp	12084.1	4.082216
Los Angeles Presbyterian Church 1883	34 03 08.742	269.4	344 37 53.7	164 40 40.7	Los Cerritos	29040.5	4.463004
	118 14 45.928	1177.9	357 33 59.4	177 34 18.6	Dominguez Hill	20757.4	4.317173
			35 18 18.5	215 13 20.1	West Beach	23754.4	4.375744
			63 44 43.2	243 40 49.1	De Camp	11974.2	4.078246
Los Angeles Signal Service 1883	34 03 19.603	604.0	345 54 36.7	165 57 11.0	Los Cerritos	29216.1	4.465622
	118 14 23.224	595.7	35 58 16.8	215 53 05.7	West Beach	24365.7	4.386778
			63 33 21.9	243 29 15.0	De Camp	12644.6	4.101904
			67 57 20.3	247 56 51.5	L.A. Normal School	1424.2	3.153570
Los Angeles, High School, flagstaff 1883	34 03 18.512	570.4	345 20 06.4	165 22 47.1	Los Cerritos	29256.3	4.466220
	118 14 34.663	889.0	358 23 19.8	178 23 32.7	Dominguez Hill	21048.1	4.323212
			35 27 12.5	215 22 07.8	West Beach	24167.1	4.383224
			63 05 18.9	243 01 18.6	De Camp	12367.3	4.092274

Newport Bay to Point Dume—Continued.

Station.	Latitude and longitude.	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Los Angeles, electric light mast (Hill street) 1883	34 03 17.466 118 14 47.612	538.2 1221.1	344 41 20.9	164 44 08.8	Los Cerritos	29311.2	4.467033
			357 28 46.9	177 29 07.0	Dominguez Hill	21027.8	4.322794
			34 50 55.9	214 46 08.3	West Beach	23949.5	4.379296
			62 30 31.0	242 26 37.8	De Camp	12057.2	4.081246
West Los Angeles, Methodist Episcopal Church, spire* 1883	34 01 13.63 118 17 06.38	420.0 163.7	76 11 30	256 08 54	De Camp	7346.8	3.86610
			220 33 30	40 34 33	L.A. Normal School	4405.7	3.64401
Wilmington Water Works, main tank*	33 46 07.18 118 15 38.24	221.2 984.0	134 18 21	314 13 53	West Beach	17305.1	4.23817
			248 58 59	69 02 15	Los Cerritos	9686.6	3.98617
Los Angeles Longitude Station 1889	34 03 03.78 118 15 16.91	116.4 433.7					
Los Angeles Longitude Station 1892	34 03 02.20 118 15 16.50	67.8 423.1					
Los Angeles Latitude Station 1892	34 03 02.20 118 15 16.55	67.8 424.4					
Los Angeles NW. Base Latitude Station 1890	33 55 05.69 118 03 23.24	175.2 597.1					
Dominguez Hill Zenith Telescope Station 1870	33 51 55.63 118 14 11.46	1713.8 294.5					
Dominguez Hill Meridian Instrument Station 1870	33 51 55.63 118 14 11.39	1713.8 292.8					
Cove* 1855	33 48 35.37 118 22 53.91	1089.7 1386.6	171 01 11	351 00 45	West Beach	7606.9	3.881208
			245 16 51	65 21 42	Dominguez Hill	14778.3	4.169623
Salt Pond 1856	33 50 43.690 118 22 31.770	1346.0 816.8	153 44 30.0	333 43 51.9	West Beach	3969.8	3.598768
			260 10 42.2	80 15 20.8	Dominguez Hill	13046.3	4.115487
Rocky Point 1856	33 47 39.545 118 24 14.714	1218.3 378.5	185 30 05.4	5 30 24.7	West Beach	9276.2	3.967372
			205 00 26.0	25 01 23.3	Salt Pond	6260.8	3.796628
Point Vincent N.W.	33 46 52.220 118 25 20.526	1608.8 528.1	193 34 11.3	13 35 07.2	West Beach	10998.9	4.041350
			211 18 41.4	31 20 15.2	Salt Pond	8348.4	3.921605
			229 15 38.3	49 16 14.9	Rocky Point	2234.4	3.349164
Finale* 1870	33 46 30.31 118 23 00.62	933.8 16.0	333 21 33	153 21 45	Scorpion	1295.7	3.112500
			21 53 11	201 52 54	Last	2981.7	3.318411
Far Knob 1870–72	33 45 30.232 118 19 55.701	931.4 1433.5	296 39 31.8	116 40 15.5	Outpost	2268.1	3.355660
			301 52 42.0	121 54 46.9	Deadmans Island	6817.3	3.833610
			314 50 39.1	134 51 21.4	East Slope	2760.8	3.441036
			318 55 42.4	138 56 59.6	Solitary	5447.8	3.736222
East Slope 1870	33 44 27.035 118 18 39.655	832.9 1020.7	43 03 03.1	223 02 44.5	Cactus	1265.5	3.102251
			184 17 19.8	4 17 21.3	Outpost	931.8	2.969333
			226 10 40.6	46 11 29.5	Sepulveda	3137.6	3.496600
			293 21 12.9	113 22 35.5	Deadmans Island	4173.1	3.620457
			323 06 53.0	143 07 28.0	Solitary	2701.2	3.431554
			331 06 22.6	151 06 59.1	R. R. Flagstaff	3503.9	3.544549
Mustard 1870	33 43 23.186 118 18 26.909	714.3 692.8	131 10 18.1	311 09 52.5	Cactus	1583.5	3.199627
			134 48 48.0	314 47 52.2	San Pedro	3646.2	3.561845
			170 31 52.5	350 31 45.4	East Slope	1994.3	3.299801
			174 54 08.8	354 54 03.1	Outpost	2907.9	3.463577
			264 53 49.4	84 55 05.0	Deadmans Island	3517.0	3.546172
			278 30 20.2	98 30 48.1	Solitary	1307.5	3.116444
			319 20 48.3	139 21 16.6	Point Fermin	2009.8	3.303163
Timms Windmill 1870	33 44 29.790 118 17 11.814	917.8 304.1	15 54 56.3	195 54 42.4	Solitary	2335.0	3.368292
			43 17 50.3	223 17 08.6	Mustard	2819.3	3.450134
			72 06 14.7	252 05 07.4	Cactus	3284.1	3.516412
			87 51 23.8	267 50 35.0	East Slope	2262.7	3.354622

*No check on this position.

Newport Bay to Point Dume—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Spring	33 44 34.988	1077.9	245 51 54.8	65 52 27.7	Outpost	1673.6	3.223658
1870	118 19 36.288	934.1	289 44 43.3	109 46 37.4	Deadmans Island	5619.6	3.749709
			320 21 25.1	140 22 31.9	Point Fermin	4852.5	3.685964
			321 04 43.1	141 05 21.6	Mustard	2843.2	3.453804
			333 04 36.9	153 04 49.7	Cactus	1312.0	3.117925
Bench	33 43 55.376	1706.0	203 09 59.2	23 10 10.5	Spring	1327.5	3.123025
1870	118 19 56.577	1456.4	267 24 00.7	87 24 24.8	Cactus	1117.5	3.048248
			293 14 33.1	113 15 22.8	Mustard	2512.5	3.400106
			304 48 44.9	124 50 03.0	Point Fermin	4407.1	3.644151
Coyote	33 44 46.872	1444.0	270 48 37.0	90 48 50.4	San Pedro	621.7	2.793553
1870	118 20 31.555	812.2	307 17 17.0	127 18 00.5	Cactus	2534.9	3.403968
			308 46 25.5	128 47 34.6	Mustard	4116.3	3.614503
			312 13 54.2	132 15 31.7	Point Fermin	6103.2	3.785558
			330 25 20.2	150 25 39.6	Bench	1824.2	3.261082
Unknown	33 43 41.240	1270.5	201 03 28.5	21 03 45.3	Coyote	2166.8	3.335825
1870	118 21 01.803	46.4	255 27 16.6	75 27 52.8	Bench	1734.8	3.239237
			291 25 55.7	111 27 50.0	Point Fermin	5691.5	3.755225
Knob	33 42 52.678	1622.9	115 22 50.1	295 21 42.1	Unknown	3491.7	3.543037
1870	118 18 59.265	1526.0	142 37 45.0	322 37 13.2	Bench	2430.7	3.385739
			169 44 02.0	349 43 54.3	Cactus	2014.5	3.304175
			285 15 57.2	105 16 43.5	Point Fermin	2220.9	3.346532
Portuguese Point	33 44 14.230	438.4	250 49 53.1	70 50 55.6	Coyote	3064.2	3.486319
1870	118 22 24.003	617.9	278 41 26.0	98 42 47.9	Bench	3839.3	3.584256
			295 38 58.2	115 39 43.9	Unknown	2347.5	3.370612
Ranchita	33 45 25.278	778.8	304 17 20.6	124 17 58.1	Coyote	2100.1	3.322231
1870	118 21 38.965	1002.8	316 24 58.6	136 25 55.5	Bench	3823.3	3.582436
			343 22 50.7	163 23 11.4	Unknown	3345.0	3.524401
			27 54 30.3	207 54 05.3	Portuguese Point	2477.0	3.393920
Sea Bench	33 43 31.854	981.4	102 52 15.5	282 51 48.2	Unknown	1298.6	3.113463
1870	118 20 12.630	325.2	147 33 09.9	327 32 21.9	Ranchita	4141.3	3.617138
			168 05 56.8	348 05 46.3	Coyote	2362.1	3.373290
			209 41 38.3	29 41 47.2	Bench	834.3	2.921307
			293 57 12.2	113 58 39.0	Point Fermin	4411.6	3.644601
Long Point	33 44 11.397	351.1	236 01 00.8	56 02 13.6	Ranchita	4073.4	3.609958
1870	118 23 50.210	1292.5	257 55 10.9	77 57 01.2	Coyote	5229.0	3.718417
			267 44 28.4	87 45 16.2	Portuguese Point	2220.8	3.346510
			274 40 25.6	94 42 35.3	Bench	6034.5	3.780644
			282 05 00.4	102 06 33.9	Unknown	4433.8	3.646773
			282 15 15.3	102 17 16.1	Sea Bench	5732.2	3.758324
Gus	33 45 04.474	137.8	275 58 35.1	96 00 26.5	Coyote	5195.2	3.715602
1870	118 23 52.299	1326.1	300 17 07.1	120 18 41.7	Unknown	5083.0	3.706123
			304 15 12.0	124 16 00.9	Portuguese Point	2749.8	3.439303
			358 06 57.4	178 06 58.6	Long Point	1636 2	3.213828
Wash Rock Point*	33 44 29.14	897.8	265 04 03	85 06 20	Coyote	6378.2	3.804700
1870	118 24 38.44	989.4	284 48 21	104 50 21	Unknown	5768.8	3.761082
Portuguese Bend	33 44 19.914	613.5	82 54 18.1	262 53 47.7	Portuguese Point	1417.1	3.151411
1870	118 21 29.373	756.2	85 52 15.2	265 50 57.0	Long Point	3634.8	3.560484
			110 28 32.6	290 27 13.3	Gus	3926.6	3.594021
			329 13 04.2	149 13 19.5	Unknown	1386.9	3.142046
Last	33 45 27.614	850.7	271 25 30.0	91 26 32.0	Ranchita	2878.2	3.459120
1870	118 23 30.766	791.8	285 12 37.8	105 14 17.3	Coyote	4780.2	3.679446
			12 01 54.9	192 01 44.1	Long Point	2401.0	3.380387
			37 51 33.0	217 51 21.1	Gus	903.0	2.955691
Scorpion	33 45 52.722	1624.3	297 42 52.2	117 44 15.8	San Pedro	4379.6	3.641436
1870	118 22 38.038	978.8	299 04 38.8	119 05 11.6	Ranchita	1739.5	3.240433
			301 55 23.2	121 56 33.5	Coyote	3835.7	3.583843
			311 00 34.0	131 02 03.7	Bench	5508.3	3.741016
			60 19 09.3	240 18 40.0	Last	1561.9	3.193663
Yonder	33 44 47.002	1448.0	209 27 01.6	29 27 08.2	Gus	618.2	2.791105
1870	118 24 04.108	105.7	214 26 25.4	34 26 43.9	Last	1517.2	3.181051
			252 28 08.9	72 29 29.4	Ranchita	3917.3	3.592988
			281 49 21.8	101 50 47.7	Portuguese Bend	4069.4	3.609529
			291 23 26.4	111 24 21.9	Portuguese Point	2767.5	3.442087
			293 20 17.0	113 21 58.2	Unknown	5111.6	3.708554
			341 56 11.0	161 56 18.8	Long Point	1153.9	3.062152
Buenavista	34 03 18.597	573.0	358 24 31.6	178 24 44.3	Dominguez Hill	21050.5	4.323262
1870	118 14 34 380	881.8	35 27 49.9	215 22 45.0	West Beach	24173.4	4.383338

*No check on this position.

Point Dume to Santa Barbara.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Point Hueneme Lighthouse	34 08 45.022	1387.3	46 40 44.7	226 34 52.4	Anacapa	22181.1	4.3459823
1876–1898	119 12 34.332	879.5	147 06 35.4	327 02 30.8	Chaffee	20483.4	4.3114031
			287 01 02.5	107 05 55.7	Laguna	14007.4	4.1463578
Santa Barbara Mission, south tower	34 26 18.848	580.8	342 08 44.6	162 13 45.3	Santa Cruz East	44692.8	4.6502377
	119 42 45.161	1153.0	3 06 06.0	183 06 01.6	Santa Barbara	3741.6	3.5730594
			99 06 32.4	278 50 02.9	Gaviota	45169.6	4.6548465
			73 00 40.9	252 56 14.1	Pelican	12605.8	4.100571
			55 42 17.0	235 40 58.1	Hill	4319.4	3.635428
			103 05 32.6	283 03 12.5	Cluster	6500.4	3.812942
			127 08 19.1	307 07 33.3	Thompson	2596.8	3.414442
			264 03 04.7	84 03 23.2	Mission	837.3	2.922890
Topographical 1	34 13 20.914	644.4	139 17 09.9	319 14 25.2	Chaffee	11472.5	4.059657
1867	119 14 56.668	1450.5	161 55 34.4	341 55 00.4	San Buenaventura	4987.8	3.697911
			239 19 09.2	59 26 15.8	Santa Clara (old)	22521.6	4.352599
			306 27 52.4	126 34 05.8	Laguna	21190.9	4.326149
Mesa	34 15 31.258	963.2	43 28 14.6	223 26 50.9	Topographical 1	5532.9	3.742955
1867	119 12 27.950	715.1	97 44 05.7	277 42 07.9	San Buenaventura	5401.2	3.732491
			244 22 12.8	64 27 55.8	Santa Clara (old)	17266.1	4.237193
			321 28 20.0	141 33 10.1	Laguna	21240.5	4.327165
Martin	34 17 48.000	1479.0	305 01 17.7	125 03 30.0	Mesa	7338.4	3.865604
1867	119 16 22.842	584.2	344 59 43.5	165 00 32.1	Topographical 1	8519.7	3.930426
			349 19 46.7	169 20 01.2	San Buenaventura	3549.3	3.550139
			95 01 53.4	274 59 57.3	Chaffee	5300.0	3.724279
Middle Point	34 07 08.591	264.7	163 54 26.6	343 52 48.5	Mesa	16120.9	4.207390
1867	119 09 33.295	853.2	277 22 43.9	97 25 55.5	Laguna	8827.2	3.945823
Rabbit	34 07 44.861	1382.3	344 45 39.1	164 45 52.5	Laguna	2337.5	3.368743
1867	119 04 15.713	402.7	82 12 21.0	262 09 22.8	Middle Point	8214.6	3.914587
			138 47 11.5	318 42 34.8	Mesa	19114.5	4.281363
Pelican	34 24 19.061	587.3	270 10 54.6	90 15 16.8	Santa Barbara	11853.4	4.073843
1862	119 50 37.184	949.7	10 28 42.3	190 26 12.9	Santa Cruz West	37443.6	4.573378
Hill	34 24 59.839	1843.8	291 07 46.1	111 09 00.6	Santa Barbara	3609.2	3.557408
1862	119 45 04.897	125.1	21 56 08.6	201 50 32.3	Santa Cruz West	41036.6	4.613171
			81 36 14.2	261 33 06.4	Pelican	8578.7	3.933422
Cluster	34 27 06.566	202.3	310 19 12.2	130 21 27.9	Santa Barbara	8043.3	3.905434
1862	119 46 53.196	1358.0	324 41 20.3	144 42 21.5	Hill	4784.7	3.679854
			47 57 09.9	227 55 03.3	Pelican	7703.8	3.886705
Thompson	34 27 09.721	299.5	340 35 19.1	160 36 00.5	Santa Barbara	5623.2	3.749982
1863	119 44 06.258	159.7	20 30 54.0	200 30 20.9	Hill	4272.9	3.630721
			62 14 57.5	242 11 16.6	Pelican	11282.1	4.052389
			88 42 20.9	268 40 46.6	Cluster	4262.4	3.629654
Mission	34 26 21.663	667.5	15 09 27.4	195 09 04.5	Santa Barbara	3960.6	3.597763
1862	119 42 12.539	320.1	60 12 19.8	240 10 42.4	Hill	5072.0	3.705176
			117 02 06.2	297 01 01.9	Thompson	3258.9	3.513072
Bens	34 25 52.964	1632.0	63 44 54.0	243 42 42.2	Santa Barbara	6639.3	3.822125
1862	119 38 59.946	1530.5	100 12 36.6	280 10 47.7	Mission	4996.1	3.698627
White	34 24 58.686	1808.3	79 37 19.6	259 34 46.9	Santa Barbara	7014.4	3.845990
1862	119 38 22.942	585.8	113 34 52.4	293 32 42.7	Mission	6395.8	3.805892
			150 32 17 4	330 31 56.5	Bens	1920.9	3.283509
Ridge	34 26 00.306	9.4	68 24 31.9	248 22 45.8	White	5156.4	3.712345
1863	119 35 15.193	387.9	87 45 36.4	267 43 29.4	Bens	5742.9	3.759131
Mound	34 24 52.207	1608.7	92 09 05.3	272 07 06.8	White	5358.9	3.729075
1863	119 34 53.243	1359.7	106 34 12.8	286 31 53.5	Bens	6571.9	3.817689
			165 02 47.1	345 02 34.7	Ridge	2171.9	3.336838
Boyle	34 25 46.320	1427.3	46 38 41.9	226 38 02.8	Mound	2428.5	3.385335
1863	119 33 44.099	1126.0	100 30 15.9	280 29 24.4	Ridge	2365.5	3.373915
Sheep	34 23 47.657	1468.5	116 36 33.3	296 35 05.4	Mound	4442.5	3.647630
1863	119 32 17.709	452.3	132 03 26.1	312 01 45.8	Ridge	6103.3	3.785562
			148 53 59.7	328 53 10.9	Boyle	4270.4	3.630470
Oregon	34 27 52.480	1617.1	293 53 48.6	113 54 59.3	Cluster	3491.1	3.542965
1890	119 48 58.236	1486.3	21 01 21.3	201 00 25.4	Pelican	7044.7	3.847860

Point Dume to Santa Barbara—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m	° ′ ″	° ′ ″		meters	
More	34 25 12.041	371.0	67 01 04.1	246 59 39.0	Pelican	4179.0	3.621072
1900	119 48 06.549	167.2	165 03 33.0	345 03 03.8	Oregon	5116.7	3.708991
			207 56 58.6	27 57 40.1	Cluster	3995.0	3.601520
Wisconsin	34 28 12.854	396.1	324 33 41.2	144 34 13.4	Cluster	2506.9	3.399135
1900	119 47 50.139	1279.0	4 18 04.5	184 17 55.2	More	5587.1	3.747190
			30 38 20.3	210 36 45.9	Pelican	8371.6	3.922810
			70 08 38.7	250 08 00.2	Oregon	1847.9	3.266672
Conover	34 27 28.326	872.8	293 18 02.7	113 18 37.2	Cluster	1694.7	3.229095
1900	119 47 54.171	1382.7	4 18 16.0	184 18 00.0	More	4211.2	3.624408
			35 31 40.9	215 30 08.8	Pelican	7164.7	3.855200
Olmstead	34 23 20.900	644.0	115 28 32.5	295 26 21.8	Mound	6545.3	3.815930
1866	119 31 01.865	47.6	137 15 12.6	317 13 40.9	Boyle	6102.9	3.785534
Snake	34 24 04.445	137.0	73 02 28.4	253 00 51.2	Olmstead	4596.5	3.662425
1866	119 28 09.756	249.2	98 09 33.6	278 05 45.6	Mound	10409.5	4.017431
			110 12 42.9	290 09 34.0	Boyle	9097.0	3.958899
Rincon	34 22 42.017	1294.7	109 23 48.3	289 22 33.0	Olmstead	3609.4	3.557435
1866	119 28 48.591	1241.4	113 19 45.3	293 16 19.2	Mound	10141.5	4.006103
			126 58 53.5	306 56 06.5	Boyle	9445.4	3.975220
			201 19 57.0	21 20 18.9	Snake	2726.7	3.435639
Mount Hoar	34 22 20.844	642.3	96 48 17.1	276 46 16.0	Rincon	5519.8	3.741923
1866	119 25 14.063	359.3	125 26 09.1	305 24 29.9	Snake	5507.7	3.740972
Punta Gorda	34 21 21.414	659.8	124 57 49.6	304 56 31.1	Rincon	4335.1	3.637001
1866	119 26 29.535	754.6	226 28 38.3	46 29 20.9	Mount Hoar	2659.4	3.424787
Las Petes	34 19 39.578	1219.5	123 28 22.7	303 26 37.9	Punta Gorda	5691.4	3.755218
1866	119 23 23.765	607.5	124 07 48.5	304 04 45.2	Rincon	10025.6	4.001112
			150 26 33.2	330 25 31.0	Mount Hoar	5712.9	3.756859
			298 27 42.1	118 29 43.0	Chaffee	6238.4	3.795071
Ridge	34 20 55.149	1699.3	311 37 54.8	131 40 17.2	Martin	8676.7	3.938353
1866	119 20 36.431	931.0	322 19 20.6	142 21 58.0	San Buenaventura	11689.4	4.067791
			347 11 44.5	167 12 11.1	Chaffee	5438.3	3.735465
			61 26 57.2	241 25 22.8	Las Petes	4870.0	3.687528
			110 26 10.1	290 23 33.4	Mount Hoar	7570.1	3.879102
Ord	34 25 38.212	1177.4	296 10 13.3	116 12 23.2	Snake	6546.7	3.816025
1866	119 31 59.794	1526.8	340 43 17.5	160 43 50.2	Olmstead	4482.2	3.651492
			72 15 59.5	252 14 21.5	Mound	4650.5	3.667497
San Buenaventura	34 16 52.192	1608.2	125 28 51.8	305 27 44.4	Chaffee	3761.7	3.575386
Church, spire	119 17 49.515	1266.5	232 11 29.5	52 12 18.3	Martin	2805.5	3.448010
1866			301 35 33.3	121 36 36.6	San Buenaventura	3374.7	3.528232
Cross	34 17 05.288	162.9	119 05 52.4	299 04 42.0	Chaffee	3660.2	3.563504
1866	119 17 44.234	1131.4	237 41 28.6	57 42 14.4	Martin	2462.8	3.391421
			308 24 10.0	128 25 10.3	San Buenaventura	3495.7	3.543530
Mill, chimney	34 23 20.897	643.9	115 24 17.6	295 22 06.5	Mound	6562.6	3.817074
1863	119 31 01.117	28.5	127 08 41.6	307 06 18.0	Ridge	8138.2	3.910531
			137 07 22.4	317 05 50.3	Boyle	6115.9	3.786461
Gedney	34 25 12.034	370.8	184 16 26.9	4 16 35.2	Oregon	4957.6	3.695275
1896	119 49 12.714	324.7	225 15 20.2	45 16 39.2	Cluster	5014.2	3.700206
			245 06 33.3	65 09 26.5	Thompson	8623.7	3.935692
			273 22 43.2	93 25 03.3	Hill	6339.5	3.802058
			52 53 37.9	232 52 50.2	Pelican	2705.2	3.432194
			73 33 40.1	253 32 54.2	Crane	2170.3	3.336512
Crane	34 24 52.095	1605.2	203 47 03.3	23 47 57.5	Oregon	6074.5	3.783508
1896	119 50 34.222	873.9	233 41 43.4	53 43 48.3	Cluster	7001.0	3.845163
			246 47 34.6	66 51 13.8	Thompson	10775.0	4.032419
			268 20 56.4	88 24 02.5	Hill	8413.5	3.924976
			4 15 02.7	184 15 01.0	Pelican	1020.7	3.008887
Ledge	34 06 55.367	1706.0	63 23 13.3	243 22 41.4	Laguna	1630.0	3.212198
1868	119 02 54.881	1406.5	126 22 00.5	306 21 15.2	Rabbit	2572.2	3.410307
Mugu	34 05 34.164	1052.7	106 47 46.5	286 44 15.1	Middle Point	10085.4	4.003693
1868	119 03 16.540	424.0	153 00 48.2	333 00 28.4	Laguna	1988.2	3.298464
			192 30 31.7	12 30 43.8	Ledge	2562.8	3.408722

Point Dume to Santa Barbara—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Vista	34 27 31.551	972.2	286 50 01.9	106 53 27.2	Ridge	9692.6	3.986439
1890	119 41 18.551	473.5	22 00 00.2	201 59 06.7	Santa Barbara	6445.4	3.809249
			81 04 59.6	261 03 24.7	Thompson	4333.3	3.636815
Bens 2	34 25 53.668	1653.7	63 43 26.7	243 41 14.1	Santa Barbara	6682.6	3.824946
1890	119 38 58.476	1493.0	130 09 25.4	310 08 06.2	Vista	4678.0	3.670061
			267 55 40.4	87 57 46.4	Ridge	5704.6	3.756223
Spring	34 27 12.185	375.5	295 25 04.1	115 26 47.0	Ridge	5157.4	3.712434
1890	119 38 17.639	450.3	23 18 54.1	203 18 31.0	Bens 2	2634.4	3.420682
			52 36 32.9	232 33 57.2	Santa Barbara	8854.6	3.947170
			97 22 39.5	277 20 57.2	Vista	4656.2	3.668030
Hassler	34 26 15.720	484.4	55 29 19.0	235 28 57.1	Bens 2	1199.2	3.078890
1890	119 38 19.774	504.8	181 47 38.1	1 47 39.3	Spring	1740.7	3.240727
			275 44 26.4	95 46 10.5	Ridge	4736.5	3.675454
Front	34 24 59.486	1833.0	74 15 55.6	254 13 11.7	Santa Barbara L. H.	7694.7	3.886194
1890	119 38 26.765	683.5	79 16 31.9	259 14 01.4	Santa Barbara	6922.9	3.840290
			154 07 44.3	334 07 26.4	Bens 2	1855.5	3.268468
			249 01 21.5	69 03 09.6	Ridge	5238.4	3.719198
Peak	34 05 47.665	1468.7	77 38 14.7	257 37 33.2	Mugu	1942.1	3.288272
1857	119 02 02.537	65.0	115 51 02.5	295 50 01.2	Laguna	3110.1	3.492781
			147 15 24.0	327 14 54.6	Ledge	2480.2	3.394486
Hueneme	34 08 44.497	1371.2	180 26 04.4	360 26 06.5	Mesa	12533.5	4.098071
1857	119 12 31.665	811.2	278 11 22.1	98 16 00.4	Rabbit	12839.3	4.108540
			287 02 10.9	107 07 02.7	Laguna	13937.4	4.144181
			302 52 15.7	122 53 55.9	Middle Point	5442.5	3.735800
Thompson's house, south gable *	34 26 22.29	686.8	42 38 46	222 37 54	Hill	3453.5	3.538262
1862	119 43 33.28	849.6	150 03 36	330 03 17	Thompson	1686.7	3.227033
White house, chimney	34 27 01.450	44.7	264 03 16.2	84 04 10.5	Thompson	2463.6	3.391570
1862	119 45 42.252	1078.6	319 26 20.0	139 27 55.7	Santa Barbara	6644.4	3.822458
			345 43 02.4	165 43 23.5	Hill	3866.7	3.587340
Sand	34 25 06.953	214.2	272 58 40.0	93 00 12.8	Hill	4201.5	3.623405
1862	119 47 49.202	1256.5	71 01 51.3	251 00 16.4	Pelican	4536.7	3.656742
			201 12 01.0	21 12 32.7	Cluster	3953.3	3.596957
Sand Hill *	34 10 12.61	388.6	160 46 43	340 45 54	Topographical 1	6144.6	3.788496
1867	119 13 37.64	964.0	189 17 32	9 18 11	Mesa	9978.9	3.999082
Bluff	34 24 19.964	615.2	69 50 15.5	269 47 08.2	Pelican	8464.1	3.927583
1862	119 45 05.785	147.8	181 03 26.2	1 03 26.7	Hill	1228.9	3.089505
			271 13 23.0	91 14 38 0	Santa Barbara	3390.0	3.530197
			287 22 15.1	107 23 16.8	Santa Barbara L. H.	2918.8	3.465206
Camp	34 24 03.896	120.0	92 46 39.4	272 43 03.9	Pelican	9747.5	3.988895
1862	119 44 15.983	408.2	111 16 17.1	291 15 48.9	Bluff	1365.0	3.135117
			144 04 20.8	324 03 53.2	Hill	2128.8	3.328141
			258 43 05.9	78 43 52.7	Santa Barbara	2159.0	3.334243
			283 58 22.2	103 58 55.7	Santa Barbara L. H.	1559.8	3.193058
Clay	34 25 03.772	116.2	89 16 38.1	269 13 13.4	Hill	9247.7	3.966034
1862	119 39 02.796	71.4	116 22 04.3	296 20 17.0	Mission	5406.6	3.732928
			182 44 58.5	2 45 00.1	Bens	1517.5	3.181118
			278 45 08.2	98 45 30.7	White	1029.8	3.012736
Niderer's (John) house, west chimney *	34 25 11.50	354.4	87 28 34	267 25 35	Hill	8079.8	3.907403
1862	119 39 48.81	1246.5	120 30 49	300 29 27	Mission	4259.4	3.629346
White house, east gable*	34 26 33.20	1023.0	245 39 11	65 40 06	Thompson	2730.1	3.436180
1862	119 45 43.70	1115.7	340 59 39	161 00 01	Hill	3042.7	3.483263
Hartley's house, west gable *	34 26 16.42	506.0	208 00 59	28 01 18	Thompson	1860.4	3.269597
1862	119 44 40.49	1033.8	14 47 41	194 47 27	Hill	2440.7	3.387510
Santa Barbara Latitude Station *	34 24 41.17	1268.7	158 25 09	338 24 42	Mission	3329.9	3.522435
1852	119 41 24.56	627.2	239 03 59	59 05 21	Bens	4304.8	3.633952

* No check on this position.

Point Dume to Santa Barbara—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m*	° ′ ″	° ′ ″		*meters*	
Burton	34 24 42.80	1318.8	160 49 39.6	340 49 16.1	Mission	3225.1	3.508547
1870	119 41 31.05	793.0	240 43 37.6	60 45 03.0	Bens	4423.0	3.645712
Burton's wharf, end	34 24 37.18	1145.5	116 47 48.6	296 47 40.0	Burton	384.1	2.584428
1870	119 41 17.63	450.2	156 28 10.1	336 27 39.1	Mission	3511.4	3.545483
			236 23 56.3	56 25 14.2	Bens	4220.6	3.625373
Burton's house, northeast corner *	34 24 43.09	1327.9	395 03 21	215 03 21	Burton	10.9	1.036229
	119 41 30.81	786.8					
1870							
River	34 16 31.105	958.4	145 33 07.9	325 32 25.1	Chaffee	3435.3	3.535964
1870	119 18 33.313	852.2	229 59 56.4	50 00 24.0	Cross	1638.7	3.214496
			285 37 50.6	105 39 18.5	San Buenaventura	4148.4	3.617882
Monument	34 16 55.276	1703.4	52 33 55.9	232 33 34.4	River	1225.2	3.088195
1870	119 17 55.281	1414.0	125 36 42.4	305 35 38.2	Chaffee	3586.4	3.554667
			222 29 13.2	42 29 19.4	Cross	418.3	2.621534
			301 39 03.1	121 40 09.6	San Buenaventura	3550.1	3.550240
San Buenaventura Azimuth Mark *	34 17 05.69	175.4	294 02 54	114 04 42	San Buenaventura	5356.7	3.728894
	119 19 08.36	213.8					
1870							
Plain 2 *	34 16 35.82	1103.6	23 19 18	203 19 06	San Buenaventura	1376.5	3.138770
1870	119 15 35.85	917.0	99 37 28	279 35 28	San Buen. Az. Mark	5513.0	3.741385
San Buenaventura Latitude Station	34 15 59.20	1824.1					
	119 15 57.15	1462.0					
1870							
Santa Barbara Latitude Station	34 24 17.66	544.2					
	119 42 52.88	1350.7					
1869							
Meigs Windmill	34 24 09.516	293.2	245 52 47.2	65 52 59.5	Santa Barbara	609.3	2.784803
1890	119 43 14.858	379.5	4 57 24.7	184 57 23.6	Santa Barbara L. H.	552.0	2.741915
Aligned	34 24 31.343	965.8	310 23 52.1	130 24 03.2	Santa Barbara	653.6	2.815292
1904	119 43 12.574	321.1	4 57 25.9	184 57 23.6	Santa Barbara L. H.	1227.0	3.088859
			4 57 25.9	184 57 24.7	Meigs Windmill	675.1	2.829348
Meigs Field	34 24 25.476	785.0	221 19 06.9	41 19 10.4	Aligned	240.7	2.381499
1904	119 43 18.797	480.1	290 17 22.9	110 17 37.5	Santa Barbara	700.1	2.845167
			348 26 15.6	168 26 17.7	Meigs Windmill	501.9	2.700655
			357 05 30.4	177 05 31.6	Santa Barbara L. H.	1043.0	3.018288

Santa Barbara to Point Arguello.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Fogg	34 27 32.284	994.8	274 36 33.8	94 40 10.2	Cluster	9797.5	3.991115
1863	119 53 15.772	402.6	325 46 05.1	145 47 34.8	Pelican	7200.2	3.857346
Bruce	34 25 42.271	1302.5	208 50 25.1	28 51 06.5	Fogg	3870.1	3.587717
1863	119 54 28.912	738.2	293 24 26.9	113 26 37.9	Pelican	6449.2	3.809505
Don	34 27 35.106	1081.7	271 00 32.1	91 02 20.0	Fogg	4866.2	3.687194
1863	119 56 26.395	673.7	319 12 30.9	139 13 37.4	Bruce	4591.7	3.661972
Nicolas	34 26 10.484	323.0	207 53 04.5	27 53 35.1	Don	2950.1	3.469842
1863	119 57 20.453	522.2	281 12 46.2	101 14 23.2	Bruce	4465.3	3.649849
Alcatraz	34 27 03.670	113.1	257 49 28.2	77 51 07.8	Don	4597.9	3.662562
1863	119 59 22.485	573.9	297 44 15.0	117 45 23.5	Nicolas	3520.1	3.546557
Buck	34 28 37.735	1162.8	300 16 25.3	120 17 38.6	Don	3826.8	3.582838
1863	119 58 35.879	915.6	337 00 06.0	157 00 48.7	Nicolas	4928.9	3.692748
			22 18 59.3	202 18 32.9	Alcatraz	3133.0	3.495966

* No check on this position.

Santa Barbara to Point Arguello—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m*	° ′ ″	° ′ ″		*meters*	
Capitan	34 27 36.610	1128.1	247 28 30.1	67 30 10.9	Buck	4919.5	3.691917
1863	120 01 33.951	866.6	286 49 06.4	106 50 20.8	Alcatraz	3505.8	3.544793
			292 16 43.2	112 19 06.8	Nicolas	6994.2	3.844739
Ortega	34 28 46.715	1439.4	273 03 05.4	93 05 00.0	Buck	5170.8	3.713557
1863	120 01 58.220	1485.7	343 59 59.0	164 00 12.7	Capitan	2247.2	3.351640
Goat	34 28 07.900	243.4	243 40 18.9	63 41 12.5	Ortega	2697.4	3.430947
1863	120 03 32.961	841.3	287 36 04.0	107 37 11.3	Capitan	3186.8	3.503352
Tahuivas	34 29 47.717	1470.3	290 58 25.3	111 00 13.2	Ortega	5247.9	3.719983
1863	120 05 10.249	261.5	321 05 03.7	141 05 58.8	Goat	3952.6	3.596878
Refugio	34 28 27.340	842.4	178 34 25.6	358 34 24.2	Tahuivas	2477.5	3.394009
1863	120 05 07.832	199.9	262 57 04.5	82 58 51.8	Ortega	4875.3	3.688005
			283 53 20.4	103 54 13.2	Goat	2494.1	3.396920
Young	34 28 42.008	1294.4	221 16 15.8	41 16 55.2	Tahuivas	2694.2	3.430422
1872	120 06 19.905	508.0	283 48 00.8	103 48 41.6	Refugio	1893.9	3.277368
Ledge	34 29 18.272	563.0	244 55 18.8	64 56 01.8	Tahuivas	2141.1	3.330635
1872	120 06 26.260	670.0	308 05 50.4	128 06 34.8	Refugio	2543.2	3.405389
			351 44 34.0	171 44 37.6	Young	1129.1	3.052750
Black	34 29 05.954	183.5	249 25 10.4	69 26 26.5	Tahuivas	3662.7	3.563797
1872	120 07 24.648	628.9	255 42 07.8	75 42 40.9	Ledge	1537.4	3.186794
			294 03 43.5	114 04 20.2	Young	1809.4	3.257528
Quemada	34 28 22.882	705.1	202 06 19.0	22 06 31.0	Black	1432.5	3.156093
1872	120 07 45.775	1168.2	254 56 27.5	74 57 16.1	Young	2269.2	3.355869
Rock	34 28 46.020	1418.0	261 05 00.9	81 06 27.9	Black	3968.3	3.598607
1872	120 09 58.291	1487.5	281 53 40.9	101 54 55.9	Quemada	3456.0	3.538574
Stow	34 28 13.483	415.4	194 03 05.1	14 03 10.7	Rock	1033.5	3.014306
1872	120 10 08.123	207.3	248 48 08.5	68 49 41.0	Black	4474.0	3.650695
			265 25 50.3	85 27 10.9	Quemada	3644.3	3.561617
Camp	34 28 44.843	1381.8	268 47 21.6	88 47 59.8	Rock	1723.6	3.236442
1872	120 11 05.821	148.5	303 16 17.5	123 16 50.2	Stow	1761.2	3.245799
Onofre	34 28 13.925	429.1	194 28 54.1	14 28 59.6	Camp	984.0	2.992977
1872	120 11 15.464	394.6	243 19 48.0	63 20 31.8	Rock	2203.8	3.343164
			270 26 54.5	90 27 32.6	Stow	1718.6	3.235177
Brush	34 28 54.434	1677.3	276 20 49.5	96 21 48.4	Camp	2669.7	3.426461
1872	120 12 49.800	1270.8	297 23 57.3	117 24 50.7	Onofre	2711.7	3.433243
Ram	34 28 17.272	532.2	186 58 11.8	6 58 14.9	Brush	1153.6	3.062060
1872	120 12 55.286	1410.9	253 04 31.0	73 05 33.0	Camp	2919.8	3.465350
			272 18 36.6	92 19 33.1	Onofre	2549.6	3.406471
Burke	34 29 11.159	343.8	281 57 45.1	101 58 39.0	Brush	2484.8	3.395292
1872	120 14 25.063	639.5	305 55 37.3	125 56 28.1	Ram	2829.4	3.451692
Bald	34 28 24.049	741.0	229 34 06.9	49 34 44.7	Burke	2238.5	3.349966
1872	120 15 31.843	812.6	257 13 45.7	77 15 17.4	Brush	4239.7	3.627340
			272 58 46.1	93 00 14.7	Ram	4000.8	3.602146
Knob	34 29 19.393	597.6	274 01 18.2	94 02 38.0	Burke	3607.5	3.557203
1872	120 16 46.097	1176.2	311 58 55.2	131 59 37.2	Bald	2549.2	3.406400
Alta	34 28 43.477	1339.7	174 06 16.1	354 06 13.6	Knob	1112.6	3.046329
1872	120 16 41.618	1062.0	256 14 02.3	76 15 19.6	Burke	3587.4	3.554774
			288 34 38.4	108 35 17.9	Bald	1878.5	3.273817
Turn	34 28 39.881	1228.9	234 57 19.1	54 57 57.6	Knob	2120.5	3.326448
1872	120 17 54.139	1381.6	266 34 04.9	86 34 45.9	Alta	1853.9	3.268092
Anita	34 28 02.770	85.4	198 17 34.4	18 17 42.8	Turn	1204.4	3.080771
1872	120 18 08.953	228.5	240 37 22.5	60 38 11.9	Alta	2557.5	3.407815
Low	34 28 09.826	302.8	249 41 00.8	69 41 36.3	Turn	2668.2	3.426226
1872	120 19 32.196	821.7	275 50 14.3	95 51 01.4	Anita	2135.6	3.329511
Gull	34 27 51.468	1585.9	143 59 38.2	323 59 29.1	Low	699.3	2.844650
1872	120 19 16.088	410.6	234 29 36.6	54 30 23.0	Turn	2568.9	3.409747
			258 30 22.7	78 31 00.7	Anita	1748.4	3.242653

Santa Barbara to Point Arguello—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Seal	34 27 33.406	1029.4	232 08 54.6	52 09 26.6	Low	1829.0	3.262219
1872	120 20 28.785	734.7	253 17 52.8	73 18 33.9	Gull	1937.1	3.287157
Ridge	34 28 19.165	590.5	279 27 05.4	99 27 43.7	Low	1751.5	3.243404
1872	120 20 39.893	1018.1	291 44 48.7	111 45 36.1	Gull	2302.8	3.362257
			348 37 48.4	168 37 54.7	Seal	1438.2	3.157820
Duck	34 27 27.584	850.0	226 15 21.8	46 15 58.6	Ridge	2298.9	3.361513
1872	120 21 44.970	1147.9	264 43 24.0	84 44 07.1	Seal	1952.8	3.290667
Mound	34 28 13.493	415.8	264 37 08.7	84 37 49.9	Ridge	1865.7	3.270844
1872	120 21 52.678	1344.4	299 58 24.7	119 59 12.2	Seal	2471.9	3.393031
			352 04 56.3	172 05 00.7	Duck	1428.2	3.154792
Undo	34 27 56.358	1736.6	255 51 16.7	75 52 03.2	Mound	2161.4	3.334735
1872	120 23 14.802	377.7	291 08 03.6	111 08 54.4	Duck	2458.3	3.390629
Bank	34 27 21.967	676.9	176 23 41.1	356 23 39.6	Undo	1061.8	3.026046
1872	120 23 12.186	311.1	231 57 16.4	51 58 01.3	Mound	2576.6	3.411040
			265 32 50.6	85 33 39.9	Duck	2232.9	3.348865
Lime	34 28 07.439	229.2	288 03 39.8	108 04 03.0	Undo	1101.1	3.041826
1872	120 23 55.819	1424.6	321 31 05.2	141 31 29.9	Bank	1789.8	3.252807
Coxo	34 27 01.117	34.4	89 15 43.8	269 14 13.7	Pt. Conception L. H.	4068.0	3.609383
1869	120 25 31.283	798.6	230 00 21.2	50 01 15.3	Lime	3180.1	3.502447
			243 56 53.4	63 58 10.7	Undo	3877.2	3.588519
			259 43 58.2	79 45 16.9	Bank	3608.2	3.557294
Wildcat	34 27 58.482	1802.0	265 27 33.4	85 28 50.6	Lime	3494.5	3.543388
1869	120 26 12.315	314.3	283 44 14.4	103 45 56.3	Bank	4733.2	3.675156
			329 20 55.7	149 21 18.9	Coxo	2054.6	3.312723
			58 55 17.5	238 54 10.6	Pt. Conception L. H.	3526.4	3.547332
Point Conception East	34 27 05.825	179.5	84 38 48.5	264 38 01.6	Pt. Conception L. H.	2123.4	3.327029
Base	120 26 47.811	1220.5	209 10 33.4	29 10 53.5	Wildcat	1858.3	3.269124
1869			274 14 27.4	94 15 10.7	Coxo	1959.2	3.292014
Coyote	34 28 25.789	794.6	312 10 37.7	132 10 58.3	Wildcat	1253.1	3.097998
1869	120 26 48.702	1242.9	322 51 16.2	142 52 00.0	Coxo	3272.8	3.514926
			359 28 16.1	179 28 16.6	Pt. Conception E. B.	2464.1	3.391651
Point Conception West	34 27 28.760	886.2	216 31 36.4	36 32 05.3	Coyote	2186.9	3.339828
Base	120 27 39.707	1013.5	298 04 31.8	118 05 01.2	Pt. Conception E. B.	1501.4	3.176496
1869							
Mesa	34 28 26.162	806.1	270 18 40.8	90 19 26.8	Coyote	2073.0	3.316594
1874	120 28 09.931	253.4	336 26 05.4	156 26 22.5	Pt. Conception W. B.	1929.6	3.285475
La Costa	34 29 28.075	865.1	323 05 05.5	143 06 21.0	Coxo	5662.9	3.753040
1869	120 27 44.527	1136.1	323 24 44.6	143 25 16.2	Coyote	2390.1	3.378420
			358 05 00.6	178 05 03.3	Pt. Conception W. B.	3678.6	3.565678
			18 46 09.8	198 45 55.4	Mesa	2014.9	3.304249
Black Point	34 29 22.215	684.5	264 57 58.5	84 58 44.1	La Costa	2060.6	3.313991
1874	120 29 04.977	127.0	320 52 33.7	140 53 04.9	Mesa	2226.2	3.347571
Feldspar	34 29 54.041	1665.2	305 21 11.0	125 21 36.0	La Costa	1382.6	3.140710
1874	120 28 28.725	732.8	349 57 21.1	169 57 31.7	Mesa	2750.0	3.439329
			43 19 39.0	223 19 18.5	Black Point	1348.0	3.129698
Bluff	34 31 55.109	1698.1	311 19 44.4	131 21 18.6	Feldspar	5647.6	3.751863
1874	120 31 14.957	381.4	324 51 11.5	144 52 25.1	Black Point	5760.9	3.760493
Espada	34 33 08.036	247.6	337 17 29.4	157 18 25.0	Feldspar	6479.6	3.811550
1874	120 30 06.773	172.7	347 13 57.2	167 14 32.3	Black Point	7134.6	3.853369
			37 44 05.4	217 43 26.7	Bluff	2841.2	3.453502
Prospect	34 34 14.334	441.7	306 20 37.1	126 21 38.9	Espada	3446.5	3.537374
1874	120 31 55.656	1418.7	346 23 58.4	166 24 21.5	Bluff	4413.7	3.644805
			117 34 12.4	297 33 13.7	Arguello	2971.6	3.472992
Flint	34 32 35.749	1101.6	173 21 34.7	353 21 23.3	Arguello	4442.6	3.647635
1874	120 33 18.854	480.8	214 55 04.2	34 55 51.4	Prospect	3705.0	3.568790
			258 30 07.3	78 31 56.2	Espada	4997.6	3.698758
			291 36 40.9	111 37 51.1	Bluff	3398.5	3.531291
Point	34 27 39.624	1220.9	235 07 21.3	55 07 49.0	Goat	1523.8	3.182930
1863	120 04 21.944	560.0	271 13 39.6	91 15 14.7	Capitan	4288.8	3.632336
			278 13 24.1	98 16 13.6	Alcatraz	7723.6	3.887818

Santa Barbara to Point Arguello—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters.*	
Curlew	34 26 09.333	287.6	90 55 06.0	270 54 16.7	Nicolas	2228.0	3.347918
1863	119 55 53.197	1358.2	162 13 26.3	342 13 07.5	Don	2775.5	3.443339
			291 10 26.5	111 11 14.2	Bruce	2307.9	3.363223
Dwelling house, chimney	34 26 49.231	1517.0	158 35 25.6	338 34 56.5	Buck	3591.3	3.555248
1863	119 57 44.508	1136.4	234 39 34.6	54 40 18.8	Don	2444.1	3.388126
			332 46 40.1	152 46 53.7	Nicolas	1342.6	3.127956
Sage	34 28 09.430	290.6	99 23 07.5	279 22 11.8	Quemada	2544.0	3.405509
1872	120 06 07.424	189.5	162 23 50.2	342 23 43.1	Young	1053.1	3.022486
			250 03 03.1	70 03 36.8	Refugio	1617.9	3.208939
Oats	34 29 10.655	328.3	285 00 32.9	105 01 35.7	Rock	2929.4	3.466775
1872	120 11 49.171	1254.6	304 19 56.3	124 20 53.5	Stow	3122.8	3.494551
			305 42 44.7	125 43 09.3	Camp	1362.4	3.134303
			333 47 48.2	153 48 07.2	Onofre	1948.2	3.289629
			45 43 52.7	225 43 15.2	Ram	2356.3	3.372226
			72 06 02.0	252 05 27.6	Brush	1625.8	3.211057
Ward	34 27 05.806	178.9	118 12 03.6	298 11 34.4	Pt. Conception W. B	1496.9	3.175195
1874	120 26 48.023	1225.8	161 47 46.6	341 47 14.7	La Costa	4614.9	3.664160
			179 35 49.5	359 35 49.2	Coyote	2464.6	3.391748
			209 18 44.3	29 19 04.5	Wildcat	1861.5	3.269862
			274 12 43.0	94 13 26.4	Coxo	1964.3	3.293198
Point Conception Astronomic Station	34 27 09.558	294.5	160 32 33.9	340 32 00.3	La Costa	4526.8	3.655794
1850	120 26 45.427	1159.4	177 57 43.8	357 57 41.9	Coyote	2350.4	3.371144
			209 16 25.1	29 16 43.8	Wildcat	1728.2	3.237604
			277 49 07.9	97 49 49.8	Coxo	1910.4	3.281134
			29 48 51.8	209 48 50.4	Ward	133.26	2.124696
Point Conception	34 26 59.240	1825.4	188 04 26.1	8 04 40.5	La Costa	4632.0	3.665771
1869	120 28 10.025	255.9	217 53 15.6	37 54 01.6	Coyote	3379.4	3.528840
			220 23 20.1	40 23 37.3	Pt. Conception W. B.	1194.3	3.077103
			238 42 34.2	58 43 40.9	Wildcat	3548.1	3.549993
			264 28 17.2	84 29 03.7	Pt. Conception E. B.	2108.4	3.323962
			269 10 11.8	89 11 41.6	Coxo	4052.6	3.607738
Abalone	34 26 37.743	1163.0	117 40 17.6	297 39 49.6	Point Conception	1426.5	3.154272
1869	120 27 20.534	524.2	162 42 30.6	342 42 19.7	Pt. Conception W. B.	1646.4	3.216538
			214 59 05.1	34 59 43.7	Wildcat	3036.7	3.482398
			223 59 22.3	43 59 40.8	Pt. Conception E. B.	1202.7	3.080164
			255 30 43.3	75 31 45.1	Coxo	2880.5	3.459465
Lone tree	34 29 25.314	780.0	326 44 26.5	146 45 31.1	Coxo	5313.0	3.725342
1869	120 27 25.429	648.8	347 24 21.6	167 24 42.9	Pt. Conception E. B.	4404.0	3.643848
			5 47 40.1	185 47 32.0	Pt. Conception W. B.	3609.8	3.557486
			14 11 38.4	194 11 13.2	Point Conception	4642.7	3.666768
Barone	34 27 40.327	1242.6	47 04 56.1	227 04 25.9	Point Conception	1859.1	3.269291
1869	120 27 16.691	426.0	58 45 19.5	238 45 06.5	Pt. Conception W. B.	687.1	2.837033
			207 01 00.2	27 01 16.0	Coyote	1572.4	3.196576
			251 11 36.4	71 12 12.9	Wildcat	1735.7	3.239469
Espada Ranch House, chimney	34 30 48.156	1483.8	125 01 11.8	304 58 42.9	Gravel	8171.4	3.912297
1874	120 30 08.775	223.8	140 42 57.6	320 42 20.1	Bluff	2665.6	3.425796
			145 16 13.2	325 14 14.0	Arguello	9405.2	3.973368
			180 40 43.2	0 40 44.3	Espada	4310.5	3.634528
Horn Peak*	34 29 43.04	1326.2	338 43 06	158 43 33	Wildcat	3457.4	3.538768
1869	120 27 01.49	38.1	352 11 46	172 11 53	Coyote	2402.6	3.380692
Tallest tree on sierra	34 29 35.304	1087.8	16 47 36.5	196 47 04.8	Coxo	4962.6	3.695705
1869	120 24 35.115	895.9	48 46 22.7	228 44 21.0	Point Conception	7294.2	3.862980
			50 23 53.6	230 22 09.1	Pt. Conception W. B.	6115.1	3.786402
Oak	34 24 27.014	832.4	170 36 20.8	350 35 59.9	Fogg	5786.4	3.762407
1863	119 52 38.768	990.1	248 59 48.6	69 04 38.3	Thompson	14013.4	4.146545
			271 03 55.8	91 09 26.8	Santa Barbara	14961.3	4.174969
			274 30 10.0	94 31 18.7	Pelican	3115.0	3.493453
Gaviota Latitude Station	34 30 08.36	257.6					
1875	120 11 53.02	1352.6					
Arguello Latitude Sta.	34 34 58.64	1806.8					
1876	120 33 40.02	1020.0					
Range	34 27 50.193	1546.6	171 16 05.6	351 16 01.9	Coyote	1109.7	3.045203
1890	120 26 42.101	1074.6	251 25 38.0	71 25 54.9	Wildcat	802.0	2.904149
			3 52 45.1	183 52 43.3	Pt. Concep. Ast. Sta.	1255.0	3.098634

* No check on this position.

San Clemente Island.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Malva	32 59 31.022	955.6	233 34 16.9	53 34 37.7	Harbor	1232.6	3.090808
1860–2	118 34 19.019	493.7					
San Clemente Island North Base	32 59 57.462	1770.0	279 19 28.0	99 19 38.6	Harbor	509.8	2.707434
1860–2	118 34 00.198	5.1	30 57 42.4	210 57 32.1	Malva	949.8	2.977640
San Clemente Island South Base	32 59 34.845	1073.3	82 31 43.3	262 31 24.5	Malva	905.4	2.956847
1860–2	118 33 44.441	1153.8	149 34 59.0	329 34 50.4	S.Clemente Id.N.B.	807.9	2.907372
			188 42 27.8	8 42 29.8	Harbor	621.3	2.793273
Ridge	32 59 14.805	456.0	106 10 29.5	286 09 53.4	Malva	1794.0	3.253824
1860–2	118 33 12.653	328.5	149 18 07.8	329 17 52.5	Harbor	1432.2	3.156001
Clay	32 58 53.684	1653.6	136 18 20.1	316 17 57.6	Malva	1590.9	3.201655
1860–2	118 33 36.686	952.7	223 48 03.1	43 48 16.2	Ridge	901.5	2.954968
Wall	32 58 35.887	1105.4	123 28 27.7	303 28 10.4	Clay	994.1	2.997413
1860–2	118 33 04.753	123.4	170 17 24.6	350 17 20.3	Ridge	1216.3	3.085048
Ram	32 58 14.836	457.0	176 19 15.8	356 19 14.2	Clay	1199.2	3.078893
1860–2	118 33 33.722	875.7	229 14 11.1	49 14 26.9	Wall	993.2	2.997044
Vulpus	32 57 28.581	880.4	123 38 50.3	303 38 05.4	Ram	2572.2	3.410302
1860–2	118 32 11.267	292.6	146 11 10.4	326 10 41.2	Wall	2495.7	3.397189
Gull*	32 57 51.06	1572.9	25 48 59	205 48 52	Vulpus	769.4	2.886166
1860–2	118 31 58.37	1515.8	128 41 53	308 41 17	Wall	2208.8	3.344150
Black Point	32 56 45.989	1416.6	142 12 53.1	322 12 08.6	Ram	3463.5	3.539512
1860–2	118 32 12.004	311.8	157 58 25.7	337 57 56.2	Wall	3652.1	3.562547
			180 50 13.7	0 50 13.7	Vulpus	1312.2	3.117993
Malva 2	32 57 09.743	300.1	26 42 56.5	206 42 48.8	Black Point	819.2	2.913385
1860–2	118 31 57.826	1501.9	128 50 48.3	308 49 56.1	Ram	3197.5	3.504804
			148 58 19.6	328 58 12.3	Vulpus	677.2	2.830711
Snipe	32 56 45.894	1413.7	90 06 41.1	270 06 08.2	Black Point	1568.6	3.195507
1860–2	118 31 11.617	301.7	121 28 27.1	301 28 01.9	Malva 2	1407.3	3.148372
Rock	32 55 45.642	1405.9	127 55 11.1	307 54 21.1	Black Point	3025.4	3.480789
1860–2	118 30 40.121	1042.4	142 04 58.4	322 04 16.1	Malva 2	3284.3	3.516441
			156 12 50.0	336 12 32.9	Snipe	2028.4	3.307160
Martin	32 56 07.196	221.6	33 08 04.3	213 07 55.2	Rock	792.9	2.899232
1860–2	118 30 23.439	608.9	133 36 37.8	313 36 11.6	Snipe	1728.4	3.237648
Bluff	32 55 36.926	1137.4	140 37 23.1	320 36 46.5	Black Point	2752.5	3.439731
1860–2	118 31 04.777	124.1	154 16 17.2	334 15 48.3	Malva 2	3174.0	3.501611
			175 13 10.8	355 13 07.1	Snipe	2132.0	3.328789
			247 15 26.8	67 15 40.2	Rock	694.6	2.841712
Ledge	32 54 58.813	1811.6	151 55 51.6	331 55 35.5	Rock	1634.9	3.213489
1860–2	118 30 10.511	273.1	170 56 31.4	350 56 24.4	Martin	2133.2	3.329026
Peak	32 54 52.405	1614.2	97 45 07.9	277 44 37.5	Ledge	1464.2	3.165613
1860–2	118 29 14.676	381.3	126 27 33.9	306 26 47.4	Rock	2760.1	3.440931
			142 12 49.5	322 12 12.1	Martin	2920.6	3.465471
Green	32 53 53.394	1644.7	144 53 26.3	324 52 56.6	Ledge	2463.6	3.391573
1860–2	118 29 15.981	415.3	181 04 10.6	1 04 11.3	Peak	1818.2	3.259638
Boulder	32 53 45.541	1402.8	97 20 58.7	277 20 19.4	Green	1892.0	3.276916
1860–2	118 28 03.781	98.3	138 11 38.1	318 10 59.6	Peak	2763.4	3.441451
			142 26 28.8	322 23 25.5	Harbor	14353.6	4.156960
			186 33 29.5	6 35 42.0	Catalina Peak	54815.2	4.738901
Sedge	32 52 24.028	740.1	148 35 47.8	328 35 12.6	Green	3225.5	3.508603
1860–2	118 28 11.313	294.1	184 27 25.8	4 27 29.9	Boulder	2518.7	3.401175
Thirst	32 53 01.515	46.7	57 40 03.4	237 39 25.3	Sedge	2158.9	3.334224
1860–2	118 27 01.145	29.8	129 48 04.7	309 47 30.7	Boulder	2119.0	3.326127
Vine	32 52 00.039	1.2	127 13 21.6	307 13 01.3	Sedge	1221.7	3.086969
1860–2	118 27 33.892	881.2	166 33 25.5	346 33 09.3	Boulder	3341.6	3.523960
			204 12 08.9	24 12 26.7	Thirst	2076.3	3.317253

* No check on this position.

San Clemente Island—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Alta	32 52 35.337	1088.5	53 34 58.6	233 34 27.8	Vine	1831.4	3.262790
1860–2	118 26 37.205	967.2	81 54 10.0	261 53 18.9	Sedge	2471.1	3.392898
			142 20 39.9	322 20 26.8	Thirst	1018.6	3.008012
Dome Hill	32 50 50.971	1570.1	152 57 09.7	332 56 47.0	Vine	2389.0	3.378216
1860–2	118 26 52.108	1355.0	176 39 24.2	356 39 19.2	Thirst	4028.3	3.605121
			186 52 14.9	6 52 23.0	Alta	3238.5	3.510314
Fork	32 51 59.764	1840.9	90 16 27.7	270 15 50.1	Vine	1802.2	3.255810
1860–2	118 26 24.573	638.9	163 19 03.9	343 18 57.1	Alta	1144.0	3.058415
Gray	32 51 58.674	1807.4	92 05 11.3	272 04 52.0	Fork	923.5	2.965427
1860–2	118 25 49.076	1275.9	132 04 26.3	312 04 00.2	Alta	1685.6	3.226744
Gulch	32 51 26.573	818.5	156 32 43.6	336 32 34.3	Fork	1114.5	3.047099
1860–2	118 26 07.510	195.3	159 58 37.5	339 58 21.3	Alta	2254.6	3.353065
			205 51 24.5	25 51 34.5	Gray	1098.9	3.040957
Rest	32 51 06.349	195.6	105 44 57.9	285 44 11.8	Gulch	2296.2	3.361016
1860–2	118 24 42.514	1105.5	132 36 03.5	312 35 01.4	Alta	4050.4	3.607500
			132 58 10.0	312 57 33.9	Gray	2365.1	3.373842
Kelp	32 50 27.330	841.9	121 43 24.5	301 42 59.9	Dome Hill	1385.1	3.141488
1860–2	118 26 06.801	176.9	179 25 15.4	359 25 15.0	Gulch	1825.1	3.261268
			189 18 01.2	9 18 10.8	Gray	2851.4	3.455054
			241 15 13.4	61 15 59.1	Rest	2499.8	3.397905
Slope	32 49 50.809	1565.1	112 03 24.7	292 02 26.8	Kelp	2996.9	3.476678
1860–2	118 24 19.996	520.1	136 32 39.7	316 31 41.4	Gulch	4004.5	3.609007
			165 52 33.8	345 52 21.6	Rest	2399.6	3.380137
Seal	32 48 14.828	456.8	166 57 59.2	346 57 39.5	Kelp	4189.7	3.622184
1860–2	118 25 30.469	792.6	193 16 43.0	13 17 09.0	Rest	5429.0	3.734716
			211 47 40.2	31 48 18.4	Slope	3478.9	3.541440
Guds	32 49 45.162	1391.1	92 39 29.5	272 38 11.1	Slope	3766.1	3.575888
1860–2	118 21 55.354	1439.7	101 15 12.9	281 12 56.5	Kelp	6667.4	3.823954
			119 55 28.6	299 53 58.0	Rest	5015.3	3.700298
			124 00 14.5	304 04 07.8	Gray	7338.6	3.865612
Knob	32 50 32.621	1004.8	54 24 28.5	234 23 51.0	Slope	2212.8	3.344938
1860–2	118 23 10.813	281.1	87 58 25.8	267 56 50.3	Kelp	4579.7	3.660834
			113 32 59.8	293 32 10.1	Rest	2601.2	3.415168
			122 48 00.6	302 46 34.8	Gray	4895.2	3.689766
Cactus	33 00 25.745	793.2	316 03 27.4	136 03 46.7	Harbor	1324.8	3.122134
1860–2	118 34 16.229	421.3	2 27 36.7	182 27 35.2	Malva	1687.3	3.227202
Mound	33 01 07.768	239.3	344 38 37.1	164 38 50.1	Harbor	2331.7	3.367673
1878	118 34 04.604	119.5	13 07 19.1	193 07 12.8	Cactus	1329.3	3.123611
Mesa	33 01 13.699	422.0	275 12 27.4	95 13 09.4	Mound	2010.6	3.303331
1878,	118 35 21.752	564.6	310 58 24.4	130 59 00.1	Cactus	2252.7	3.352702
San Clemente Longitude	33 01 42.77	1317.6	299 13 08	119 13 48	Mound	2208.2	3.34404
Station*	118 35 18.86	489.4	4 47 31	184 47 29	Mesa	898.6	2.95355
1852							
North Head*	33 01 49.72	1531.7	318 02 21	138 03 28	Harbor.	4760.9	3.67769
1860–2	118 35 43.44	1127.2	332 50 33	152 51 19	Malva	4801.7	3.68140

* No check on this position.

Santa Catalina Island.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Cliff	33 26 02.133	65.7	313 06 40.4	133 08 38.8	Catalina Peak	7614.5	3.881640
1875	118 27 36.630	946.3	106 06 16.5	286 02 42.3	West Peak	10445.6	4.018934
Goat	33 24 56.620	1744.4	223 09 31.4	43 10 11.7	Cliff	2767.1	3.442026
1875	118 28 49.902	1289.3	293 08 08.5	113 10 47.2	Catalina Peak	8104.3	3.908718
Red Peak	33 28 32.737	1008.6	302 56 07.1	122 58 39.8	Cliff	8529.1	3.930903
1875	118 32 13.742	354.8	321 38 56.3	141 40 50.7	Goat	8488.2	3.928817
			58 45 11.1	238 44 09.6	West Peak	3368.1	3.527381
Granite	33 26 46.389	1429.2	122 37 55.8	302 37 04.8	West Peak	2835.7	3.452665
1875	118 32 32.770	846.4	188 31 40.3	8 31 50.8	Red Peak	3313.0	3.520226
			280 05 01.9	100 07 45.1	Cliff	7769.9	3.890416
			300 24 44.2	120 26 47 1	Goat	6677.0	3.824584
Ridge	33 26 35.927	1106.8	158 28 05.0	338 27 49.4	West Peak	1990.1	3.298869
1875	118 33 36.962	954.7	258 59 39.2	79 00 14.6	Granite	1689.0	3.227640
Stony Point	33 28 22.996	708.5	259 56 02.0	79 56 38.1	Red Peak	1717.8	3.234983
1875	118 33 19.250	497.0	338 01 56.7	158 02 22.3	Granite	3209.2	3.506400
			39 22 27.8	219 22 02.4	West Peak	1872.4	3.272387
Prospect	33 26 36.057	1110.9	95 43 54.3	275 42 46.5	Granite	3192.4	3.504118
1875	118 30 29.786	769.3	143 15 18.4	323 14 21.1	Red Peak	4486.5	3.651908
			283 08 20.7	103 09 56.1	Cliff	4593.2	3.662118
			319 53 05.4	139 54 00.5	Goat	4005.4	3.602644
Well	33 26 04.220	130.0	122 38 14.4	302 37 31.1	Granite	2409.2	3.381876
1875	118 31 14.219	367.3	229 28 48.0	49 29 12.5	Prospect	1509.7	3.178898
			270 38 20.5	90 40 20.4	Cliff	5621.1	3.749822
			299 10 34.6	119 11 54.2	Goat	4270.6	3.630492
Bird Rock	33 27 48.077	1481.2	318 35 17.7	138 36 19.1	Cliff	4351.5	3.638638
1875	118 29 28.056	724.4	35 42 09.6	215 41 35.6	Prospect	2732.2	3.436506
			68 17 30.9	248 15 49.1	Granite	5135.0	3.710540
			107 50 26.6	287 48 55.3	Red Peak	4494.0	3.652634
Santa Catalina Island	33 26 29.868	920.2	69 59 15.9	249 58 29.6	Well	2308.2	3.363273
Latitude Station	118 29 50.259	1298.2	100 34 52.3	280 34 30.5	Prospect	1038.6	3.016451
1852			193 23 06.3	13 23 18.5	Bird Rock	2476.8	3.393883
White Rock	33 27 05.158	158.9	42 28 41.2	222 28 20.0	S. C. Island Lat. Sta.	1474.0	3.168510
1875	118,29 11.721	302.7	66 01 59.9	246 01 16.9	Prospect	2206.6	3.343725
			162 18 22.3	342 18 13.3	Bird Rock	1387.9	3.142364
Santa Catalina Island	33 26 21.612	665.8	75 35 17.2	155 34 32.7	Well	2151.8	3.332811
North Base	118 29 53.538	1382.9	115 25 29.7	295 25 09.7	Prospect	1036.7	3.015636
1875			193 52 31.7	13 52 45.7	Bird Rock	2743.9	3.438370
			198 24 55.4	18 24 57.2	S. C. Island Lat. Sta.	268.1	2.428274
			218 50 01.8	38 50 24.8	White Rock	1722.3	3.236113
Santa Catalina Island	33 25 59.398	1830.0	94 49 43.1	274 49 05.5	Well	1767.0	3.247227
South Base	118 30 06.059	156.5	151 30 52.7	331 30 39.6	Prospect	1285.0	3.108895
1875			205 17 39.6	25 17 46.5	North Base	756.954	2.879069
Cactus Peak	33 20 14.111	434.7	159 15 32.2	339 14 21.9	Goat	9307.2	3.968820
1876	118 26 42.331	1094.7	172 32 48.4	352 32 18.5	Cliff	10813.2	4.033956
			216 59 09.0	37 00 37.4	Catalina Peak	6907.0	3.839290
Slide	33 27 29.270	901.8	258 22 09.7	78 22 31.2	West Peak	1030.9	3.013208
1875	118 34 44.345	1145.2	291 14 03.8	111 15 16.3	Granite	3645.9	3.561804
			313 21 15.9	133 21 53.0	Ridge	2393.6	3.379052
West Point	33 28 24.671	760.1	270 45 02.3	90 46 25.2	Stony Point	3879.8	3.588808
1875	118 35 49.498	1278.0	299 06 10.4	119 07 07.9	West Peak	3081.3	3.488729
			315 24 26.4	135 25 02.4	Slide	2396.6	3.379598
Black Point*	33 28 30.44	937.8	275 57 25	95 58 12	Stony Point	2207.8	3.343968
1875	118 34 44.30	1143.8	83 58 38	263 58 02	West Point	1692.9	3.228625
Fish	33 26 32.113	989.4	155 54 52.5	335 54 35.7	Slide	1928.9	3.285300
1875	118 34 13.864	358.1	186 27 00.6	6 27 05.3	West Peak	1981.2	3.296930
			262 58 10.2	82 58 30.5	Ridge	960.4	2.982436
Bluff	33 26 22:457	691.9	108 20 23.4	288 19 56.7	Ridge	1319.2	3.120296
1875	118 32 48.484	1252.3	208 49 52.9	28 50 01.6	Granite	841.6	2.925126
			282 59 07.8	102 59 59.8	Well	2498.9	3.397749

* No check on this position.

Santa Catalina Island—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Spur*	33 25 52.69	1623.3	117 54 15	297 53 22	Ridge	2846.9	3.454372
1875	118 31 59.56	1538.6	152 35 31	332 35 13	Granite	1863.5	3.270338
Cone	33 25 23.212	715.1	149 21 33.5	329 21 17.5	Well	1468.4	3.166856
1875	118 30 45.247	1169.0	190 05 23.9	10 05 32.4	Prospect	2279.5	3.357834
			216 35 15.7	36 35 44.2	S. C. Island N. B.	2240.8	3.350412
			222 14 23.5	42 14 45.1	S. C. Island S. B.	1505.9	3.177794
			285 21 45.9	105 22 49.5	Goat	3090.7	3.490056
Oak	33 26 32.688	1007.1	170 11 28.8	350 11 15.1	Red Peak	3753.3	3.574419
1875	118 31 48.976	1265.0	237 26 40.2	57 27 57.8	Bird Rock	4317.4	3.635221
			267 05 22.4	87 06 06.0	Prospect	2048.0	3.311340
			314 19 39.3	134 19 58.4	Well	1255.1	3.098674
Pablo	33 27 55.405	1706.9	41 44 09.7	221 43 29.2	Granite	2849.1	3.454710
1875	118 31 19.337	499.3	129 18 43.2	309 18 13.2	Red Peak	1815.6	3.259012
			274 29 01.2	94 30 02.5	Bird Rock	2882.4	3.459756
			295 09 02.0	115 10 12.3	White Rock	3641.1	3.561230
Cherry	33 27 11.683	359.9	126 41 31.1	306 40 19.5	Red Peak	4180.2	3.621196
1875	118 30 03.920	101.2	219 33 16.1	39 33 36.0	Bird Rock	1454.3	3.162650
			278 28 35.8	98 29 04.5	White Rock	1363.0	3.134501
			31 19 49.4	211 19 35.1	Prospect	1284.9	3.108867
Quartz	33 20 22.344	688.4	169 05 16.4	349 04 41.7	Goat	8605.6	3.934780
1876	118 27 46.852	1211.6	181 26 41.5	1 26 47.1	Cliff	10471.5	4.020008
			278 38 17.7	98 38 53.3	Cactus Peak	1687.7	3.227293
Brush	33 24 25.861	796.7	350 51 03.6	170 51 11.2	Catalina Peak	2268.4	3.355710
1876	118 24 15.510	400.8	97 38 02.6	277 35 31.5	Goat	7152.9	3.854485
			119 43 59.8	299 42 09.0	Cliff	5983.0	3.776919
Silver	33 19 32.162	990.9	100 59 19.5	280 56 57.8	Cactus Peak	6791.8	3.831986
1877	118 22 24.515	634.0	159 46 43.0	339 45 49.7	Catalina Peak	7256.2	3.860711
Timms	33 21 31.666	975.6	9 31 06.8	189 30 53.6	Silver	3733.0	3.572058
1876	118 22 00.648	16.8	71 51 36.6	251 49 01.7	Cactus Peak	7665.5	3.884539
			135 01 24.4	315 00 17.9	Catalina Peak	4421.2	3.645540
Dakin	33 21 00.636	19.6	36 22 58.3	216 22 15.6	Silver	3385.4	3.529606
1876	118 21 06.874	177.7	124 30 54.0	304 30 24.5	Timms	1687.3	3.227189
			132 07 55.3	312 06 19.3	Catalina Peak	6087.9	3.784470
East Peak	33 18 41.964	1292.8	112 29 20.2	292 28 00.8	Silver	4044.9	3.606907
1876	118 20 00.017	0.4	149 11 04.0	329 09 57.7	Timms	6088.1	3.784485
			157 58 13.9	337 57 37.2	Dakin	4608.8	3.663586
East Mountain	33 19 05.604	172.6	63 27 27.3	243 26 56.4	East Peak	1629.5	3.212068
1876	118 19 03.662	94.7	98 57 55.5	278 56 05.2	Silver	5259.1	3.720912
			134 31 37.4	314 30 00.2	Timms	6418.4	3.807428
			138 02 58.0	318 01 50.3	Dakin	4765.7	3.678129
Lone Tree	33 19 37.167	1145.1	82 11 49.7	262 11 25.8	Silver	1135.2	3.055086
1876	118 21 41.029	1061.2	171 49 02.6	351 48 51.9	Timms	3563.7	3.551905
			198 57 15.5	18 57 34.3	Dakin	2718.9	3.434401
			283 25 26.1	103 26 52.5	East Mountain	4184.8	3.621674
			303 03 09.9	123 04 05.4	East Peak	3117.5	3.493804
High Mountain	33 22 31.162	960.0	233 23 20.5	53 23 57.6	Catalina Peak	2170.2	3.336503
1876	118 25 08.957	231.5	290 37 03.9	110 38 47.5	Timms	5201.8	3.716150
			29 46 02.4	209 45 11.1	Cactus Peak	4863.7	3.686966
Freeman	33 20 36.416	1121.9	82 22 01.8	262 20 13.0	Cactus Peak	5163.3	3.712924
1876	118 23 24.443	631.6	168 45 56.5	348 45 36.1	Catalina Peak	4923.6	3.692279
			231 50 25.2	51 51 11.3	Timms	2755.3	3.440168
			321 56 12.4	141 56 45.3	Silver	2514.0	3.400370
Round Top	33 20 01.744	53.7	97 11 40.9	277 10 36.7	Cactus Peak	3045.9	3.483719
1876	118 24 45.476	1176.1	190 53 43.3	10 54 07.5	Catalina Peak	6005.7	3.778560
			284 01 27.5	104 02 45.0	Silver	3757.8	3.574938
Ord	33 20 16.135	497.1	1 17 52.4	181 17 51.3	East Mountain	2173.4	3.337149
1876	118 19 01.760	45.5	73 45 47.2	253 44 19.7	Lone Tree	4290.4	3.632500
			112 58 28.5	292 57 19.8	Dakin	3513.8	3.545773
Whitleys Peak	33 22 43.201	1331.0	335 22 40.5	155 23 11.2	Dakin	3475.7	3.541044
1876	118 22 02.878	74.4	358 30 04.6	178 30 05.8	Timms	2204.6	3.343326
			106 45 32.8	286 44 27.5	Catalina Peak	3203.4	3.505612

* No check on this position.

Santa Catalina Island—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back Azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Corral 1876	33 21 47.476 118 20 49.833	1462.6 1288.4	75 06 28.4 118 03 30.7 132 16 55.4	255 05 49.5 298 01 45.1 312 16 15.2	Timms Catalina Peak Whitleys Peak	1894.5 5615.2 2552.0	3.277493 3.749366 3.406885
North Spur 1876	33 21 28.428 118 20 00.261	875.8 6.8	341 35 47.1 359 55 46.9 63 34 17.0 117 22 18.3 126 00 57.7	161 36 18.0 179 55 46.9 243 33 40.4 297 20 05.6 305 59 50.3	East Mountain East Peak Dakin Catalina Peak Whitleys Peak	4637.1 5128.4 1923.4 7022.7 3918.4	3.666250 3.709980 3.284070 3.846506 3.593114
Fletcher 1876	33 24 09.224 118 23 20.807	284.2 537.6	322 45 37.0 336 52 43.2 31 22 41.0	142 46 19.9 156 53 27.3 211 22 18.6	Whitleys Peak Timms Catalina Peak	3328.6 5277.7 2022.7	3.522268 3.722445 3.305939
Knob 1876	33 18 41.634 118 20 46.056	1282.7 1191.4	121 26 31.0 140 16 23.6 269 30 25.0	301 25 36.9 320 15 53.4 89 30 50.3	Silver Lone Tree East Peak	2984.8 2224.6 1191.0	3.474918 3.347252 3.075900
Pot* 1876	33 25 09.65 118 26 48.43	297.3 1251.3	82 43 13 142 24 02	262 42 06 322 23 36	Goat Cliff	3164.2 2040.9	3.50026 3.30982
Green* 1876	33 25 02.46 118 25 14.66	75.8 378.6	88 09 51 116 38 05	268 07 52 296 36 47	Goat Cliff	5564.0 4102.6	3.74539 3.61306
Grape* 1876	33 22 17.29 118 28 49.24	532.7 1272.9	179 48 07 256 56 35	359 48 06 76 59 13	Goat Catalina Peak	4908.7 7632.9	3.69097 3.88269
Carlos* 1876	33 21 21.46 118 28 34.83	661.2 900.5	176 38 17 305 29 27	356 38 09 125 30 29	Goat Cactus Peak	6640.0 3573.2	3.82217 3.55306
White Bluff* 1876	33 23 31.16 118 28 43.30	960.0 1119.1	176 17 36 274 19 55	356 17 32 94 22 30	Goat Catalina Peak	2638.3 7302.8	3.42133 3.86349
Edge* 1876	33 19 02.92 118 21 22.99	90.0 594.6	156 08 44 286 44 02	336 08 34 106 44 48	Lone Tree East Peak	1153.7 2241.2	3.06208 3.35049
Long Point* 1876	33 24 05.33 118 22 09.39	164.2 242.7	356 11 45 61 00 22	176 11 49 240 59 21	Whitleys Peak Catalina Peak	2535.8 3314.5	3.40412 3.52042
White* 1876	33 23 26.96 118 22 05.25	830.6 135.7	357 24 01 81 57 49	177 24 02 261 56 45	Whitleys Peak Catalina Peak	1349.5 3036.0	3.13017 3.48230
Southeast Point* 1876	33 18 12.27 118 19 30.46	378.0 788.1	140 06 50 202 52 38	320 06 34 22 52 53	East Peak East Mountain	1192.1 1783.3	3.07632 3.25123
Northeast Point* 1876	33 18 41.52 118 18 37.57	1279.2 971.9	90 22 32 137 43 07	270 21 47 317 42 53	East Peak East Mountain	2132.7 1003.0	3.32893 3.00130
Southeast Rock,* highest part	33 17 50.22 118 19 36.79	1547.2 951.9	125 54 46 159 21 08	305 53 14 339 20 55	Silver East Peak	5356.0 1703.6	3.72884 3.23137
Sugar Loaf Spur* 1876	33 20 54.08 118 19 43.89	1666.1 1134.9	342 42 25 95 22 53	162 42 47 275 22 07	East Mountain Dakin	3500.1 2155.3	3.54408 3.33350
Black Ridge* 1876	33 19 19.20 118 26 18.12	591.6 468.6	159 41 22 266 12 05	339 41 08 86 14 13	Cactus Peak Silver	1803.8 6055.3	3.25619 3.78213

* No check on this position.

San Nicolas Island.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
San Nicolas	33 15 11.974	368.9	164 26 11.0	344 16 32.5	Devils Peak	89389.6	4.9512870
1879	119 31 26.015	673.4	188 45 22.6	8 50 01.1	Anacapa	84756.6	4.9281736
			241 29 12.2	61 45 08.5	Santa Barbara Id.	51099.2	4.7084142
Azimuth	33 16 27.011	832.2	341 29 27.5	161 29 43.9	San Nicolas	2437.7	3.38698
1879	119 31 55.910	1447.0					
Slope 2	33 15 18.700	576.1	80 30 26.8	260 30 00.6	San Nicolas	1255.7	3.09889
1879	119 30 38.170	988.0	136 17 28.5	316 16 45.9	Azimuth	2911.6	3.46413
Summit 2	33 14 59.000	1817.7	156 45 28.7	336 45 25.1	San Nicolas	435.0	2.63832
1879	119 31 19.383	501.8	160 46 46.0	340 46 26.0	Azimuth	2871.5	3.45811
			240 21 46.9	60 22 09.5	Slope 2	1227.4	3.08898
Begg Rock	33 21 45.791	1410.8	302 54 07.7	122 59 29.5	Azimuth	18057.6	4.25666
1879	119 41 41.748	1079.3	307 14 55.5	127 20 33.6	San Nicolas	20022.6	4.30152
			307 50 55.2	127 56 37.1	Summit 2	20402.8	4.30969
Ridge	33 14 29.277	902.0	116 02 13.1	296 02 33.2	Summit 2	2085.2	3.31915
1858	119 30 07.018	181.7	152 05 40.1	332 05 23.0	Slope 2	1722.9	3.23627
Port	33 15 26.706	822.8	45 34 14.6	225 33 36.4	Ridge	2527.1	3.40262
1858	119 28 57.312	1483.5	84 36 40.6	264 35 45.3	Slope 2	2622.3	3.41868
Bluff	33 14 48.770	1502.5	79 49 43.1	259 48 32.3	Ridge	3397.3	3.53114
1858	119 27 57.854	1497.7	127 12 55.4	307 12 22.8	Port	1932.5	3.28613
Cliff	33 13 54.365	1674.9	110 30 56.7	290 29 55.8	Ridge	3070.2	3.48716
1858	119 28 15.951	413.0	195 37 00.0	15 37 09.9	Bluff	1740.3	3.24063
San Nicolas Id. N. Base	33 14 25.065	772.2	51 37 51.4	231 37 26.1	Cliff	1523.5	3.18285
1858	119 27 29.818	772.0	135 10 47.3	315 10 31.9	Bluff	1029.6	3.01268
San Nicolas Id. S. Base	33 14 08.717	268.6	76 02 40.5	256 02 02.8	Cliff	1832.8	3.26311
1858	119 27 07.256	187.9	130 46 02.4	310 45 50.0	San Nicolas Id.N.B.	771.3	2.88720
Kelp	33 13 46.308	1426.7	96 59 00.5	276 58 17.6	Cliff	2043.1	3.31029
1858	119 26 57.628	1492.1	145 05 01.3	325 04 53.7	San Nicolas Id.N.B.	1456.1	3.16319
			160 08 52.6	340 08 47.4	San Nicolas Id. S.B.	734.0	2.86569
Spur	33 14 05.960	183.6	23 08 41.4	203 08 35.9	Kelp	658.4	2.81849
1879	119 26 47.634	1233.4	99 29 43.3	279 29 32.6	San Nicolas Id.S.B.	515.1	2.71188
Bonn	33 13 51.266	1579.4	75 02 27.6	255 02 15.5	Kelp	591.8	2.77214
1879	119 26 35.549	920.4	123 13 19.2	303 13 01.8	San Nicolas Id.S.B.	981.3	2.99180
			145 20 47.8	325 20 41.2	Spur	550.3	2.74057
San Nicolas Id. Astronomic Station 2*	33 14 00.42	12.9	68 38 02	248 37 46	Bonn	774	2.88869
1879	119 26 07.71	199.7	99 22 44	279 22 22	Spur	1048	3.02018
Spring*	33 17 03.80	117.2	305 31 32	125 33 01	Port	5146	3.71150
1879	119 31 39.12	1012.4	20 58 11	200 58 02	Azimuth	1214	3.08416
Slope	33 15 19.04	586.7	264 50 27	84 51 22	Port	2629	3.41980
1858	119 30 38.47	995.8	332 01 32	152 01 50	Ridge	1736	3.23953
Summit	33 14 58.98	1817.0	239 37 32	59 37 55	Slope	1223	3.08727
1858	119 31 19.22	497.6	296 04 41	116 05 21	Ridge	2081.	3.31828
North Head*	33 16 13.86	426.9	311 16 24	131 17 04	Slope	2560	3.40819
1858	119 31 52.79	1366.4	339 21 20	159 21 38	Summit	2465	3.39183

* No check on this position.

Santa Barbara Island.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Mer Slope 1871	33 28 25.942 119 02 18.303	799.2 472.6	52 47 20.7	232 47 15.9	Santa Barbara Id.	283.5	2.45248
Southwest Ridge 1871	33 28 06.824 119 02 19.666	210.2 507.8	155 28 15 183 25 07	335 28 11 3 25 08	Santa Barbara Id. Mer Slope	459.0 590.0	2.66183 2.77088
Santa Barbara Id. South Base 1871	33 28 15.505 119 02 04.656	477.7 120.2	55 23 37 132 22 55	235 23 29 312 22 48	South West Ridge Mer Slope	470.9 477.0	2.67292 2.67855
Santa Barbara Id. North Base 1871	33 28 34.963 119 02 03.691	1077.2 95.3	2 22 46 53 37 20	182 22 45 233 37 12	S. Barbara Id. S. B. Mer Slope	600.0 468.6	2.77815 2.67079
East Mound 1871	33 28 54.707 119 02 10.043	1685.4 259.3	344 54 42 13 31 52	164 54 45 193 31 47	S. Barbara Id. N. B. Mer Slope	630.0 911.5	2.79934 2.95976
Corral 1871	33 28 19.762 119 01 55.930	608.8 1444.2	59 48 02 108 14 34 156 50 00 161 18 07	239 47 57 288 14 22 336 49 55 341 17 59	S. Barbara Id. S. B. Mer Slope S. Barbara Id. N. B. East Mound	260.7 608.3 509.4 1136.6	2.41618 2.78409 2.70706 3.05561
Middle Ridge 1871	33 28 40.374 119 02 11.914	1243.8 307.6	20 21 20 186 14 34	200 21 16 6 14 35	Mer Slope East Mound	474.2 444.2	2.67599 2.64760
Cave Point * 1871	33 28 37.14 119 01 40.63	1144.3 1049.0	70 28 12 125 28 31	250 27 51 305 28 15	Mer Slope East Mound	1032.1 932.5	3.01372 2.96964
Fisherman 1871	33 28 55.608 119 02 39.215	1713.2 1012.4	272 06 30 303 39 22 329 25 33 343 51 09	92 06 46 123 39 37 149 25 44 163 51 18	East Mound Middle Ridge Mer Slope Santa Barbara Id.	753.7 846.8 1061.5 1130.0	2.87718 2.92779 3.02594 3.05307

Santa Cruz Island.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Summit Peak (Anacapa Island) 1876	34 00 40.316 119 25 39.510	1242.3 1013.8	111 06 10.0 233 22 09.8 252 00 32.7 274 13 47.2	291 01 35.0 53 29 29.7 72 12 45.1 94 15 14.6	Santa Cruz East Pt. Hueneme L. H. Laguna Anacapa	13507.6 25066.2 35241.5 4021.8	4.1305770 4.3990877 4.5470544 3.6044190
Dixon 1873	33 59 11.745 119 52 08.053	361.9 206.7	85 16 39.29 104 01 30.44 155 02 10.3	265 12 40.94 283 55 16.82 335 00 32.5	Sand Point Corral Santa Cruz West	10983.7 17665.6 10614.2	4.0407471 4.2471289 4.0258888
John 1857	34 02 42.079 119 51 20.976	1296.6 538.1	10 33 42.6 118 55 33.6	190 33 16.3 298 53 29.4	Dixon Santa Cruz West	6592.2 6497.4	3.819031 3.812738
Ragged Mountain 1857	33 59 21.911 119 49 12.507	675.1 321.0	86 02 12.4 136 02 19.7 151 53 13.5	266 00 34.3 315 59 03.7 331 52 01.6	Dixon Santa Cruz West John	4516.5 12937.5 6993.0	3.654807 4.111852 3.844661
Devils Peak 1857	34 01 45.792 119 47 01.859	1410.9 47.7	37 06 28.2 104 38 36.7	217 05 15.1 284 36 11.7	Ragged Mountain John	5558.0 6869.3	3.744918 3.836915
Flagstaff 1874	34 01 23.926 119 52 09.337	737.2 239.5	141 17 50.4 207 15 12.6 265 05 40.1	321 16 13.4 27 15 39.7 85 08 32.2	Santa Cruz West John Devils Peak	7111.7 2708.8 7917.1	3.851972 3.432772 3.898565
Center 1856	33 59 42.238 119 45 08.455	1301.4 217.0	84 18 33.0 142 36 54.0	264 16 16.6 322 35 50.6	Ragged Mountain Devils Peak	6294.9 4791.6	3.798990 3.680480
Red Peak 1857	34 00 54.956 119 43 02.511	1693.3 64.4	55 16 41.0 104 19 39.6	235 15 30.6 284 17 25.8	Center Devils Peak	3932.6 6337.4	3.594676 3.801911
Grouse 1857	33 59 14.284 119 42 24.561	440.1 630.5	101 35 03.9 162 34 19.7	281 33 32.3 342 33 58.5	Center Red Peak	4293.7 3251.1	3.632831 3.512031

* No check on this position.

Santa Cruz Island—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Cave	33 57 43.990	1355.5	118 27 11.8	298 25 10.5	Ragged Mountain	6335.9	3.801806
1857	119 45 35.469	910.8	190 46 27.7	10 46 42.8	Center	3708.7	3.569224
			240 24 09.3	60 25 55.9	Grouse	5635.3	3.750917
Valley Peak 2	33 59 58.882	1814.2	58 10 23.9	238 09 35.7	Grouse	2605.2	3.415840
1857	119 40 58.321	1496.7	118 28 25.5	298 27 16.1	Red Peak	3625.0	3.559306
Harbor	34 00 54.055	1665.5	25 52 08.6	205 51 50.6	Valley Peak 2	1889.2	3.276270
1857	119 40 26.202	672.3	90 24 33.6	270 23 06.2	Red Peak	4010.7	3.603222
Mount Pleasant	34 00 09.328	287.4	84 18 09.0	264 16 58.8	Valley Peak 2	3236.4	3.510062
1857	119 38 52.833	1355.9	102 23 44.6	282 21 24.9	Red Peak	6559.2	3.816853
			119 54 49.2	299 53 57.0	Harbor	2763.9	3.441526
Coche Point	34 02 22.428	691.0	48 01 57.4	228 00 18.1	Mount Pleasant	6130.9	3.787526
1857	119 35 55.198	1415.9	68 38 02.8	248 35 31.2	Harbor	7466.7	3.873130
			241 48 18.5	61 49 28.1	Santa Cruz East	3617.6	3.558440
Ridge	34 00 22.362	689.0	84 12 40.9	264 11 14.8	Mount Pleasant	3973.2	3.599136
1857	119 36 18.797	482.3	189 17 35.6	9 17 48.8	Coche Point	3748.6	3.573865
High Mount	34 01 35.847	1104.5	41 22 08.6	221 21 25.2	Ridge	3016.7	3.479533
	119 35 01.101	28.2	135 58 01.9	315 57 31.6	Coche Point	1996.4	3.300247
			209 48 22.8	29 49 02.1	Santa Cruz East	3623.5	3.559124
Azimuth Mark*	34 03 53.80	1657.7	336 45 21.8	156 46 05.1	Flagstaff	5025.4	3.701167
1874	119 53 26.64	683.2	110 42 16.9	290 41 23.1	Santa Cruz West	2634.9	3.420760
East Point*	34 01 59.11	1821.1	75 46 16	255 45 14	High Mount	2913.9	3.464476
1857	119 33 11.00	282.3	157 09 29	337 09 07	Santa Cruz East	2633.9	3.420600
Platts Harbor*	34 02 22.31	687.5	307 51 28	127 52 44	Harbor	4429.7	3.646376
1857	119 42 42.51	1090.3	10 47 44	190 47 33	Red Peak	2739.8	3.437726
Punta Diablo*	34 03 26.23	808.2	34 15 03	214 14 17	Devils Peak	3743.7	3.573302
1874	119 45 39.73	1018.8	81 11 28	261 08 17	John	8857.3	3.947302
Punta Gorda*	34 04 01.03	31.7	8 06 48	188 06 40	John	2457.1	3.390427
1874	119 51 07.46	191.2	96 42 53	276 40 41	Santa Cruz West	6075.1	3.783555
Posa*	33 58 33.62	1036.0	130 59 37	310 59 07	Dixon	1790.6	3.253004
1874	119 51 15.40	395.2	244 44 23	64 45 32	Ragged Mountain	3487.6	3.542527
Alta	34 02 26.212	807.6	282 44 08.2	102 46 08.3	Devils Peak	5641.6	3.751406
1873	119 50 36.360	932.7	339 14 30.3	159 15 17.2	Ragged Mountain	6072.4	3.783358
White Hill	34 00 06.176	190.3	186 01 20.4	6 01 31.4	John	4830.2	3.683968
1874	119 51 40.733	1045.3	246 45 41.8	66 48 17.8	Devils Peak	7786.0	3.891312
			289 42 42.2	109 44 05.1	Ragged Mountain	4041.2	3.606512
Black Hill	33 59 54.934	1692.6	193 58 16.1	13 58 44.0	John	5307.0	3.724847
1874	119 52 10.930	280.5	282 30 49.0	102 32 28.8	Ragged Mountain	4690.9	3.671252
			356 49 28.9	176 49 30.6	Dixon	1332.8	3.124754
Gull*	33 59 56.52	1741.4	157 24 51	337 23 36	Santa Cruz West	8927.3	3.950722
1874	119 52 49.04	1258.5	203 53 00	23 53 49	John	5579.1	3.746563
Bluff*	34 00 55.99	1725.0	151 51 35	331 50 20	Santa Cruz West	7269.7	3.861515
1874	119 52 49.04	1258.4	214 38 40	34 39 29	John	3973.6	3.599185
Bench Mark*	34 01 16.93	521.6	146 31 32	326 30 09	Santa Cruz West	6911.7	3.839588
1874	119 52 34.08	874.4	215 33 07	35 33 48	John	3225.0	3.508525
Kinton*	34 00 28.23	869.7	157 30 19	337 29 13	Santa Cruz West	7863.9	3.895637
1874	119 53 05.42	139.2	213 00 17	33 01 15	John	4918.2	3.691805
Black Point	34 02 17.91	551.9	142 26 43.7	322 05 38.4	Santa Cruz West	4901.8	3.690353
1874	119 53 06.24	160.1	254 34 30.6	74 35 29.5	John	2800.9	3.447296
			312 06 06.0	132 08 16.8	Ragged Mountain	8085.5	3.907707
Mesa	34 03 47.151	1452.8	307 47 05.2	127 48 01.6	John	3271.7	3.514770
1874	119 53 01.784	45.7	350 46 06.9	170 46 37.0	Dixon	8596.7	3.934334
			110 07 21.1	290 06 13.3	Santa Cruz West	3303.6	3.518993
Toro	34 03 05.140	158.4	309 34 51.7	129 35 10.5	John	1115.1	3.047299
1874	119 51 54.482	1397.3	2 46 23.6	182 46 16.0	Dixon	7199.5	3.857305
			116 44 02.0	296 42 16.6	Santa Cruz West	5405.5	3.732835

*No check on this position.

Santa Cruz Island—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
West Point*	34 03 28.33	873.0	203 58 22	23 58 39	Santa Cruz West	1877.9	3.273673
1874	119 55 32.52	834.0	326 25 04	146 26 58	Dixon	9487.8	3.977165
Valley Peak 1	33 59 56.399	1737.7	59 19 02.3	239 18 14.7	Grouse	2542.4	3.405252
1856	119 40 59.372	1523.7	119 44 06.0	299 42 57.1	Red Peak	3638.6	3.560938
			262 59 47.9	83 00 58.7	Mount Pleasant	3271.7	3.514770
Valley 1	33 59 56.746	1748.6	270 15 58.5	90 16 47.4	Valley Peak 1	2245.9	3.351397
1856	119 42 26.887	689.9	357 23 14.4	177 23 15.7	Grouse	1309.7	3.117166
Valley 2	33 59 07.474	230.3	96 17 20.9	276 16 39.4	Grouse	1916.8	3.282579
1856	119 41 10.330	265.2	127 41 48.1	307 41 05.3	Valley 1	2483.0	3.394979
			190 34 00.5	10 34 06.6	Valley Peak 1	1533.4	3.185661
			241 37 03.8	61 38 20.7	Mount Pleasant	4010.5	3.603202
Shaw	33 59 19.131	589.4	214 30 32.3	34 30 49.7	Valley 1	1406.5	3.148139
1856	119 42 57.936	1487.2	279 53 13.4	99 53 32.1	Grouse	869.6	2.939297
Santa Cruz Id. W. Base	33 59 47.922	1476.4	255 50 00.0	75 50 23.5	Valley 1	1111.2	3.045813
1856	119 43 08.871	227.7	312 20 26.0	132 20 50.8	Grouse	1538.7	3.187142
			342 26 34.3	162 26 40.4	Shaw	930.4	2.968670
Santa Cruz Id. E. Base	33 59 44.799	1380.3	333 46 28.6	153 46 38.7	Grouse	1048.1	3.020389
1856	119 42 42.605	1093.5	26 27 12.4	206 27 03.8	Shaw	883.3	2.946118
			98 07 31.1	278 07 16.4	Santa Cruz Id. W. B.	680.9	2.833101
Sugar Loaf*	33 58 10.87	334.9	197 18 11	17 18 26	Shaw	2202.9	3.342994
1856	119 43 23.46	602.4	217 43 50	37 44 23	Grouse	2470.6	3.392794
Santa Cruz W. Lat. Sta.	34 04 24.15	744.3					
1874	119 55 02.17	55.6					

Santa Rosa Island.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Farrell	33 57 45.658	1406.6	113 43 37.80	293 36 31.80	New San Miguel	21344.1	4.3292776
1860	120 10 27.711	711.5	114 12 34.88	294 06 13.42	San Miguel 2	19187.1	4.2830089
			152 45 37.55	332 32 33.94	Arguello	77471.7	4.8891431
			177 54 25.11	357 53 36.86	Gaviota	59870.8	4.7772147
			220 45 11.08	41 00 27.37	Santa Barbara L. H.	63817.8	4.8049421
			242 34 51.01	62 43 28.47	Santa Cruz West	26718.2	4.4268065
Brockway	34 00 53.382	1644.9	32 11 03.50	212 09 44.26	Farrell	6833.2	3.8346236
1860	120 08 05.948	152.6	95 39 06.60	275 31 25.57	San Miguel 2	21239.5	4.3271437
Gulch	34 00 14.727	453.8	246 54 10.73	66 55 11.61	Brockway	3037.0	3.4824389
1860	120 09 54.821	1406.8	10 25 04.21	190 24 45.83	Farrell	4669.9	3.6693063
La Mesa (F)	33 59 41.401	1275.5	47 53 35.00	227 52 09.13	Farrell	5317.3	3.7256872
1872	120 07 54.062	1387.5	108 20 27.53	288 19 20.00	Gulch	3264.7	3.5138498
			172 10 10.82	352 10 04.14	Brockway	2238.6	3.3499855
Black Mountain	33 58 44.154	1360.3	78 33 56.37	258 30 42.89	Farrell	9070.2	3.9576145
1872	120 04 41.444	1063.8	103 28 18.42	283 17 58.67	New San Miguel	29226.1	4.4657714
			109 38 59.95	289 37 12.30	La Mesa (F)	5249.1	3.7200860
			127 12 04.44	307 10 10.09	Brockway	6587.8	3.8187381
Pecho	33 57 52.317	1611.8	106 56 01.65	286 45 59.92	New San Miguel	28851.3	4.4601656
1872	120 05 13.477	346.0	129 12 16.74	309 10 47.00	La Mesa (F)	5318.7	3.7258044
			232 20 54.94	52 26 36.61	Santa Cruz West	19778.4	4.2961907
Soledad	33 57 03.945	121.5	110 52 10.19	290 42 44.79	New San Miguel	27759.5	4.4434119
1872	120 06 18.272	469.2	153 07 39.00	333 06 45.47	La Mesa (F)	5439.0	3.7355200
			218 49 50.70	38 50 44.78	Black Mt.	3963.8	3.5981167
			228 08 24.96	48 09 01.15	Pecho	2233.6	3.3490040
Summit	33 57 09.887	304.6	110 09 35.47	290 08 30.13	Farrell	3199.4	3.5050698
1872	120 08 30.732	789.1	191 23 50.90	11 24 11.39	La Mesa (F)	4762.2	3.6778121
			273 04 14.27	93 05 28.25	Soledad	3406.2	3.5322685

* No check on this position.

Santa Rosa Island—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Divide	33 56 03.952	121.8	115 02 24.95	294 53 17.51	New San Miguel	27726.3	4.4428915
1872	120 06 50.162	1288.4	128 11 47.27	308 10 51.14	Summit	3285.9	3.5166508
			203 53 38.34	23 53 56.15	Soledad	2021.7	3.3057250
Grouse 2	33 55 29.116	897.0	119 52 33.35	299 44 27.78	New San Miguel	25699.4	4.4099230
1872	120 08 40.728	1046.1	146 51 44.60	326 50 44.86	Farrell	5024.6	3.7010972
			184 43 37.90	4 43 43.51	Summit	3115.4	3.4935132
			249 17 16.55	69 18 18.27	Divide	3035.9	3.4822903
Alta	33 56 35.622	1097.4	83 04 54.43	263 02 00.38	Divide	8072.8	3.9070262
1860	120 01 38.124	979.1	96 56 17.41	276 53 41.14	Soledad	7246.7	3.8601381
			113 09 19.75	293 07 19.47	Pecho	6013.4	3.7791175
			215 04 32.46	35 08 13.59	Santa Cruz West	17640.9	4.2465214
Sand Point	33 58 42.191	1299.8	43 24 43.95	223 23 23.68	Alta	5367.3	3.7297540
1860	119 59 14.487	371.9	211 29 46.46	31 32 07.32	Santa Cruz West	12354.5	4.0918239
Ridge	33 58 53.198	1638.9	273 52 08.93	93 54 07.61	Sand Point	5002.9	3.6992247
1860	120 02 28.940	742.9	342 53 17.79	162 53 46.18	Alta	4435.0	3.6468978
			66 04 01.91	246 02 29.97	Pecho	4621.7	3.6647995
Corral	34 01 30.193	930.3	247 01 10.83	67 05 47.05	Santa Cruz West	13740.0	4.1379876
1859	120 03 16.098	413.0	309 50 16.06	129 52 31.17	Sand Point	8077.0	3.9072503
			345 57 01.56	165 57 27.92	Ridge	4986.2	3.6977723
Black Hill	33 59 40.516	1248.2	208 38 42.0	28 39 22.2	Corral	3850.7	3.585544
1860	120 04 28.050	719.9	295 29 10.5	115 30 17.1	Ridge	3387.0	3.529811
Santa Rosa Island West Base	34 01 01.271	39.2	250 31 09.3	70 32 04.3	Corral	2673.1	3.427020
1860	120 04 54.327	1393.9	344 50 05.8	164 50 20.5	Black Hill	2577.9	3.411261
			87 11 04.0	267 09 16.8	Brockway	4922.7	3.692200
Santa Rosa Island East Base	34 00 56.146	1730.0	326 57 25.8	146 58 19.5	Ridge	4518.6	3.655008
1860	120 04 04.928	126.4	14 17 15.1	194 17 02.2	Black Hill	2404.6	3.381042
			97 06 16.2	277 05 48.6	S. R. Id. West Base	1277.3	3.106283
Round Top	33 59 37.128	1144.0	92 18 17.3	272 17 05.7	La Mesa (G)	3291.5	3.517390
1860	120 05 45.932	1178.8	207 03 03.2	27 03 42.1	S. R. Id. West Base	2911.2	3.464068
			267 00 12.4	87 00 55.9	Black Hill	2001.5	3.301362
La Mesa (G)	33 59 41.405	1275.7	108 20 29.6	288 19 22.1	Gulch	3264.3	3.513794
1860	120 07 54.078	1387.9	172 10 47.5	352 10 40.9	Brockway	2238.5	3.349955
Lime Point*	34 01 07.23	222.8	274 22 03	94 22 55	S. R. Id. West Base	2405.4	3.381186
1860	120 06 27.80	713.3	338 50 16	158 50 39	Round Top	2976.7	3.473737
Spur	33 57 18.013	555.0	165 21 43.4	345 21 12.4	Gulch	5627.5	3.750313
1860	120 08 59.403	1525.3	200 46 49.1	20 47 25.6	La Mesa (G)	4725.5	3.674452
Grouse 1*	33 55 57.81	1781.2	175 08 24	355 08 18	Farrell	3334.8	3.523066
1860	120 10 16.71	429.1	218 46 18	38 47 01	Spur	3169.7	3.501013
East Point*	33 56 35.89	1105.8	89 54 58	269 53 13	Alta	4818.7	3.682928
1860	119 58 30.48	782.7	163 48 48	343 48 24	Sand Point	4052.1	3.607679
Corvron	33 57 30.236	931.6	226 51 21.4	46 52 20.8	Ridge	3738.5	3.572694
1860	120 04 15.207	390.4	292 37 57.7	112 39 25.4	Alta	4370.5	3.640527
Barton	33 56 55.166	1699.7	155 59 54.3	335 59 43.8	Corvron	1182.8	3.072926
1860	120 03 56.468	1450.0	211 42 21.0	31 43 09.9	Ridge	4274.9	3.630928
			279 36 33.8	99 37 51.1	Alta	3603.2	3.556692
Vaca*	33 56 34.62	1066.7	232 03 30	52 04 18	Corvron	2787.4	3.445194
1860	120 05 40.82	1048.3	256 42 03	76 43 01	Barton	2753.5	3.439886
Borrego*	33 55 00.05	1.5	169 29 26	349 29 12	Barton	3607.3	3.557178
1860	120 03 30.84	792.3	224 30 22	44 31 25	Alta	4129.4	3.615891
Bald Hill*	33 56 01.80	55.5	213 58 43	33 59 08	Barton	1982.9	3.297293
1860	120 04 39.62	1017.6	317 06 56	137 07 34	Borrego	2596.3	3.414348
South Point*	33 53 55.30	1703.8	221 42 21	41 44 08	Barton	7424.7	3.870678
1860	120 07 08.84	227.1	250 22 31	70 24 33	Borrego	5945.1	3.774156
Fox*	34 00 02.10	64.7	260 43 51	80 44 43	Gulch	2417.3	3.383332
1872	120 11 27.79	713.2	339 51 02	159 51 36	Farrell	4477.8	3.651065

* No check on this position.

Santa Rosa Island—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Sand *	34 00 00.31	9.6	266 00 26	86 02 45	Gulch	6409.2	3.806806
1871	120 14 03.97	101.9	306 45 25	126 47 26	Farrell	6930.2	3.840745
Blunt	33 58 53.802	1657.7	112 23 18.1	292 18 13.1	San Miguel 2	15130.0	4.179840
1871	120 12 44.537	1143.2	240 11 56.1	60 13 31.0	Gulch	5019.0	3.700613
			258 50 56.4	78 53 38.8	La Mesa (F)	7598.4	3.880720
			300 51 28.3	120 52 44.8	Farrell	4092.2	3.611954
			315 11 31.2	135 13 47.4	Grouse 2	8886.1	3.948713
Point *	34 00 09.93	306.0	268 13 32	88 15 17	Gulch	4815.3	3.682619
1872	120 13 02.37	60.8	348 57 17	168 57 27	Blunt	2389.7	3.378351
West Point *	33 59 50.65	1560.6	261 45 17	81 47 09	Gulch	5182.8	3.714566
1860	120 13 14.70	377.2	311 55 28	131 57 02	Farrell	5762.3	3.760597
Bee Rock, northwest end	33 57 01.544	47.6	181 37 24	1 37 27	Blunt	3460.1	3.53909
1872	120 12 48.356	1241.6	249 21 50	69 23 09	Farrell	3858.5	3.58642
			294 06 13	114 08 32	Grouse 2	6968.0	3.84311
Bee Rock, southeast end	33 56 58.879	1814.1	180 11 53	0 11 53	Blunt	3540.9	3.54911
1872	120 12 45.014	1155.8	247 45 10	67 46 27	Farrell	3808.6	3.58077
			293 46 14	113 48 30	Grouse 2	6856.3	3.83609

San Miguel Island.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
San Miguel 2	34 02 00.505	15.6	109 20 18.51	289 19 33.96	New San Miguel	2163.7	3.3352028
1871	120 21 49.879	1279.5	163 29 26.41	343 22 46.61	Arguello	63600.4	4.8034601
			196 18 48.17	16 24 24.00	Gaviota	54171.9	4.7337740
			263 45 06.17	84 00 06.10	Santa Cruz West	41454.2	4.6175689
Harbor 2	34 03 52.918	1630.6	284 53 51.87	105 01 23.63	Brockway	21428.1	4.3309838
1871	120 21 33.002	846.3	303 29 15.16	123 35 27.32	Farrell	20480.5	4.3113399
			7 07 29.12	187 07 19.66	San Miguel 2	3490.6	3.5428953
			42 00 47.33	221 59 53.30	New San Miguel	3697.2	3.5678749
Gull Island	34 03 29.532	910.0	284 47 52.9	104 54 32.2	Brockway	19048.2	4.279854
1871	120 19 59.870	1535.4	305 46 22.4	125 51 42.3	Farrell	18226.9	4.260713
			45 49 03.9	225 48 02.3	San Miguel 2	3935.2	3.594968
			67 23 23.0	247 21 36.9	New San Miguel	5268.4	3.721680
			106 47 45.8	286 46 53.6	Harbor 2	2494.7	3.397013
Green Mountain	34 02 27.350	842.7	224 44 12.4	44 45 09.4	Harbor 2	3712.1	3.569615
1858	120 23 14.889	381.9	249 01 33.4	69 03 22.6	Gull Island	5356.2	3.728860
			290 45 54.3	110 46 41.9	San Miguel 2	2332.3	3.367776
			308 34 39.7	128 34 42.8	New San Miguel	177.7	2.249768
Seal Point	34 04 25.084	727.9	299 30 36.8	119 31 42.8	Gull Island	3473.8	3.540809
1871	120 21 57.753	1480.8	327 21 46.3	147 22 00.1	Harbor 2	1176.9	3.070721
			28 36 39.8	208 35 56.6	Green Mountain	4131.9	3.616148
Brockway 2	34 02 50.746	1563.7	238 01 18.0	58 02 59.8	Seal Point	5490.6	3.739619
1871	120 24 59.391	1523.3	250 05 18.3	70 07 13.9	Harbor 2	5629.1	3.750437
			285 02 41.4	105 03 40.0	Green Mountain	2775.7	3.443376
Black Point	34 01 48.708	1500.9	130 32 11.2	310 31 22.4	Brockway 2	2941.4	3.468556
1858	120 23 32.235	827.0	200 29 32.3	20 29 42.0	Green Mountain	1271.0	3.104149
			208 24 12.6	28 24 25.5	New San Miguel	1227.5	3.089031
			262 06 41.9	82 07 39.3	San Miguel 2	2650.8	3.423384
Cape	34 02 28.188	868.6	76 27 00.5	256 25 43.4	San Miguel 2	3637.7	3.560827
1858	120 19 32.022	821.4	88 36 48.6	268 34 47.0	New San Miguel	5579.5	3.746593
			89 45 30.7	269 43 25.9	Green Mountain	5716.8	3.757150
			130 05 10.6	310 04 02.9	Harbor 2	4055.0	3.607992
			159 18 02.1	339 17 46.6	Gull Island	2020.6	3.305472
San Miguel	34 02 00.600	18.5	82 03 51.3	262 02 54.0	Black Point	2651.0	3.423413
1858	120 21 49.888	1279.8	110 42 46.7	290 41 59.1	Green Mountain	2331.0	3.367545
			256 28 27.2	76 29 44.5	Cape	3637.2	3.560770

* No check on this position.

San Miguel Island—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Harbor	34 03 35.620	1097.6	304 34 42.1	124 35 48.0	Cape	3660.0	3.563479
1858	120 21 29.503	756.7	10 07 38.8	190 07 27.4	San Miguel	2974.0	3.473339
			52 07 03.8	232 06 04.8	Green Mountain	3425.0	3.534658
Cactus	34 01 28.559	880.0	107 03 51.2	287 02 41.0	San Miguel	3366.1	3.527125
1858	120 19 44.448	1140.3	189 50 31.6	9 50 38.6	Cape	1864.7	3.270603
San Miguel Island South Base	34 01 42.123	1298.0	218 52 08.1	38 52 33.1	Cape	1823.0	3.260797
1858	120 20 16.623	426.4	296 50 58.8	116 51 16.8	Cactus	925.2	2.966236
San Miguel Island North Base	34 02 01.595	49.1	237 47 30.1	57 47 58.5	Cape	1537.4	3.186788
1858	120 20 22.735	583.3	316 01 05.9	136 01 27.3	Cactus	1414.5	3.150607
			345 21 09.1	165 21 12.6	S. Miguel Id. S. Base	620.1	2.792483
Richardsons Rock, highest point of northern rock	34 06 08.38	258.2	282 39 13.9	102 44 22.7	Seal Point	14480.4	4.160781
1858–71	120 31 08.78	223.2	285 44 34.6	105 49 57.3	Harbor 2	15340.3	4.185834
			299 13 54.9	119 18 20.5	Green Mountain	13929.4	4.143934
			302 42 34.2	122 46 01.2	Brockway 2	11259.8	4.051530
			304 18 49.2	124 23 05.0	Black Point	14179.7	4.151668
Wilsons Rock, central point	34 06 19.052	587.0	321 10 41.6	141 11 43.4	Seal Point	4506.6	3.653847
1858–71	120 23 47.934	1228.6	322 27 15.0	142 28 30.6	Harbor 2	5678.0	3.754196
			353 13 43.0	173 14 01.6	Green Mountain	7189.2	3.856678
			15 56 15.7	195 55 35.7	Brockway 2	6674.6	3.824422
Rock Awash	34 06 34.7	1069.2	317 13	137 14	Harbor 2	6789.4	3.83183
1858–71	120 24 32.8	822.2	345 18	165 18	Green Mountain	7878.0	3.89642
			5 38	185 38	Brockway 2	6932.8	3.84091
West Point*	34 01 53.13	1637.1	218 16 37	38 17 08	Brockway 2	2261.4	3.354381
1871	120 25 54.01	1385.6	272 08 06	92 09 25	Black Point	3639.6	3.561052
Bench Mark*	34 03 22.09	680.7	339 34 48	159 35 01	Cape	1772.0	3.248466
1871	120 19 56.12	1439.3	110 56 00	290 55 06	Harbor 2	2659.9	3.424859
Cactus 2*	34 01 19.76	608.9	108 22 35	288 21 13	San Miguel 2	3984.7	3.600395
1871–3	120 19 22.47	576.6	173 22 16	353 22 11	Cape	2122.6	3.326866
Castle Rock, point near west end*	34 03 18.66	575.0	169 07 26	349 03 17	Arguello	59630.6	4.775469
1875–76	120 26 17.55	450.1	203 57 52	24 05 58	Gaviote	54274.9	4.734599
Brockway*	34 02 14.95	460.7	264 21 47	84 23 12	Green Mountain	3898.3	3.590876
1858	120 25 46.13	1183.3	283 14 04	103 15 19	Black Point	3528.7	3.547609
New San Miguel Lat. Sta.	34 02 23.60	727.1					
1873	120 23 09.34	239.6					

Point Arguello to Point Sal

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Gravel	34 33 20.259	624.2	203 38 45.7	23 39 15.3	Arguello	3320.1	3.521150
1874	120 34 31.260	797.0	247 12 09.4	67 13 37.7	Prospect	4302.5	3.633721
			306 36 13.8	126 36 54.9	Flint	2299.8	3.361693
Spur	34 34 17.663	544.3	253 05 54.6	73 07 27.8	Arguello	4379.9	3.641466
1874	120 36 23.441	597.5	301 43 44.1	121 44 47.7	Gravel	3362.6	3.526673
Point Arguello	34 33 18.718	576.8	204 03 10.8	24 03 28.8	Spur	1989.0	3.298645
1874	120 36 55.246	1408.7	238 17 24.6	58 19 15.8	Arguello	5878.9	3.769298
			269 14 51.8	89 16 13.4	Gravel	3671.2	3.564808
Rustad	34 34 15.445	475.9	257 25 07.8	77 27 21.6	Arguello	6164.2	3.789879
1874	120 37 35.067	893.9	267 51 02.6	87 51 43.2	Spur	1827.0	3.261741
			329 51 03.4	149 51 26.0	Point Arguello	2021.3	3.305641

*** No check on this position.**

Point Arguello to Point Sal—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Sage	34 33 48.796	1503.6	207 46 19.0	27 46 28.7	Rustad	928.0	2.967549
1874	120 37 52.031	1326.6	248 29 43.4	68 30 33.7	Spur	2427.1	3.385084
			302 37 31.0	122 38 03.2	Point Arguello	1718.9	3.235260
Pedrenales	34 34 26.779	825.2	290 23 36.6	110 23 57.6	Rustad	1002.0	3.000878
1874	120 38 11.914	303.6	336 34 57.0	156 35 08.3	Sage	1275.3	3.105628
Alvord	34 35 34.671	1068.3	282 10 26.8	102 12 20.2	Arguello	5211.5	3.716961
1874	120 36 58.904	1501.2	20 41 12.8	200 40 52.4	Rustad	2609.4	3.416545
			41 39 26.6	221 38 45.2	Pedrenales	2799.8	3.447127
Promontory	34 36 16.442	506.6	299 34 21.7	119 35 12.2	Alvord	2607.4	3.416216
1874	120 38 27.895	710.8	340 08 28.9	160 08 59.0	Rustad	3964.0	3.598132
			353 07 35.4	173 07 44.5	Pedrenales	3403.6	3.531937
Lompoc	34 36 47.241	1455.6	308 06 40.4	128 08 15.0	Arguello	5404.5	3.732756
1874	120 36 25.870	659.2	20 37 46.7	200 37 27.9	Alvord	2389.3	3.378279
			73 02 03.5	253 00 54.2	Promontory	3250.6	3.511968
Sand Hill	34 37 37.190	1145.9	313 39 20.6	133 39 56.6	Lompoc	2229.4	3.348190
1874	120 37 29.181	743.4	348 26 59.3	168 27 16.5	Alvord	3853.3	3.585836
			31 01 02.4	211 00 29.1	Promontory	2903.3	3.462879
Powell	34 37 24.268	747.8	10 04 51.5	190 04 47.0	Lompoc	1158.9	3.064042
1878	120 36 17.908	456.3	102 22 29.2	282 21 48.7	Sand Hill	1858.7	3.269213
Bald	34 38 08.986	276.9	311 58 01.1	131 58 35.3	Powell	2060.4	3.313950
1878	120 37 18.046	459.6	332 10 38.0	152 11 07.7	Lompoc	2848.1	3.454551
			16 08 42.8	196 08 36.5	Sand Hill	1020.0	3.008594
Blank	34 38 49.600	1528.4	3 02 54.8	183 02 51.7	Powell	2633.1	3.420471
1878	120 36 12.411	316.1	53 11 04.2	233 10 26.9	Bald	2088.2	3.319772
Bear Valley	34 39 25.968	800.2	323 16 03.0	143 16 21.7	Blank	1398.2	3.145577
1878	120 36 45.247	1152.2	349 28 43.9	169 28 59.5	Powell	3814.1	3.581395
			19 24 03.5	199 23 44.9	Bald	2514.9	3.400517
Slope	34 40 17.127	527.7	13 56 50.4	193 56 20.9	Powell	5488.2	3.739428
1878	120 35 25.980	661.4	23 40 26.8	203 40 00.4	Blank	2944.8	3.469057
			52 00 48.9	232 00 03.8	Bear Valley	2561.0	3.408404
Hammer	34 40 49.743	1532.7	307 17 49.3	127 18 18.8	Slope	1658.4	3.219698
1878	120 36 17.800	453.2	357 52 37.7	177 52 42.2	Blank	3704.2	3.568700
			15 18 59.3	195 08 43.7	Bear Valley	2674.4	3.427221
Valley View	34 42 02.614	80.6	14 34 02.2	194 33 43.3	Slope	3358.4	3.526133
1878	120 34 52.802	1343.8	43 56 29.4	223 55 41.0	Hammer	3118.1	3.493895
Marsh	34 42 08.140	250.8	276 17 48.0	96 18 22.5	Valley View	1551.4	4.190720
1878	120 35 53.392	1358.8	348 28 06.8	168 28 24.5	Slope	3490.7	3.542917
			14 25 27.5	194 25 13.6	Hammer	2494.4	3.396957
Burned	34 43 18.888	582.0	329 22 55.7	149 23 26.8	Valley View	2731.0	3.436320
1878	120 35 47.454	1207.5	3 57 53.8	183 57 50.4	Marsh	2185.3	3.339511
			9 32 29.2	189 32 11.9	Hammer	4660.2	3.668409
Bluff	34 42 52.323	1612.2	227 50 19.4	47 50 39.6	Burned	1219.6	3.086232
1878	120 36 22.986	585.0	303 42 46.1	123 43 37.4	Valley View	2759.2	3.440790
			331 02 51.6	151 03 08.4	Marsh	1555.9	3.191978
			357 59 53.0	177 59 55.9	Hammer	3779.5	3.577435
Landing	34 43 59.805	1842.8	305 59 00.3	125 59 39.1	Burned	2145.6	3.331559
1878	120 36 55.692	1417.1	338 11 14.2	158 11 32.9	Bluff	2239.8	3.350203
			350 38 49.5	170 39 11.0	Hammer	5935.5	3.773457
Chaparral	34 44 23.339	719.1	330 54 42.4	150 55 07.1	Burned	2272.6	3.356519
1878	120 36 30.876	785.5	355 54 18.9	175 54 23.4	Bluff	2811.8	3.448983
			41 02 34.9	221 02 20.8	Landing	961.5	2.982930
Rancheria	34 44 28.570	880.4	276 09 51.1	96 10 24.5	Chaparral	1500.0	3.176101
1878	120 37 29.502	750.4	315 51 29.5	135 51 48.8	Landing	1235.1	3.091697
			330 17 06.8	150 17 44.7	Bluff	3414.7	3.533348
Tangent	34 44 58.407	1799.7	323 45 33.1	143 45 50.8	Chaparral	1339.8	3.127031
1878	120 37 02.012	51.2	354 54 41.9	174 54 45.5	Landing	1813.7	3.258579
			37 15 25.2	217 15 09.5	Rancheria	1155.1	3.062628
Brown Hill	34 45 28.857	889.2	317 27 46.8	137 28 06.1	Tangent	1273.4	3.104952
1878	120 37 35.857	912.1	355 01 35.5	175 01 39.1	Rancheria	1864.7	3.270620

Point Arguello to Point Sal—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Gulch	34 45 54.594	1682.2	351 47 41.0	171 47 46.6	Tangent	1749.3	3.242859
1878	120 37 11.827	300.9	37 37 09.8	217 36 56.1	Brown Hill	1001.2	3.000529
Dune	34 46 02.802	86.3	285 24 43.6	105 25 04.2	Gulch	951.6	2.978442
1878	120 37 47.900	1218.1	343 40 46.5	163 40 53.4	Brown Hill	1089.9	3.037393
Beach	34 46 45.812	1411.6	205 46 41.0	25 47 00.8	San Antonio	2032.3	3.307995
1878	120 37 31.799	808.6	342 09 40.9	162 09 52.3	Gulch	1658.0	3.219574
			17 10 05.2	197 09 56.0	Dune	1387.1	3.142115
Prominent	34 46 44.037	1356.9	10 29 20.7	190 29 14.4	Gulch	1549.5	3.190180
1878	120 37 00.735	18.7	43 20 59.3	223 20 32.4	Dune	1747.2	3.242353
			93 57 49.6	273 57 31.9	Beach	7917.3	2.898577
			182 51 35.7	2 51 37.8	San Antonio	1887.1	3.275793
Outer	34 47 46.881	1444.6	53 16 24.8	233 15 26.6	Prominent	3237.8	3.510247
1878	120 35 18.672	474.8	88 49 15.4	268 48 19.3	San Antonio	2500.9	3.398100
			195 44 17.0	15 44 39.4	Edge	3679.8	3.565824
Corral	34 33 26.416	814.0	79 49 21.3	259 48 51.9	Point Arguello	1341.8	3.127680
1874	120 36 03.445	87.8	162 06 40.2	342 06 28.9	Spur	1659.4	3.219940
			232 13 48.0	52 15 09.8	Arguello	4656.8	3.668089
			274 36 27.5	94 37 19.7	Gravel	2357.8	3.372516
Camp	34 47 10.656	328.3	37 30 18.5	217 30 04.4	Prominent	1034.0	3.014504
1878	120 36 35.977	914.7	153 18 24.8	333 18 12.8	San Antonio	1191.5	3.076085
			240 23 49.9	60 24 34.0	Outer	2260.2	3.354142
Hollow	34 47 14.430	444.6	206 29 20.4	26 29 31.0	San Antonio	1059.4	3.025061
1878	120 37 15.619	397.1	276 34 46.2	96 35 08.8	Camp	1014.5	3.006271
			337 59 50.4	157 59 58.9	Prominent	1010.1	3.004377
			25 00 33.7	205 00 24.5	Beach	973.1	2.988158
Middle	34 48 14.771	455.1	22 31 53.3	202 31 34.9	Camp	2138.9	3.330195
1878	120 36 03.739	95.0	56 04 39.8	236 04 09.4	San Antonio	1632.6	3.212886
			218 37 24.1	38 38 12.2	Edge	3433.7	3.535762
			306 52 24.6	126 52 50.3	Outer	1432.1	3.155980
Pond	34 48 52.248	1609.9	158 03 00.7	338 01 29.3	Point	10862.2	4.035919
1878	120 36 45.249	1150.0	162 24 23.8	342 23 30.9	Reef 1	7790.1	3.891542
			184 09 59.0	4 10 13.4	Lospe	8843.6	3.946627
			244 27 39.5	64 28 51.3	Edge	3544.5	3.549551
			312 27 39.1	132 28 28.5	Outer	2983.3	3.474695
			317 34 51.8	137 35 15.5	Middle	1564.2	3.194301
			355 41 35.5	175 41 40.8	Camp	3139.4	3.496844
			8 14 53.3	188 14 46.6	San Antonio	2087.6	3.319654
Purissima Point	34 45 22.356	688.9	204 53 05.0	24 53 18.0	Dune	1373.9	3.137962
1878	120 38 10.634	270.5	257 14 05.5	77 14 25.3	Brown Hill	906.9	2.957556
			292 54 49.5	112 55 26.2	Tangent	1895.0	3.277602
			327 44 04.3	147 44 27.8	Rancheria	1960.0	3.292251
Lompoc Warehouse,	34 44 01.108	34.1	220 22 20	40 22 33	Chaparral	899.2	2.953863
north gable	120 36 53.773	1368.0	336 10 48	156 11 22	Marsh	3805.0	3.580355
1878			339 42 53	159 43 11	Bluff	2259.7	3.354047
			50 34 53	230 34 52	Landing	63.2	1.800594
Lompoc Warehouse,	34 44 00.577	17.8	218 28 06	38 28 18	Chaparral	895.9	2.952247
south gable	120 36 52.784	1342.8	336 25 44	156 26 18	Marsh.	3779.9	3.577484
1878			340 10 28	160 10 45	Bluff	2235.7	3.349410
			72 11 51	252 11 49	Landing	77.7	1.890377
Lompoc Wharf, derrick	34 43 56.912	1753.6	248 32 47	68 32 52	Landing	243.8	2.387086
1878	120 37 04.612	117.3	316 23 22	136 24 37	Valley View	4863.4	3.686943
			331 58 38	151 59 02	Bluff	2254.5	3.353052

Point Sal to Saddle Peak.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To stations	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Green Peak	35 12 23.900	736.6	134 52 34.6	314 51 46.8	Pecho	2957.7	3.470949
1872	120 49 37.536	949.4	192 37 04.2	12 37 18.1	Schumacher	2783.8	3.444634
			240 33 50.2	60 35 02.1	Saddle Peak	3621.7	3.558908
Bare Hill	35 11 49.746	1533.1	101 32 52.0	281 30 54.4	Green Peak	5265.1	3.721404
1872	120 46 13.599	344.0	113 25 19.2	293 22 33.8	Pecho	7904.5	3.897875
			129 39 09.3	309 37 25.6	Schumacher	5908.2	3.771453
			144 43 30.2	324 42 44.5	Saddle Peak	3469.0	3.540205
San Luis Hill	35 10 07.388	227.7	126 33 41.0	306 31 31.7	Green Peak	7065.3	3.849128
1871	120 45 53.181	1345.8	157 10 26.5	337 09 29.1	Saddle Peak	6495.2	3.812594
			170 42 01.9	350 41 50.2	Bare Hill	3196.4	3.504660
Valley View	35 10 46.947	1446.8	75 39 48.4	255 37 59.9	San Luis Hill	4918.3	3.691811
1871	120 42 44.884	1135.7	106 00 14.8	285 56 17.0	Green Peak	10858.8	4.035780
			110 08 39.3	290 06 39.1	Bare Hill	5624.0	3.750044
			123 13 40.4	303 10 54.4	Saddle Peak	8704.9	3.939765
Indian	35 11 53.803	1658.1	67 25 02.8	247 23 10.2	Valley View	5361.6	3.729294
1872–3	120 39 29.234	739.5	71 22 38.3	251 18 57.1	San Luis Hill	10253.1	4.010855
			102 31 02.0	282 26 23.5	Saddle Peak	12527.3	4.097859
Price	35 09 51.636	1591.4	93 16 48.2	273 13 33.8	San Luis Hill	8554.5	3.932197
1872	120 40 15.694	397.2	114 18 39.4	294 17 13.5	Valley View	4142.3	3.617237
			197 20 13.4	17 20 40.2	Indian	3944.1	3.595946
White Rock	35 09 48.933	1508.0	96 24 41.3	276 22 45.8	San Luis Hill	5105.6	3.708047
1871	120 42 32.690	827.3	123 41 03.7	303 38 56.5	Bare Hill	6716.0	3.827110
			170 12 30.2	350 12 23.2	Valley View	1814.2	3.258696
			268 36 47.3	88 38 06.2	Price	3468.1	3.540088
Mallagh	35 10 28.572	880.6	51 08 53.6	231 08 19.1	White Rock	1947.1	3.289387
1871	120 41 32.774	829.3	107 14 49.3	287 14 07.8	Valley View	1910.5	3.281144
San Luis Obispo East Base	35 10 05.538	170.7	69 46 13.3	249 45 41.7	White Rock	1479.6	3.170132
1871	120 41 37.834	957.5	90 31 32.9	270 29 05.8	San Luis Hill	6462.1	3.810377
			114 44 11.6	294 41 32.7	Bare Hill	7681.0	3.885415
			126 57 10.0	306 56 31.4	Valley View	2123.0	3.326951
			190 13 27.7	10 13 30.6	Mallagh	721.3	2.858112
San Luis Obispo West Base	35 10 27.736	854.8	268 08 27.7	88 08 45.8	Mallagh	795.7	2.900774
1871	120 42 04.204	106.4	315 42 27.0	135 42 42.2	S. Luis Obispo E. B.	955.643	2.980296
			31 05 07.8	211 04 51.4	White Rock	1396.3	3.144964
Meierhoff	35 10 03.710	114.3	86 38 19.6	266 35 56.3	Price	6309.1	3.799967
1873	120 36 06.827	172.8	123 32 23.5	303 30 26.9	Indian	6143.1	3.788388
Arroyo Grande	35 06 40.728	1255.2	117 27 51.5	297 23 12.4	San Luis Hill	13826.8	4.140723
1873	120 37 48.378	1225.1	128 53 04.9	308 50 21.2	White Rock	9243.6	3.965841
			147 38 26.0	327 37 01.2	Price	6965.6	3.842960
			202 20 02.1	22 21 00.5	Meierhoff	6762.9	3.830134
Nipomo	35 06 00.281	8.7	104 37 20.4	284 35 31.8	Arroyo Grande	4942.4	3.693941
1873	120 34 39.532	1001.2	129 58 48.4	309 55 35.1	Price	11102.5	4.045420
			163 35 29.8	343 34 39.6	Meierhoff	7820.4	3.893231
Avila	35 10 40.203	1239.0	75 37 54.2	255 36 24.4	San Luis Hill	4071.6	3.609769
1871	120 43 17.319	438.2	115 40 46.7	295 39 05.2	Bare Hill	4948.1	3.694442
			277 42 26.3	97 43 26.4	Mallagh	2669.6	3.426442
			281 43 31.3	101 44 13.4	S. Luis Obispo W. B.	1889.6	3.276361
			292 59 06.7	113 00 04.0	S. Luis Obispo E. B.	2734.8	3.436916
			324 26 20.4	144 26 46.1	White Rock	1942.1	3.288271
Cienega Sand	35 04 00.774	23.8	168 37 38.3	348 37 15.8	Arroyo Grande	5028.0	3.701396
1874	120 37 09.227	233.8	188 02 11.1	8 02 46.9	Meierhoff	11295.5	4.052907
			225 49 35.4	45 51 01.4	Nipomo	5286.2	3.723140
Burnt Sand	35 03 35.743	1101.6	96 11 39.0	276 08 57.3	Cienega Sand	7174.7	3.855806
1874	120 32 27.717	702.4	143 09 02.4	323 07 46.6	Nipomo	5566.9	3.745614
Dune	35 02 16.588	511.2	172 53 25.8	352 53 16.8	Cienega Sand	3235.5	3.509944
1874	120 36 53.423	1354.1	206 11 31.7	26 12 48.6	Nipomo	7683.0	3.885528
			250 03 58.9	70 06 31.5	Burnt Sand	7162.0	3.855037
Steele	35 01 42.480	1309.2	100 30 49.5	280 28 41.0	Dune	5769.9	3.761167
1874	120 33 09.606	243.5	125 04 43.5	305 02 25.8	Cienega Sand	7419.0	3.870348
			164 00 12.4	244 59 20.7	Nipomo	8264.8	3.917233
			196 54 54.4	16 55 18.5	Burnt Sand	3648.2	3.562084

Point Sal to Saddle Peak—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Guadalupe	34 59 52.074	1604.6	150 11 22.8	330 10 25.0	Dune	5132.9	3.710367
1874	120 35 12.749	323.3	158 56 25.0	338 55 18.2	Cienega Sand	8213.1	3.914505
			211 14 33.0	31 16 07.6	Burnt Sand	8062.9	3.906491
			222 31 55.5	42 33 06.1	Steele	4617.8	3.664433
Oso Flaco	35 00 40.265	1240.9	190 22 40.4	10 23 06.1	Cienega Sand	6296.3	3.799082
1874	120 37 53.888	1366.3	206 32 23.8	26 33 15.5	Nipomo	11023.2	4.042308
			207 18 25.3	27 19 00.0	Dune	3340.7	3.523840
			236 47 11.4	56 50 18.6	Burnt Sand	9879.0	3.994713
			255 04 50.5	75 07 33.7	Steele	7457.8	3.872612
			289 57 39.7	109 59 12.1	Guadalupe	4347.5	3.638240
Smith Sand	34 55 59.482	1832.8	192 53 22.4	12 54 07.2	Oso Flaco	8876.5	3.948243
1874	120 39 11.983	304.1	220 14 14.0	40 16 31.1	Guadalupe	9391.9	3.972755
			220 58 51.8	41 02 19.5	Steele	14007.3	4.146355
Rock	34 54 10.715	330.2	137 10 01.9	317 08 51.8	Smith Sand	4571.2	3.660030
1867	120 37 09.528	241.9	174 38 50.7	354 38 25.3	Oso Flaco	12057.0	4.081239
			195 43 20.8	15 44 27.7	Guadalupe	10928.6	4.038566
			203 35 46.0	23 38 03.5	Steele	15193.9	4.181670
Peak	34 54 21.790	671.4	160 13 03.0	340 12 38.6	Smith Sand	3199.3	3.505053
1867	120 38 29.317	744.3	279 33 26.7	99 34 12.4	Rock	2054.2	3.312650
Green Ridge	34 55 11.473	353.5	12 39 48.9	192 39 39.4	Rock	1918.9	3.283068
1874	120 36 52.958	1344.2	57 57 56.3	237 57 01.1	Peak	2885.7	3.460255
			112 45 27.6	292 44 08.0	Smith Sand	3826.2	3.582766
			171 19 51.1	351 19 16.2	Oso Flaco	10249.3	4.010694
			196 22 35.8	16 23 33.3	Guadalupe	9004.7	3.954469
			205 09 55.2	25 11 46.3	Steele	13314.8	4.124336
Point	34 54 19.162	590.4	186 10 57.9	6 11 05.5	Smith Sand	3109.5	3.492691
1867	120 39 25.179	639.3	191 08 58.1	11 09 50.5	Oso Flaco	11970.3	4.078105
			266 43 36.7	86 44 08.6	Peak	1420.5	3.152435
Reef 1	34 52 53.213	1639.7	147 12 37.8	327 11 59.3	Point	3150.7	3.498410
1878	120 38 17.969	456.3	173 58 28.6	353 58 22.1	Peak	2744.7	3.438496
			245 02 03.8	65 03 11.3	Lospe	3305.7	3.519258
Edge	34 49 41.818	1288.5	136 44 41.7	315 42 36.8	Reef 1	8100.3	3.908502
1878	120 34 39.394	1001.2	139 40 48.6	319 38 14.8	Point	11213.0	4.049721
			160 42 21.8	340 41 24.3	Lospe	7726.9	3.888007
San Antonio	34 47 45.200	1392.8	162 47 14.4	342 45 49.7	Point	12710.0	4.104146
1878	120 36 57.031	1449.8	167 46 52.1	347 46 05.9	Reef 1	9711.7	3.987295
			178 28 12.0	358 28 04.8	Rock	11884.0	4.074960
			184 56 37.4	4 56 58.6	Lospe	10927.0	4.038497
			224 13 06.5	44 14 25.1	Edge	5015.1	3.700281
Valdez	35 07 36.939	1138.4	51 30 22.2	231 29 32.8	Arroyo Grande	2782.6	3.444448
1873	120 36 22.379	566.6	125 07 09.9	305 04 55.6	Price	7218.8	3.858465
			184 58 23.2	4 58 32.2	Meierhoff	4540.1	3.657066
			318 49 35.7	138 50 34.9	Nipomo	3956.7	3.597333
			10 06 13.7	190 05 46.8	Cienega Sand	6766.3	3.830352
South Point	35 09 10.564	325.6	129 08 43.3	309 07 20.2	Valley View	4706.2	3.672670
1872	120 40 20.637	522.3	185 38 38.8	5 38 41.6	Price	1271.9	3.104444
			320 07 53.1	140 09 20.7	Arroyo Grande	6015.0	3.779235
Camp Hill	35 08 35.919	1107.0	108 30 59.3	288 29 46.8	South Point	3363.6	3.526810
1873	120 38 14.624	370.2	127 17 49.6	307 16 39.9	Price	3851.6	3.585644
			302 35 39.2	122 36 43.8	Valdez	3373.2	3.528045
			349 23 41.5	169 23 56.6	Arroyo Grande	3611.4	3.557680
Caballo	35 11 38.215	1177.7	124 43 15.8	304 42 29.5	Green Peak	2472.2	3.393078
1872	120 48 17.204	435.2	199 24 08.5	19 24 34.1	Saddle Peak	3379.2	3.528810
			263 30 24.0	83 31 35.3	Bare Hill	3147.1	3.497909
			307 30 57.4	127 32 20.4	San Luis Hill	4595.0	3.662286
West Point	35 12 30.639	944.2	137 06 10.4	317 04 55.3	Last	4837.4	3.684612
1872	120 50 03.521	89.1	142 33 32.0	322 32 59.2	Pecho	2366.7	3.374136
			206 45 35.3	26 46 04.2	Schumacher	2809.9	3.448688
			247 34 46.9	67 36 13.8	Saddle Peak	4122.9	3.615203
Cove	35 12 32.626	1005.5	161 09 43.8	341 09 16.8	Last	3679.1	3.565738
1872	120 51 26.767	677.2	200 07 58.9	20 08 14.1	Pecho	1936.0	3.286916
			271 39 33.5	91 40 21.5	West Point	2106.5	3.323564

Point Sal to Saddle Peak—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Santa Maria 1874	34 58 03.832 120 38 06.749	118.1 171.2	183 52 11.1	3 52 18.5	Oso Flaco	4831.6	3.684097
			193 25 13.3	13 25 55.3	Dune	8007.8	3.903514
			228 10 25.6	48 13 15.9	Steele	10108.3	4.004679
			232 54 14.1	52 55 53.8	Guadalupe	5532.0	3.742882
			340 34 29.2	160 35 11.3	Green Ridge	5631.8	3.750648
			348 34 03.1	168 34 35.7	Rock	7329.0	3.865046
			23 22 02.7	203 21 25.3	Smith Sand	4174.2	3.620575
Norriss 1874	34 57 28.459 120 34 44.913	876.9 1139.8	37 35 52.7	217 34 39.0	Green Ridge	5327.2	3.726498
			67 59 35.4	247 57 02.2	Smith Sand	7310.6	3.863955
			102 02 01.5	282 00 05.8	Santa Maria	5235.3	3.718940
			170 56 15.2	350 55 59.2	Guadalupe	4481.6	3.651433
			197 09 05.5	17 10 00.0	Steele	8192.6	3.913422
Whaler Point 1871	35 09 39.073 120 45 21.643	1204.2 557.8	239 04 40.7	59 05 52.3	Avila	3667.0	3.564314
			265 55 17.5	85 56 54.8	White Rock	4286.7	3.632122
San Luis Obispo Lat. Sta. 1852 1871	35 10 43.557 120 44 45.256	1342.4 1145.2	296 38 10.6	116 39 27.0	White Rock	3753.3	3.574414
			384 51 51.1	204 51 30.2	Whaler Point	2190.1	3.340476
San Luis Point Island, shanty 1872	35 09 35.408 120 45 14.550	1091.2 368.2	236 02 51	56 03 59	Avila	3576.1	3.553405
			239 47 06	59 48 32	Valley View	4382.4	3.641709
			264 10 38	84 12 11	White Rock	4117.6	3.614642
Pecho Rock, highest point 1872	35 10 47.586 120 48 58.182	1466.5 1472.2	204 27 08	24 27 57	Saddle Peak	5215.5	3.717295
			213 36 01	33 36 25	Caballo	1873.3	3.272599
			245 16 57	65 18 32	Bare Hill	4583.4	3.661192
			284 48 26	104 50 13	San Luis Hill	4842.5	3.685066
Bird Rock, highest point 1871	35 08 55.378 120 41 01.050	1706.7 26.6	106 43 47	286 40 59	San Luis Hill	7719.5	3.887588
			133 08 18	313 06 59	Avila	4725.3	3.674432
			156 42 23	336 42 01	S. Luis Obispo E. B.	2354.0	3.371811
			164 22 59	344 22 42	Mallagh	2982.1	3.474522
Boat Rock 1871	35 10 14.214 120 43 25.753	438.0 651.6	194 55 12	14 55 17	Avila	828.9	2.918494
			225 42 30	45 42 54	Valley View	1444.7	3.159778
			275 34 54	95 35 56	S. Luis Obispo E. B.	2744.1	3.438394
Hump, center of rock 1874	34 50 07.39 120 22 59.34	227.8 1507.8	130 43 52	310 35 20	Oso Flaco	29931.2	4.476124
			134 07 13	314 00 13	Guadalupe	25907.9	4.413432
			136 46 37	316 38 39	Dune	30870.5	4.489544
			144 10 41	324 04 51	Steele	26432.8	4.422144
Substitute 1878	34 53 41.776 120 36 31.542	1287.3 800.9	338 55 17.1	158 56 21.0	Edge	7452.9	3.872324
			2 14 08.5	182 14 00.6	Pond	8928.7	3.950787
			3 22 27.9	183 22 13.3	San Antonio	11007.0	4.041670
			61 01 57.2	241 00 56.3	Reef 1	3089.1	3.489835
			104 39 33.3	284 37 54.0	Point	4556.5	3.658630
			112 25 08.3	292 24 00.9	Peak	3234.4	3.509796
			132 45 41.1	312 45 19.4	Rock	1313.5	3.118427

Saddle Peak to Piedras Blancas.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Piedras Blancas L. H. 1883–90	35 39 57.367 121 17 01.187	1768.0 29.9	161 31 27.6	341 28 50.3	Silver Peak	21316.7	4.3287203
			270 03 03.06	90 10 54.83	Rocky Butte	20350.6	4.3085766
			303 03 41.59	123 28 51.04	San Luis	78435.7	4.8945136
			317 39 08.48	137 56 13.98	Saddle Peak	66389.1	4.8220968
Stone 1883	35 29 14.760 120 57 00.244	454.9 6.1	123 19 09.1	303 07 30.4	Piedras Bl. L. H.	36146.9	4.558071
			153 30 12.1	333 26 24.1	Rocky Butte	22088.7	4.344172
			303 12 04.6	123 25 35.4	San Luis	42288.7	4.626224
			333 57 13.5	154 02 41.8	Saddle Peak	32680.7	4.514292
Lane 1883	35 28 36.665 120 52 58.668	1130.0 1479.2	343 42 28.8	163 45 37.2	Saddle Peak	29374.9	4.467976
			100 55 53.2	280 53 33.0	Stone	6202.0	3.792532
			142 45 06.2	322 38 57.7	Rocky Butte	26320.1	4.420288

Saddle Peak to Piedras Blancas—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Villa	35 28 04.472	137.8	131 09 34.5	310 59 52.2	Piedras Bl. L. H.	33436.0	4.524214
1883	121 00 20.312	512.2	167 35 50.4	347 33 58.8	Rocky Butte	22454.6	4.351306
			246 44 28.9	66 46 25.0	Stone	5489.2	3.739510
			264 52 21.5	84 56 37.8	Lane	11178.8	4.048394
Irving	35 33 31.314	965.1	116 49 09.8	296 40 03.4	Piedras Bl. L. H.	26439.7	4.422256
1884	121 01 23.036	580.3	164 41 35.9	344 40 20.7	Rocky Butte	12293.1	4.089662
			320 02 05.8	140 04 38.5	Stone	10313.0	4.013383
			351 04 37.2	171 05 13.6	Villa	10196.1	4.008435
Estrada	35 31 51.152	1576.4	127 39 54.6	307 32 24.6	Piedras Bl. L. H.	24557.7	4.390188
1883	121 04 08.272	208.4	183 29 14.9	3 29 36.0	Rocky Butte	14971.1	4.175255
			233 25 26.1	53 27 02.2	Irving	5181.9	3.714492
			294 02 32.1	114 06 40.7	Stone	11814.3	4.072408
			320 32 49.7	140 35 02.1	Villa	9045.1	3.956411
Gordon	35 37 27.348	842.8	105 27 34.7	285 21 06.0	Piedras Bl. L. H.	17404.3	4.240657
1885	121 05 54.236	1365.0	217 57 50.0	37 59 12.8	Rocky Butte	5812.9	3.764390
			316 47 36.3	136 50 14.1	Irving	9976.4	3.998974
			345 33 03.8	165 34 05.5	Estrada	10699.2	4.029352
Field	35 36 18.402	567.1	224 18 12.3	44 20 44.0	Rocky Butte	9375.3	3.971983
1885	121 07 52.416	1319.4	234 26 51.1	54 27 59.9	Gordon	3655.3	3.562921
			297 40 46.8	117 44 33.4	Irving	11073.8	4.044295
			325 33 32.6	145 35 43.1	Estrada	9984.8	3.999340
Gillespie	35 36 58.386	1799.4	114 41 17.4	294 36 39.1	Piedras Bl. L. H.	13225.9	4.121424
1885	121 09 03.400	85.6	236 40 42.1	56 43 55.2	Rocky Butte	9973.1	3.998832
			259 21 53.2	79 23 43.4	Gordon	4843.3	3.685145
			304 35 23.6	124 36 05.0	Field	2170.3	3.336524
Fork	35 37 55.410	1707.7	287 52 08.5	107 53 10.6	Gordon	2817.2	3.449815
1885	121 07 40.789	1026.4	5 35 27.3	185 35 20.5	Field	3004.0	3.477697
			49 47 46.2	229 46 58.1	Gillespie	2722.2	3.434915
San Simeon	35 38 33.958	1046.5	258 34 59.3	78 39 50.6	Rocky Butte	12822.4	4.107971
1871	121 11 51.788	1303.0	304 47 31.0	124 49 09.1	Gillespie	5160.3	3.712675
Bare Ridge	35 38 55.406	1707.5	305 35 04.2	125 36 04.0	Fork	3177.0	3.502012
1885	121 09 23.472	590.4	352 01 36.6	172 01 48.3	Gillespie	3641.7	3.561301
			79 57 57.9	259 56 31.5	San Simeon	3789.4	3.578570
Pico 2	35 38 15.250	470.0	101 54 19.0	281 53 15.6	San Simeon	2797.0	3.446685
1885	121 10 03.006	75.6	218 47 07.1	38 47 30.1	Bare Ridge	1587.7	3.200780
			279 41 08.2	99 42 31.1	Fork	3630.2	3.559931
			327 39 16.5	147 39 51.2	Gillespie	2803.8	3.447749
Hearst	35 39 45.500	1402.2	310 06 07.4	130 06 49.9	Bare Ridge	2396.4	3.379563
1871	121 10 36.336	914.1	343 13 20.6	163 13 40.0	Pico 2	2905.1	3.463154
			40 43 46.4	220 43 02.4	San Simeon	2909.3	3.463786
Corral	35 39 40.562	1250.1	265 39 03.9	85 39 50.3	Hearst	2009.6	3.303118
1871	121 11 56.004	1408.7	357 02 30.8	177 02 33.3	San Simeon	2055.4	3.312902
San Simeon North Base	35 39 18.290	563.7	19 29 51.9	199 29 40.7	San Simeon	1449.4	3.161183
1871	121 11 32.559	819.0	139 20 05.0	319 19 51.3	Corral	904.9	2.956621
			239 19 46.5	59 20 19.2	Hearst	1644.2	3.215944
Leitner	35 39 37.470	1154.8	264 53 24.6	84 53 49.3	Corral	1070.6	3.029609
1871	121 12 38.396	965.8	289 38 17.7	109 38 56.1	San Simeon N. Base	1758.4	3.245120
			329 04 27.9	149 04 55.1	San Simeon	2281.7	3.358259
San Simeon South Base	35 38 55.038	1696.2	135 56 06.4	315 55 37.0	Leitner	1820.1	3.260095
1871	121 11 48.072	1209.4	171 54 24.4	351 54 19.8	Corral	1417.1	3.151415
			208 34 07.5	28 34 16.5	San Simeon N. Base	815.98	2.911682
Moro Rock	35 22 11.000	339.0	337 26 04.7	157 28 39.4	Saddle Peak	17663.3	4.247073
1881	120 52 00.838	21.2	130 52 58.9	310 48 09.4	Villa	16656.8	4.221592
			149 58 55.4	329 56 01.8	Stone	15086.2	4.178580
			152 06 11.3	331 59 29.5	Rocky Butte	37157.5	4.570047
			173 00 24.6	352 59 51.1	Lane	11974.7	4.078264
Cass	35 26 56.456	1739.9	345 46 14.4	165 47 05.6	Moro Rock	9075.4	3.957864
1883	120 53 29.205	736.6	101 27 51.8	281 23 53.3	Villa	10576.3	4.024335
			128 42 47.8	308 40 45.3	Stone	6817.6	3.833633
			193 59 52.3	14 00 10.0	Lane	3182.8	3.502813
Hall	35 25 43.100	1328.3	355 52 12.2	175 52 23.1	Moro Rock	6553.5	3.816473
1883	120 52 19.534	492.7	109 48 13.2	289 43 34.4	Villa	12883.9	4.110048
			142 08 49.8	322 08 09.5	Cass	2863.4	3.456878
			169 32 59.1	349 32 36.4	Lane	5439.3	3.735540

Saddle Peak to Piedras Blancas—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
San Simeon Lat. Sta. 1874	35 38 33.958	1046.5					
	121 11 52.030	1309.1					
Mack	35 26 30.231	931.7	51 02 36.0	231 01 54.7	Hall	2309.9	3.363593
1883	120 51 08.327	210.0	102 49 36.4	282 48 14.8	Cass	3643.8	3.561551
			144 28 46.9	324 27 42.9	Lane	4787.9	3.680147
Rock	35 24 39.395	1214.1	6 55 44.5	186 55 31.8	Moro Rock	4606.8	3.663403
1883	120 51 38.821	979.5	152 23 11.6	332 22 48.0	Hall	2215.7	3.345515
			192 41 21.2	12 41 38.9	Mack	3501.3	3.544231
Toro	35 25 11.938	367.9	18 35 35.6	198 34 52.6	Moro Rock	5883.0	3.769597
1883	120 50 46.532	1174.0	52 45 42.8	232 45 12.6	Rock	1657.2	3.219372
			112 16 06.8	292 15 12.9	Hall	2535.1	3.403997
			167 09 55.6	347 09 43.0	Mack	2474.7	3.393524
Black Hill	35 21 31.928	984.0	110 16 50.8	290 15 36.1	Moro Rock	3475.6	3.541028
1881	120 49 51.693	1305.1	154 55 43.0	334 54 41.0	Rock	6378.7	3.804735
			168 28 02.9	348 27 31.1	Toro	6920.1	3.840110
Chaparral	35 17 48.211	1485.8	172 52 17.0	352 51 53.8	Moro Rock	8161.7	3.911780
1881	120 51 20.716	523.4	198 03 18.8	18 04 10.3	Black Hill	7251.8	3.860446
Sand Dune	35 17 28.619	882.0	210 27 37.7	30 29 18.7	Black Hill	8700.1	3.939523
1881	120 52 46.382	1172.0	254 24 27.7	74 25 17.2	Chaparral	2247.2	3.351647
Hazard	35 17 01.238	38.2	115 16 15.7	295 15 34.8	Sand Dune	1977.0	3.296016
1881	120 51 35.629	900.3	194 35 25.7	14 35 34.3	Chaparral	1495.8	3.174886
Valencia	35 15 48.536	1495.8	166 28 21.3	346 28 04.1	Sand Dune	3172.3	3.501379
1881	120 52 17.017	430.2	205 01 24.1	25 01 47.8	Hazard	2472.6	3.393158
Oats	35 15 25.446	784.2	111 37 18.3	291 36 37.3	Valencia	1931.6	3.285924
1881	120 51 05.975	151.0	165 45 23.3	345 45 06.0	Hazard	3045.7	3.483689
Last	35 14 25.612	789.3	178 09 01.0	358 08 59.1	Valencia	2556.8	3.407702
1881	120 52 13.752	347.7	222 53 41.9	42 54 21.0	Oats	2517.2	3.400911
			285 29 17.0	105 31 59.1	Saddle Peak	7372.4	3.867611
Pecho	35 13 31.610	974.2	131 54 44.0	311 54 01.7	Last	2491.6	3.396486
1872	120 51 00.416	10.5	177 42 23.2	357 42 20.1	Oats	3510.9	3.545424
			273 19 59.7	93 21 59.4	Saddle Peak	5259.0	3.720903
Beach	35 18 22.828	703.5	182 58 03.9	2 58 12.2	Moro Rock	7041.2	3.847646
1881	120 52 15.279	386.0	211 52 51.7	31 54 14.7	Black Hill	6863.8	3.836563
			307 43 50.9	127 44 22.3	Chaparral	1743.1	3.241326
			338 16 22.1	158 16 44.9	Hazard	2706.6	3.432430
			25 11 45.7	205 11 27.6	Sand Dune	1846.2	3.266279
Schumacher	35 13 52.049	1604.1	76 53 42.3	256 52 40.6	Pecho	2776.3	3.443474
1881	120 49 13.489	341.1	102 47 58.4	282 46 14.4	Last	4673.9	3.669678
			135 21 08.0	315 20 03.2	Oats	4046.3	3.607054
			290 12 07.3	110 13 05.4	Saddle Peak	2712.9	3.433429
Castro	35 39 09.528	293.6	251 19 13.8	71 20 12.8	Leitner	2689.9	3.429740
1871	121 14 19.706	495.8	286 24 10.5	106 25 36.7	San Simeon	3879.3	3.588754
Oak Knoll	35 39 53.416	1646.2	145 44 26.6	325 43 04.2	Cinnabar	6306.7	3.799804
1872	121 14 20.526	516.3	280 49 20.1	100 50 19.6	Leitner	2615.4	3.417538
			359 07 31.4	179 07 31.8	Castro	1352.8	3.131218
Piedra Blanca	35 39 58.186	1793.2	160 50 44.9	340 50 09.7	La Cruz	4625.3	3.665140
1872	121 17 00.078	2.0	165 10 15.9	345 09 35.8	Yellow Hill	6758.0	3.829815
			185 11 35.8	5 11 46.5	Cinnabar	5085.7	3.706348
			272 05 06.6	92 06 39.6	Oak Knoll	4015.7	3.603756
			290 22 46.6	110 24 20.1	Castro	4303.6	3.633836
Scott	35 34 36.736	1132.2	120 56 52.4	300 54 51.5	Field	6095.7	3.785025
1885	121 04 24.714	622.2	156 48 31.8	336 47 39.7	Gordon	5720.6	3.757445
			187 39 51.7	7 40 22.4	Rocky Butte	9929.1	3.996908
			293 46 06.1	113 47 51.9	Irving	4999.6	3.698034
			355 21 33.2	175 21 42.9	Estrada	5119.9	3.709260
Rosa	35 33 51.910	1599.8	149 07 11.2	329 06 08.8	Field	5260.9	3.721062
1885	121 06 05.141	129.5	241 20 39.4	61 21 37.8	Scott	2881.6	3.459633
			275 04 56.6	95 07 40.9	Irving	7132.8	3.853260
			321 38 49.8	141 39 58.1	Estrada	4745.1	3.676244
Cambria Rock	35 34 14.252	439.2	167 25 09.7	347 24 50.0	Field	3920.4	3.593325
1885	121 07 18.491	465.6	290 26 18.5	110 27 01.2	Rosa	1971.3	3.294748
			312 36 49.9	132 38 40.8	Estrada	6363.6	3.803706

Saddle Peak to Piedras Blancas—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Pico Rock	35 35 50.119	1544.6	148 46 49.8	328 46 20.4	Gillespie	2460.3	3.390985
1885	121 08 12.730	320.4	210 23 43.1	30 23 54.9	Field	1010.6	3.004560
			318 35 04.0	138 36 18.2	Rosa	4857.1	3.686380
Blank	35 39 22.654	698.2	141 51 24.9	321 51 16.6	Leitner	580.6	2.763893
1871	121 12 24.140	607.2	232 02 54.9	52 03 11.3	Corral	897.5	2.953029
			275 54 48.4	95 55 18.4	San Simeon N. Base	1304.4	3.115423
			313 09 59.5	133 10 20.5	San Simeon S. Base	1244.0	3.094830
			331 31 35.1	151 31 53.9	San Simeon	1707.2	3.232295
Castro's house, north chimney	35 39 17.728	546.4	237 54 33	57 54 56	Leitner	1145.4	3.058939
1871	121 13 16.974	427.1	263 28 48	83 29 19	Blank	1337.7	3.126353
			302 10 56	122 11 46	San Simeon	2532.2	3.403506
Pico	35 38 06.725	207.2	105 42 29.2	285 41 20.0	San Simeon	3102.0	3.491641
1871	121 09 53.095	1336.0	133 05 44.6	313 04 32.9	Corral	4233.7	3.626721
			160 20 23.8	340 19 58.6	Hearst	3232.7	3.509564
Fairview	35 40 47.056	1450.2	313 08 24.1	133 09 05.0	Oak Knoll	2417.4	3.383346
1872	121 15 30.658	771.0	56 11 44.3	236 10 52.1	Piedra Blanca	2706.6	3.432425
			127 15 13.9	307 13 46.5	La Cruz	4730.8	3.674934
			141 39 15.7	321 37 43.4	Yellow Hill	6410.2	3.806875
			153 19 55.6	333 19 14.1	Cinnabar	3982.5	3.600153
Buryar	35 39 51.586	1589.8	96 39 28.2	276 38 47.7	Piedra Blanca	1756.1	3.244550
1872	121 15 50.727	1275.9	196 26 49.6	16 27 01.3	Fairview	1782.5	3.251032
			268 34 05.6	88 34 58.2	Oak Knoll	2269.4	3.355914
			299 30 29.6	119 31 22.5	Castro	2631.0	3.420117
Chaparral Hill	35 40 43.845	1351.2	312 53 16.6	132 53 55.4	Oak Knoll	2283.4	3.358588
1872	121 15 27.044	680.2	329 46 00 8	149 46 39.9	Castro	3364.2	3.526882
			20 17 48.1	200 17 34.3	Buryar	1717.2	3.234823
			58 59 01.7	238 58 07.2	Piedra Blanca	2730.3	3.436208
			152 49 12.0	332 48 28.3	Cinnabar	4111.9	3.614038
Point	35 26 54.176	1669.6	113 11 59.4	293 10 03.0	Villa	5503.0	3.740598
1883	120 56 59.704	1505.7	269 13 29.2	89 15 31.3	Cass	5309.1	3.725020
			287 11 58.4	107 14 40.8	Hall	7398.3	3.869130
Red Rock	35 26 52.513	1618.4	109 31 43.1	289 29 19.1	Villa	6640.7	3.822212
1883	120 56 12.082	304.7	268 17 33.4	88 19 07.9	Cass	4109.4	3.613783
			290 01 08.0	110 03 22.8	Hall	6257.6	3.796410
Black Rock	35 26 40.406	1245.2	109 11 56.8	289 09 05.4	Villa	7887.7	3.896949
1883	120 55 24.873	627.3	260 22 01.1	80 23 08.2	Cass	2958.7	3.471108
			290 40 51.5	110 42 38.9	Hall	4997.3	3.698735
Cayucos	35 27 03.388	104.4	220 57 58.1	40 58 55.5	Lane	3807.5	3.580637
1883	120 54 37.684	950.4	277 02 44.4	97 03 24.1	Cass	1740.1	3.240571
			305 22 04.3	125 23 24.4	Hall	4273.6	3.630790
Cayucos Presbyterian Church	35 27 07.112	219.2	214 23 57.2	34 24 40.7	Lane	3345.1	3.524405
1883	120 54 13.630	343.8	286 20 00.4	106 20 26.1	Cass	1167.4	3.067234
			311 58 08.1	131 59 14.3	Hall	3871.0	3.587822
Willow	35 25 40.090	1235.5	160 03 10.6	340 02 50.0	Cass	2503.8	3.398591
1883	120 52 55.336	1395.9	264 07 55.0	84 08 15.7	Hall	907.9	2.958031
			314 05 30.6	134 06 14.9	Rock	2687.9	3.429419
Whale Rock	35 26 07.015	216.2	109 18 46.5	289 14 48.5	Villa	10627.9	4.026446
1883	120 53 29.964	755.7	180 43 01.4	0 43 01.9	Cass	1523.8	3.182936
			292 31 33.9	112 32 14.7	Hall	1923.3	3.284053
			313 54 50.1	133 55 54.5	Rock	3892.7	3.590246
			326 58 10.9	147 00 17.3	Black Hill	10109.9	4.004746
Ring	35 24 31.812	980.4	171 35 32.6	351 35 25.1	Hall	2220.8	3.346517
1883	120 52 06.661	168.1	251 35 48.5	71 36 04.6	Rock	740.3	2.869401
			328 25 07.2	148 26 25.3	Black Hill	6506.7	3.813358
			358 03 34.7	178 03 38.1	Moro Rock	4342.0	3.637692
Merrill	35 23 55.989	1725.5	195 11 20.3	15 11 28.6	Rock	1386.1	3.141799
1883	120 51 53.216	1342.7	325 20 58.7	145 22 09.0	Black Hill	5396.2	3.732090
			3 24 12.2	183 24 07.8	Moro Rock	3241.2	3.510711
Fisherman	35 16 24.278	748.2	214 27 25.0	34 27 56.1	Sand Dune	2404.9	3.381091
1881	120 53 40.230	1016.7	250 06 16.3	70 07 28.3	Hazard	3348.6	3.524868
			297 38 01.5	117 38 49.8	Valencia	2374.2	3.375524

Saddle Peak to Piedras Blancas—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Buckhorn	35 14 46.370	1429.0	155 21 26.1	335 20 54.2	Fisherman	3319.7	3.521099
1881	120 52 45.464	1149.3	200 34 20.7	20 34 37.1	Valencia	2046.3	3.310973
			244 24 27.4	64 25 24.8	Oats	2788.6	3.445380
			308 34 55.0	128 35 13.3	Last	1025.7	3.011025
Buchon	35 15 19.556	602.7	191 30 40.2	11 30 49.1	Fisherman	2035.5	3.308668
1881	120 53 56.304	1423.4	250 24 16.4	70 25 13.7	Valencia	2663.9	3.425524
			299 43 25.7	119 44 06.6	Buckhorn	2062.3	3.314357
Hollister Peak	35 20 39.496	1217.2	2 33 55.5	182 31 41.2	Saddle Peak	13507.2	4.130564
1883	120 47 08.915	225.1	110 57 37.3	290 54 48.3	Moro Rock	7891.5	3.897158
			136 50 02.0	316 44 19.2	Stone	21788.4	4.338225
			149 03 37.1	329 00 14.4	Lane	17150.0	4.234265
Pico's house, west gable	35 37 57.547	1773.5	106 45 11	286 43 45	San Simeon	3895.8	3.590595
1871	121 09 23.512	591.6	110 48 37	290 48 21	Pico	796.3	2.901069
			151 09 59	331 09 17	Hearst	3798.1	3.579565
Pine Mountain	35 41 24.512	755.4	298 48 42.2	119 17 26.6	San Jose	85605.0	4.9324992
1884	121 05 37.585	945.1	310 48 52.5	130 50 05.7	Rocky Butte	4171.4	3.6202826
			333 09 50.3	153 26 45.8	Lospe	98860.9	4.9950246
Piedras Blancas E. Rock	35 39 54.626	1683.5	166 11 23	346 10 56	La Cruz	4612.3	3.663917
1872	121 17 16.650	418.8	189 37 06	9 37 26	Cinnabar	5248.4	3.720024
			238 46 03	58 47 05	Fairview	3117.2	3.493759
Rocky Peak	35 42 19.450	599.4	63 13 36	243 09 07	Castro	12976.9	4.113170
1871	121 06 39.121	983.5	71 51 25	251 46 03	Buryar	14599.7	4.164345
			77 31 38	257 26 30	Chaparral Hill	13596.7	4.133434
Creek*	35 33 52.09	1605.3	154 37 26	334 36 37	Field	4991.3	3.69821
1885	121 06 27.44	691.0	270 35 28	90 35 41	Rosa	561.7	2.74951
Leffingwell*	35 35 05.14	158.4	158 39 57	338 39 37	Field	2424.4	3.38461
1885	121 07 17.36	437.1	321 07 33	141 08 15	Rosa	2898.9	3.46223
Woody Top Hill	35 43 09.984	307.7	44 40 20	224 38 39	Fairview	6192.7	3.791882
1872	121 12 37.524	943.3	48 10 44	228 08 11	Piedra Blanca	8861.1	3.947487
			79 16 13	259 13 05	La Cruz	8262.4	3.917104
			82 10 15	262 07 52	Cinnabar	6197.2	3.792197
Camp*	35 30 37.99	1170.8	114 49 19	294 47 27	Estrada	5374.3	3.73032
1884	121 00 54.66	1377.4	172 22 46	352 22 30	Irving	5389.3	3.73153
Gence	35 30 28.77	886.6	138 03 24	318 02 31	Estrada	3413.9	3.53325
1884	121 02 37.70	950.0	198 28 51	18 29 34	Irving	5932.0	3.77320
Murphy*	35 30 48.52	1495.3	144 08 19	324 07 47	Estrada	2381.7	3.37689
1884	121 03 12.89	324.8	208 52 20	28 53 24	Irving	5729.7	3.75813
Perry*	35 31 22.12	681.7	150 00 36	330 00 24	Estrada	1032.9	3.01405
1884	121 03 47.78	1203.8	222 28 15	42 29 39	Irving	5398.7	3.73229
White Rock*	35 31 59.77	1842.0	278 49 58	98 50 37	Estrada	1729.0	3.23780
1884	121 05 16.08	405.1	314 11 09	134 14 01	Villa	10399.7	4.01702
Allen*	35 32 02.70	83.2	238 15 31	58 17 13	Irving	5193.1	3.71543
1884	121 04 18.40	463.5	324 22 32	144 22 38	Estrada	437.9	2.64137
White*	35 20 50.36	1552.0	139 00 46	318 59 56	Moro Rock	3292.5	3.51753
1883	120 50 35.29	891.1	220 40 20	40 40 45	Black Hill	1689.0	3.22763
Larsen*	35 19 55.83	1720.6	151 14 35	331 13 43	Moro Rock	4752.0	3.67688
1883	120 50 30.28	764.9	198 12 25	18 12 47	Black Hill	3117.7	3.49383
Baker*	35 20 41.26	1271.6	167 47 53	347 47 39	Moro Rock	2829.4	3.45170
1883	120 51 37.15	938.1	239 36 15	59 37 16	Black Hill	3086.7	3.48949
Pine 2*	35 34 05.67	174.7	282 00 02	102 01 57	Irving	5085.5	3.70633
1885	121 04 40.55	1021.0	348 54 10	168 54 29	Estrada	4224.5	3.62578
Lone Tree	35 41 11.72	361.2	354 29 26	174 29 32	Hearst	2669.4	3.42642
1872	121 10 46.52	1169.9	31 53 13	211 52 33	Corral	3308.3	3.51961
Oak Top Hill	35 41 07.94	244.7	29 51 02	209 49 59	San Simeon	5470.9	3.73806
1872	121 10 03.55	89.3	54 24 41	234 23 11	Leitner	4789.5	3.68029
Sharp Point	35 39 22.32	687.9	83 07 14	263 02 29	San Simeon	12373.1	4.09248
1872	121 03 43.58	1096.3	92 01 59	271 56 47	Leitner	13458.9	4.12901

*No check on this position.

Saddle Peak to Piedras Blancas—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Pine Top Hill to eastward	35 41 25.66	790.8	81 06 30	260 59 53	Piedra Blanca	17332.1	4.23885
1872	121 05 39.17	984.9	98 08 48	278 02 21	Cinnabar	16826.7	4.22600
Bare Top Hill	35 40 38.26	1179.1	43 44 12	223 42 47	San Simeon	5301.3	3.72438
1872	121 09 26.11	656.6	69 42 06	249 39 15	Castro	7874.4	3.89622
Castle Top Hill	35 39 56.22	1732.6	90 14 09	270 05 17	Piedra Blanca	20358.2	4.30874
1872	121 03 30.65	770.8	104 30 45	284 23 04	Cinnabar	.0541.4	4.31263
Lone Pine	35 43 16.52	509.1	11 18 36	191 18 15	Fairview	4697.6	3.67188
1872	121 14 54.02	1357.8	69 36 21	249 34 32	La Cruz	4999.8	3.69895
San Simeon Lat. Sta.	35 38 36.3	1118.7					
1852	121 11 26.4	664.2					
Tepusquet Latitude Sta.	34 54 38.02	1171.7					
1882	120 11 10.03	254.7					
Lospe Latitude Station	34 53 38.47	1185.5					
1883	120 36 20.01	507.9					

Piedras Blancas to Point Sur.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Silver Peak	35 50 53.290	1642.3	170 44 15.5	350 42 08.8	Santa Lucia	33479.6	4.5247804
1887	121 21 30.387	762.5	306 41 58.7	126 52 28.8	Rocky Butte	33826.4	4.5292563
Cone Peak	36 03 08.330	256.8	213 47 34.7	33 50 18.6	Santa Lucia	12501.7	4.0969702
1890	121 29 44.074	1103.2	317 17 01.6	137 32 22.5	Rocky Butte	58284.6	4.7655539
			331 19 07.9	151 23 57.7	Silver Peak	25813.0	4.4118392
Rock Slide	36 07 28.485	878.0	261 44 31.0	81 50 58.4	Santa Lucia	16597.1	4.2200320
1890	121 36 02.941	73.5	310 11 55.2	130 15 38.4	Cone Peak	12415.2	4.0939534
			324 27 17.2	144 35 49.9	Silver Peak	37664.2	4.5759289
Pico Blanco	36 19 08.491	261.7	298 25 49.0	118 39 44.7	Santa Lucia	40193.6	4.6041566
1875	121 48 39.792	992.6	316 06 29.4	136 17 39.9	Cone Peak	41001.8	4.6128028
			318 42 56.6	138 50 23.8	Rock Slide	28685.1	4.4576562
Santa Lucia West	36 08 46.142	1422.3	328 27 45.0	148 40 27.2	Rocky Butte	62493.2	4.7958327
1890	121 25 11.682	292.0	350 27 58.6	170 30 08.6	Silver Peak	33527.8	4.5254055
			33 13 26.3	213 10 45.8	Cone Peak	12443.3	4.0949363
			81 41 28.7	261 35 04.5	Rock Slide	16458.5	4.2163915
			118 43 42.6	298 29 50.3	Pico Blanco	40055.5	4.6026626
Anderson	36 10 52.200	1609.0	135 16 49.4	315 10 50.0	Pico Blanco	21546.5	4.333376
1890	121 38 32.012	799.9	280 55 05.5	101 03 01.2	Santa Lucia	20523.2	4.312246
			280 55 34.8	101 03 27.1	Santa Lucia West	20377.5	4.309150
			317 14 06.0	137 19 17.2	Cone Peak	19461.2	4.289170
			329 17 58.6	149 19 26.5	Rock Slide	7301.4	3.863408
Manuel	36 16 11.538	355.6	144 44 40.8	324 43 09.3	Pico Blanco	6680.2	3.824791
1890	121 46 05.212	130.1	293 30 43.1	113 43 07.0	Santa Lucia	34331.9	4.535698
			293 34 13.0	113 46 33.5	Santa Lucia West	34190.4	4.533904
			310 58 24.9	131 02 52.7	Anderson	14999.5	4.176078
Pfeiffers Point	36 14 08.979	276.8	181 01 43.6	1 01 47.5	Pico Blanco	9233.2	3.965353
1890	121 48 46.438	1159.7	226 48 14.8	46 49 50.1	Manuel	5520.1	3.741950
			291 30 42.5	111 36 45.4	Anderson	16503.2	4.217569
			302 50 24.7	122 57 55.3	Rock Slide	22724.1	4.356486
			305 23 40.3	125 34 54.0	Cone Peak	35075.3	4.545001
Coopers Southeast Corner	36 15 28.190	868.9	187 12 43.6	7 13 04.0	Pico Blanco	6844.5	3.835339
1890	121 49 14.239	355.5	254 10 28.0	74 12 19.8	Manuel	4904.1	3.690558
			297 53 06.4	117 59 25.9	Anderson	18156.6	4.259034
			306 43 32.7	126 51 19.8	Rock Slide	24688.1	4.392488
			307 50 39.4	128 02 09.7	Cone Peak	37089.2	4.569248
			344 07 35.8	164 07 52.3	Pfeiffers Point	2538.2	3.404529

* No check on this position.

Piedras Blancas to Point Sur—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Sur River	36 17 01.724	53.1	229 55 19.2	49 57 09.4	Pico Blanco	6070.8	3.783244
1875	121 51 46.009	1148.2	280 16 44.9	100 20 06.5	Manuel	8645.2	3.936775
			307 15 35.4	127 17 05.2	Coopers SE. Corner	4760.5	3.677650
Little River Hill	36 18 59.812	1843.6	267 08 39.4	87 10 47.5	Pico Blanco	5402.8	3.732618
1875	121 52 16.112	402.0	325 09 15.0	145 11 02.6	Coopers SE. Corner	7946.4	3.900173
			348 20 15.8	168 20 33.6	Sur River	3716.5	3.570134
San Martin Top	35 52 33.361	1028.1	148 38 40.6	328 32 05.3	Rock Slide	32325.8	4.509549
1887	121 24 50.297	1261.7	159 24 37.7	339 21 45.2	Cone Peak	20909.0	4.320334
			178 58 42.7	358 58 30.4	Santa Lucia West	29987.0	4.476933
			179 15 08.1	359 14 58.9	Santa Lucia	29959.7	4.476538
			301 34 19.0	121 36 16.1	Silver Peak	5888.1	3.769973
			333 08 05.1	153 12 40.3	Piedras Bl. L. H.	26109.8	4.416804
Alder Top	35 53 03.632	111.9	77 08 27.8	257 06 52.4	San Martin Top	4187.9	3.621995
1887	121 22 07.537	189.0	141 56 22.1	321 48 11.0	Rock Slide	33886.2	4.530023
			148 29 49.5	328 25 21.3	Cone Peak	21867.8	4.339806
			170 59 43.4	350 57 55.3	Santa Lucia West	29412.9	4.468538
			171 15 51.9	351 14 07.0	Santa Lucia	29366.0	4.467845
			346 56 05.1	166 56 26.9	Silver Peak	4123.9	3.615308
Lion Peak	35 51 06.325	194.9	83 20 12.6	263 18 52.5	Silver Peak	3456.5	3.538636
1887	121 19 13.576	340.6	107 38 37.0	287 35 19.7	San Martin Top	8863.7	3.947614
			129 39 11.0	309 37 29.1	Alder Top	5667.4	3.753380
			144 40 26.6	324 34 16.4	Cone Peak	27292.2	4.436038
			164 40 30.4	344 36 59.9	Santa Lucia West	33873.8	4.529864
			164 53 54.5	344 50 27.3	Santa Lucia	33811.8	4.529068
Soda	35 50 09.793	301.8	139 22 37.8	319 21 09.2	San Martin Top	5830.8	3.765729
1887	121 22 18.961	475.9	155 06 03.5	335 01 42.3	Cone Peak	26461.8	4.422620
			183 03 40.0	3 03 46.7	Alder Top	5365.5	3.729607
			303 39 21.3	123 50 19.8	Rocky Butte	34050.6	4.532125
			337 02 46.2	157 05 51.9	Piedras Bl. L. H.	20494.0	4.311627
Gate Pine	35 55 57.482	1771.5	156 27 48.8	336 25 33.0	Cone Peak	14486.3	4.160957
1888	121 25 52.953	1327.3	182 29 37.6	2 30 01.9	Santa Lucia West	23713.6	4.374998
			182 50 35.8	2 51 03.5	Santa Lucia	23695.3	4.374662
			313 27 05.6	133 29 17.9	Alder Top	7788.3	3.891444
			345 58 21.3	165 58 57.9	San Martin Top	6484.3	3.811865
Salmon Top	35 48 45.809	1411.8	132 06 41.6	312 05 34.6	Soda	3860.7	3.586665
1887	121 20 24.847	623.8	157 17 13.1	337 16 34.7	Silver Peak	4259.5	3.629356
			202 26 16.5	22 26 58.2	Lion Peak	4685.6	3.670768
			302 36 04.0	122 45 55.4	Rocky Butte	30237.0	4.480538
			342 32 22.1	162 34 21.0	Piedras Bl. L. H.	17071.6	4.232274
Lopez	36 01 20.647	913.8	242 47 31.2	62 49 50.3	Cone Peak	6656.6	3.823253
1890	121 33 40.598	1016.5	311 06 36.0	131 11 10.7	Gate Pine	15558.6	4.191970
			321 09 18.7	141 14 30.2	San Martin Top	21209.3	4.326526
Lopez Point	36 01 12.627	389.2	223 36 18.6	43 36 30.4	Lopez	724.5	2.860026
1888	121 34 00.553	13.8	240 55 52.7	60 58 23.6	Cone Peak	7344.7	3.865975
			308 26 55.0	128 31 41.4	Gate Pine	15607.0	4.193318
			319 12 13.5	139 17 36.7	San Martin Top	21126.3	4.324824
Boronda	36 01 54.829	1690.0	157 29 41.2	337 26 59.3	Anderson	17930.9	4.253603
1890	121 33 57.352	1436.1	163 01 07.3	342 59 53.3	Rock Slide	10753.2	4.031537
			312 11 15.3	132 16 00.1	Gate Pine	16387.8	4.214520
			331 36 38.4	151 36 48.4	Lopez	882.2	2.945550
			3 31 47.1	183 31 45.3	Lopez Point	1303.1	3.114992
Dolan	36 05 18.821	580.1	131 33 41.6	311 26 25.8	Pfeiffers Point	24659.9	4.391991
1890	121 36 27.524	688.6	134 29 25.2	314 21 52.7	Coopers SE. Corner	26831.2	4.428640
			163 09 27.8	343 08 14.4	Anderson	10736.5	4.030861
			188 44 41.0	8 44 55.7	Rock Slide	4043.5	3.606755
			291 41 17.2	111 45 14.7	Cone Peak	10867.5	4.036129
			329 07 04.7	149 08 33.2	Boronda	7325.0	3.864808
Anderson Point	36 09 02.352	72.5	123 34 02.3	303 28 25.3	Pfeiffers Point	17113.8	4.233347
1890	121 39 15.386	384.6	197 45 04.8	17 45 30.4	Anderson	3555.1	3.550847
			301 00 08.8	121 02 02.4	Rock Slide	5614.5	3.749309
			328 37 54.6	148 39 33.6	Dolan	8067.8	3.906757
Bald Top	35 46 37.882	1167.5	134 42 26.2	314 40 53.5	Salmon Top	5605.8	3.748638
1887	121 17 46.149	1159.1	144 26 51.1	324 24 40.0	Silver Peak	9677.6	3.985766
			151 07 47.7	331 05 14.8	Alder Top	13579.0	4.132867
			299 54 48.7	120 03 07.3	Rocky Butte	24783.1	4.394155
			354 45 55.3	174 46 21.6	Piedras Bl. L. H	12395.4	4.093260

Piedras Blancas to Point Sur—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Jones Top	35 48 25.118	774.1	48 42 33.8	228 41 06.0	Bald Top	5007.3	3.699607
1887	121 15 16.352	410.5	94 43 54.9	274 40 54.4	Salmon Top	7771.3	3.890493
			115 58 09.9	295 54 30.9	Silver Peak	10440.2	4.018709
			129 51 42.8	309 49 23.9	Lion Peak	7754.9	3.889576
Pine Top	35 44 56.533	1742.2	137 04 10.9	317 01 37.8	Salmon Top	9645.3	3.984722
1888	121 16 02.923	73.4	140 18 34.1	320 17 33.6	Bald Top	4059.7	3.608492
			143 14 12.4	323 11 00.8	Silver Peak	13729.7	4.137662
			157 13 53.8	337 12 02.3	Lion Peak	12361.6	4.092073
			190 18 29.7	10 18 57.1	Jones Top	6534.2	3.815189
			296 04 29.7	116 11 47.8	Rocky Butte	21025.0	4.322737
Ragged Point	35 45 32.075	988.4	153 14 42.4	333 13 01.5	Soda	9586.7	3.981670
1873	121 19 27.006	678.4	166 19 53.2	346 19 19.4	Salmon Top	6145.1	3.788526
			231 18 43.3	51 19 42.1	Bald Top	3245.3	3.511250
			282 02 33.8	102 04 33.0	Pine Top	5243.0	3.719580
China Gulch	35 43 36.932	1138.2	169 20 42.6	349 20 27.1	Ragged Point	3611.0	3.557623
1873	121 19 00.430	10.8	198 29 46.3	18 30 29.5	Bald Top	5880.8	3.769439
			241 10 29.1	61 12 12.8	Pine Top	5090.7	3.706774
			336 05 43.1	156 06 52.6	Piedras Bl. L. H.	7401.3	3.869306
Yellow Hill	35 43 30.154	929.3	99 10 00.6	279 09 30.5	China Gulch	1311.9	3.117909
1873	121 18 08.896	223.6	152 25 36.7	332 24 51.1	Ragged Point	4239.3	3.627294
			185 38 20.9	5 38 34.0	Bald Top	5813.9	3.764469
			229 55 35.0	49 56 48.6	Pine Top	4136.2	3.616601
			345 26 34.0	165 27 13.4	Piedras Bl. L. H.	6775.4	3.830932
Rico	36 14 03.807	117.3	93 11 21.1	273 10 13.2	Pfeiffers Point	2873.7	3.458437
1890	121 46 51.537	1287.0	126 08 23.6	306 06 59.3	Coopers SE. Corner	4411.3	3.644565
			138 25 27.6	318 22 15.7	Little River Hill	12201.1	4.086399
			163 57 29.6	343 56 25.5	Pico Blanco	9772.1	3.989986
			196 22 02.3	16 22 29.7	Manuel	4103.3	3.613138
			295 17 11.1	115 22 06.2	Anderson	13805.2	4.140042
			309 09 05.9	129 13 35.1	Anderson Point	14704.4	4.167448
Castro	36 13 24.912	767.9	100 24 41.7	280 21 46.4	Pfeiffers Point	7533.2	3.876981
1890	121 43 49.729	1242.0	104 48 20.8	284 46 33.4	Rico	4696.0	3.671727
			115 08 59.6	295 05 47.9	Coopers SE. Corner	8949.6	3.951804
			146 38 24.6	326 37 04.5	Manuel	6149.8	3.788858
			300 38 33.7	120 41 41.4	Anderson	9227.8	3.965100
			319 42 39.9	139 45 21.8	Anderson Point	10605.6	4.025537
			323 32 40.8	143 37 01.8	Dolan	18618.5	4.269945
Timber Top	36 12 57.970	1786.8	104 14 54.3	284 11 30 0	Pfeiffers Point	8909.7	3.949864
1890	121 43 00.616	15.4	109 24 13.9	289 21 57.5	Rico	6113.8	3.786309
			116 25 28.8	296 21 48.1	Coopers SE. Corner	10415.4	4.017678
			124 06 00.5	304 05 31.5	Castro	1481.3	3.170643
			142 19 38.6	322 17 49.5	Manuel	7539.2	3.877328
			299 59 30.6	120 02 09.0	Anderson	7749.7	3.889287
			312 18 55.5	132 26 45.2	Cone Peak	26961.9	4.430751
			314 10 41.5	134 14 47.8	Rock Slide	14563.5	4.163266
			322 12 25.5	142 14 38.2	Anderson Point	9187.7	3.963207
			325 11 36.7	145 15 28.5	Dolan	17228.8	4.236256
Gamboa	36 03 19.469	600.1	142 46 44.1	322 45 38.3	Dolan	4620.2	3.664659
1890	121 34 35.816	896.4	157 04 32.9	337 02 13.7	Anderson	15152.8	4.180492
			164 09 11.2	344 08 19.9	Rock Slide	7978.6	3.901926
			339 44 16.0	159 44 38.6	Boronda	2780.7	3.444155
Helam	35 50 41.058	1265.4	41 58 24.8	221 58 04.4	Soda	1296.0	3.112602
1887	121 21 44.428	1114.9	126 35 53.2	306 34 04.2	San Martin Top	5807.7	3.764002
			223 03 42.7	43 03 50.9	Silver Peak	516.0	2.712670
			258 21 47.3	78 23 15.6	Lion Peak	3864.7	3.587121
			330 38 31.9	150 39 18.5	Salmon Top	4075.1	3.610138
Trail	35 57 06.886	212.2	130 46 14.9	310 42 48.7	Lopez Point	11604.9	4.064640
1888	121 28 09.563	239.7	134 20 59.3	314 17 44.9	Lopez	11590.9	4.064118
			168 00 42.8	347 59 47.3	Cone Peak	11388.8	4.056479
			301 58 58.2	122 00 18.4	Gate Pine	4037.3	3.606089
Plaskett Hill	35 54 52.398	1614.8	159 26 04.3	339 25 27.9	Trail	4427.3	3.646140
1888	121 27 07.506	188.2	165 37 15.6	345 35 43.8	Cone Peak	15780.4	4.198117
			222 58 14.4	42 58 58.1	Gate Pine	2741.8	3.438031
			321 13 24.6	141 14 45.2	San Martin Top	5495.8	3.740029
Mansfield	35 55 53.341	1643.9	172 15 32.0	352 14 49.2	Cone Peak	13530.3	4.131308
1888	121 28 31.260	783.6	193 29 21.7	13 29 34.4	Trail	2331.0	3.367549
			268 08 41.4	88 10 14.1	Gate Pine	3970.4	3.598836
			311 48 26.8	131 49 15.9	Plaskett Hill	2817.3	3.449826

Piedras Blancas to Point Sur—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Fancher	35 53 07.971	245.7	165 40 52.0	345 39 01.2	Cone Peak	19098.2	4.280993
1888	121 26 35.362	887.0	165 56 30.1	345 56 11.0	Plaskett Hill	3317.9	3 520858
			292 01 38.5	112 02 40.1	San Martin Top	2843.1	3.453795
Rock	35 54 29.782	917.8	293 01 50.1	113 04 16.0	Alder Top	6781.3	3.831311
1888	121 26 16.346	409.9	328 58 04.0	148 58 54.4	San Martin Top	4187.2	3.621921
			10 42 41.2	190 42 30.0	Fancher	2566.2	3.409284
Jellison	36 10 57.811	1782.0	119 15 24.9	299 11 15.9	Pfeiffers Point	12069.3	4.081681
1890	121 41 44.766	1118.6	126 49 31.7	306 46 30.5	Rico	9570.2	3.980921
			145 27 41.9	325 26 28.1	Castro	5504.8	3.740738
			152 54 34.3	332 53 49.5	Timber Top	4160.2	3.619116
			313 36 52.5	133 38 20.6	Anderson Point	5157.7	3.712460
Peter	36 12 45.763	1410.6	114 30 58.8	294 28 45.6	Pfeiffers Point	6185.6	3.791383
1890	121 45 01.062	26.5	131 05 31.6	311 04 26.3	Rico	3660.5	3.563543
			308 31 58.4	128 35 22.2	Anderson Point	11046.7	4.043232
Slate	36 08 06.062	186.8	125 35 17.7	305 29 07.6	Pfeiffers Point	19245.2	4.284323
1890	121 38 19.692	492.3	130 48 27.8	310 43 25.6	Rico	16886.6	4.227543
			141 15 21.3	321 14 48.3	Anderson Point	2224.6	3.347256
			142 03 31.5	322 00 45.8	Timber Top	11412.1	4.057364
			176 33 35.3	356 33 28.0	Anderson	5130.0	3.710114
			331 26 01.7	151 27 07.8	Dolan	5868.6	3.768536
Olmstead	36 14 00.854	26.3	71 15 56.0	251 14 38.7	Castro	3447.3	3.537473
1890	121 41 39.015	974.3	103 21 41.6	283 17 12.5	Coopers SE. Corner	11680.5	4.067463
			121 14 29.0	301 11 51.6	Manuel	7771.3	3.890495
			132 06 48.0	312 02 39.1	Pico Blanco	14149.3	4.150734
			291 23 02.4	111 32 45.0	Santa Lucia West	26507.9	4.423375
			318 18 47.3	138 25 48.8	Cone Peak	26906.8	4.429862
			321 12 26.1	141 14 16.4	Anderson	7458.7	3.872663
Chalk Peak	35 59 07.341	226.2	107 32 56.3	287 28 08.9	Lopez Point	12834.9	4.108391
1890	121 25 51.828	1298.4	110 31 25.7	290 26 50.1	Lopez	12561.5	4.098041
			113 02 35.8	292 57 50.3	Boronda	13209.5	4.120886
			141 57 35.1	321 55 18.5	Cone Peak	9433.4	3.974667
No Name	36 16 28.358	874.1	115 59 57.7	295 59 07.7	Sur River	2346.6	3.370443
1875	121 50 21.495	536.5	122 52 45.3	302 50 37.3	Point Sur	6426.2	3.807951
			123 22 52.6	303 21 26.8	False Sur	4335.2	3.637008
			142 23 20.7	322 22 25.9	Dry Hill	3789.1	3.578535
			207 12 05.6	27 13 05.8	Pico Blanco	5549.9	3.744284
La Cruz	35 42 19.952	614.9	147 34 09.1	327 33 34.1	China Gulch	2811.0	3.448865
1873	121 18 00.447	11.2	174 23 41.5	354 23 36.6	Yellow Hill	2174.0	3.337256
Cinnabar	35 42 42.524	1310.5	312 57 49.8	133 00 11.8	Leitner	8365.1	3.922473
1873	121 16 41.765	1050.0	70 37 43.5	250 36 57.5	La Cruz	2096.7	3.321532
			123 50 24.6	303 49 33.7	Yellow Hill	2636.5	3.421024
Coopers Point	36 15 00.630	19.4	137 06 46.3	317 04 29.9	Point Sur	8453.2	3.927020
1875	121 50 07.274	181.6	142 00 35.5	321 59 01.3	False Sur	6457.7	3.810078
			146 34 13.7	326 33 15.4	Sur River	4472.7	3.650570
			154 56 41.5	334 55 38.3	Dry Hill	6298.4	3.799229
			172 31 17.1	352 31 08.7	No Name	2727.2	3.435717
Coopers Pinnacle	36 14 59.584	1836.5	148 16 22.8	328 15 27.6	Sur River	4426.6	3.646068
1890	121 50 12.735	318.0	157 25 51.0	337 24 37.9	Little River Hill	8019.1	3.904128
			159 45 04.5	339 43 31.3	Sierra Hill	11330.5	4.054250
			196 48 50.3	16 49 45.3	Pico Blanco	8014.9	3.903900
			305 53 33.0	125 54 24.0	Pfeiffers Point	2660.0	3.424888
Black Mountain	36 17 21.415	660.1	69 18 07	249 16 25	No Name	4623.6	3.664981
1875	121 47 28.203	703.8	84 37 58	264 35 26	Sur River	6462.2	3.810379
			101 39 10	281 36 33	Dry Hill	6775.8	3.830962
			112 54 51	292 52 01	Little River Hill	7797.4	3.891949
Post Summit	36 17 21.387	659.2	351 24 33.4	171 24 55.2	Rico	6158.9	3.789506
1890	121 47 28.379	708.2	18 11 43.1	198 10 56.9	Pfeiffers Point	6242.4	3.795353
			37 08 41.6	217 07 39.0	Coopers SE. Corner	4376.6	3.641137
			84 38 09.0	264 35 36.6	Sur River	6457.7	3.810080
			151 38 57.6	331 38 15.3	Pico Blanco	3751.4	3.574188
Square Black Rock	36 04 22.645	698.0	134 47 18.5	314 40 07.9	Pfeiffers Point	25679.4	4.409585
1890	121 36 36.600	915.9	155 16 44.9	335 15 11.3	Anderson Point	9491.9	3.977351
			166 29 38.7	346 28 30.6	Anderson	12348.8	4.091623
			187 28 07.8	7 28 13.2	Dolan	1746.3	3.242109

Piedras Blancas to Point Sur—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Lopez Rock	36 01 35.720	1101.0	137 56 24.1	317 48 09.1	Pfeiffers Point	31318.5	4.495801
1890	121 34 46.886	1173.9	159 53 26.9	339 52 27.4	Dolan	732.3	2.864692
			170 04 42.3	350 03 57.5	Rock Slide	11038.0	4.042891
			276 25 42.6	96 26 21.6	Lopez	1670.3	3.222787
			307 53 14.7	127 58 28.4	Gate Pine	16958.9	4.229397
			318 14 36.8	138 18 17.5	Mansfield	14139.0	4.150418
Little Lopez Rock	36 01 35.049	1080.3	137 58 14.5	317 49 59.5	Pfeiffers Point	31317.4	4.495786
1890	121 34 46.782	1171.3	141 55 05.1	321 47 57.8	Rico	29343.0	4.467505
			148 13 21.5	328 08 01.4	Castro	25749.6	4.410770
			149 38 22.9	329 33 31.8	Timber Top	24404.2	4.387464
Slate Rock	36 07 36.184	1115.3	129 22 10.1	309 16 21.1	Pfeiffers Point	19106.0	4.281169
1890	121 38 54.948	1374.1	135 07 48.6	315 03 07.4	Rico	16869.3	4.227098
			145 35 54.3	325 33 00.4	Castro	13030.8	4.114969
			148 15 40.1	328 13 15.3	Timber Top	11664.7	4.066874
			169 06 38.2	349 06 26.1	Anderson Point	2704.6	3.432103
			318 56 02.3	138 57 29.2	Dolan	5614.4	3.749303
Outer Two Rocks	36 01 40.102	1236.1	141 34 15.5	321 27 05.7	Rico	29285.0	4.466645
1890	121 34 42.636	1067.5	147 37 41.6	327 30 58.8	Manuel	31821.1	4.502715
			149 14 38.1	329 09 44.5	Timber Top	24322.8	4.386014
Egg Rock	36 06 17.156	528.8	144 28 47.1	324 25 04.8	Castro	16205.0	4.209648
1890	121 37 32.758	819.4	146 28 07.7	326 24 54.3	Timber Top	14824.8	4.170988
			153 15 33.1	333 14 32.6	Anderson Point	5701.9	3.756017
Pfeiffers Little Pinnacle	36 13 57.621	1776.1	125 59 24.0	305 59 12.6	Pfeiffers Point	595.8	2.775064
1890	121 48 27.134	677.4	265 25 31.7	85 26 28.2	Rico	2394.9	3.379279
			278 15 25.3	98 18 09.2	Castro	7000.8	3.845148
			282 40 42.9	102 43 55.8	Timber Top	8359.5	3.922178
			293 16 01.6	113 18 03.4	Peter	5603.1	3.748428
Pfeiffers Rock	36 13 58.543	1804.5	141 46 37.8	321 46 31.8	Pfeiffers Point	409.4	2.612206
1890	121 48 36.293	906.3	266 26 30.7	86 27 32.6	Rico	2621.0	3.418464
			278 13 05.0	98 15 54.3	Castro	7231.2	3.859213
			292 38 01.1	112 40 08.3	Peter	5824.8	3.765279
San Martin Rock or Great White Rock	35 53 18.938	583.6	148 08 57.4	328 00 05.3	Timber Top	42815.4	4.631600
1888	121 27 56.046	1405.7	171 32 02.4	351 30 59.2	Cone Peak	18366.2	4.264019
			177 14 22.2	357 14 14.2	Trail	7033.6	3.847180
			202 54 15.3	22 54 43.7	Plaskett Hill	3127.1	3.495139
			286 45 45.0	106 47 33.9	San Martin Top	4866.3	3.687201
Middle San Martin Rock	35 53 20.130	620.4	173 53 08.9	353 52 57.0	Mansfield	4749.1	3.676610
1888	121 28 11.080	277.9	180 18 43.0	0 18 43.8	Trail	6988.9	3.844407
			209 16 15.0	29 16 52.3	Plaskett Hill	3260.2	3.513238
			285 57 20.0	105 59 17.7	San Martin Top	5238.5	3.719207
Outer San Martin Rock	35 53 28.676	883.8	177 48 34.8	357 48 30.7	Mansfield	4461.9	3.649522
1888	121 28 24.456	613.4	183 10 36.2	3 10 44.8	Trail	6735.7	3.828384
			216 47 02.8	36 47 47.9	Plaskett Hill	3222.1	3.508136
			287 35 25.1	107 37 30.6	San Martin Top	5635.8	3.750952
Black Shore Pillar	36 07 36.675	1130.5	133 55 59.8	313 51 06.8	Rico	17210.5	4.235794
1890	121 38 35.211	880.5	143 48 38.6	323 45 32.9	Castro	13303.5	4.123967
			146 12 28.5	326 09 51.8	Timber Top	11919.1	4.076243
Limekiln Rock	36 00 27.227	839.2	108 11 36	288 09 56	Lopez Point	4485.0	3.651764
1890	121 31 10.392	260.3	117 06 06	297 04 37	Lopez	4224.8	3.625803
			203 30 47	23 31 38	Cone Peak	5415.3	3.733625
Limekiln Smokestack	36 00 28.442	876.7	107 28 16.0	287 26 34.3	Lopez Point	4539.6	3.657017
1890	121 31 07.621	190.9	116 13 49.4	296 12 19.5	Lopez	4270.0	3.630423
			202 59 33.3	23 00 22.4	Cone Peak	5353.5	3.728640
Limekiln Warehouse	36 00 28.382	874.8	107 27 28.4	287 25 46.5	Lopez Point	4549.2	3.657932
1890	121 31 07.244	181.4	116 11 49.5	296 10 19.3	Lopez	4279.3	3.631369
			202 53 30.0	22 54 18.9	Cone Peak	5351.6	3.728480
Black Cone	36 12 52.973	1632.8	295 58 55.8	116 05 04.8	Santa Lucia	17391.3	4.240332
1890	121 35 31.284	781.4	50 30 41.1	230 28 54.3	Anderson	5851.8	3.767291
			111 11 28.7	291 05 13.9	Manuel	16970.7	4.229699
South Ventana North Peak	36 16 33.568	1034.7	332 43 36.4	152 48 37.9	Cone Peak	27904.6	4.445676
1890	121 38 15.093	376.7	2 18 03.9	182 17 53.9	Anderson	10530.2	4.022437
			55 11 24.3	235 08 06.4	Castro	10179.1	4.007710
			74 15 48.4	254 09 35.2	Pfeiffers Point	16379.4	4.214298

Piedras Blancas to Point Sur—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Ventana Cone	36 17 04.963	153.0	338 43 54	156 46 37	Rock Slide	19064.0	4.280215
1890	121 40 39.478	985.2	344 30 16	164 31 31	Anderson	11922.2	4.076357
			35 01 07	214 59 13	Castro	8280.2	3.918041
			65 59 35	245 54 46	Pfeiffers Point	13311.5	4.124227
			78 34 35	258 31 22	Manuel	8294.8	3.918804
Ventana Double Summit	36 17 50.060	1543.0	324 02 47.6	144 10 32.1	Cone Peak	33545.1	4.525629
1890	121 42 50.954	1271.3	331 57 16.2	152 01 17.2	Rock Slide	21700.7	4.336473
			333 19 15.1	153 21 48.2	Anderson	14411.4	4.158705
Mansfield Cone	35 57 00.285	8.8	135 28 25.8	315 25 26.4	Lopez Point	10913.8	4.037976
1888	121 28 54.914	1376.2	139 15 42.6	319 12 55.0	Lopez	10960.7	4.039840
			173 48 33.2	353 48 04.5	Cone Peak	11410.2	4.057294
			259 50 55.9	79 51 22.5	Trail	1154.6	3.062438
			325 39 18.2	145 40 21.2	Plaskett Hill	4773.4	3.678827
			343 57 58.6	163 58 12.5	Mansfield	2146.8	3.331785
Mansfield's house	35 56 02.045	63.0	140 03 34.8	320 00 16.3	Lopez	13174.6	4.119736
1888	121 28 02.796	70.1	175 08 58.1	355 08 54.1	Trail	2005.6	3.302249
			272 27 48.9	92 29 05.1	Gate Pine	3257.8	3.512928
			327 08 38.9	147 09 11.3	Plaskett Hill	2555.2	3.407429
			69 23 46.1	249 23 29.4	Mansfield	762.3	2.882114
Plaskett Rock	35 55 14.998	462.2	143 53 40.0	323 50 31.4	Lopez Point	13645.3	4.134983
1888	121 28 39.422	988.4	146 51 26.8	326 48 29.8	Lopez	13792.5	4.139643
			173 40 14.2	353 39 36.3	Cone Peak	14676.5	4.166624
			286 48 40.5	106 49 34.4	Plaskett Hill	2407.5	3.381569
			321 31 05.7	141 32 18.5	Fancher	5000.6	3.699022
White Rock 1	35 48 23.370	720.2	294 00 52.7	114 03 42.5	Bald Top.	7981.2	3.902070
1887	121 22 36.414	914.2	312 36 24.8	132 38 58.9	San Carpoforo	8998.0	3.954147
			317 57 50.7	137 59 41.4	Ragged Point	7106.3	3.851644
			328 24 30.9	148 26 37.2	China Gulch	10361.9	4.015440
San Martin Point	35 52 19.291	594.5	283 58 24.0	104 01 54.5	Lion Peak	9294.0	3.968203
1887	121 25 13.000	326.1	295 22 07.0	115 24 17.4	Silver Peak	6182.4	3.791159
			300 02 00.8	120 04 03.1	Helam	6045.9	3.781462
			312 24 39.6	132 26 21.5	Soda	5916.1	3.772032
			125 59 42.3	305 58 54.0	Fancher	2553.4	3.407117
			158 26 56.4	338 26 19.3	Rock	4324.3	3.635920
			232 42 18.9	52 42 32.2	San Martin Top	715.8	2.854817
Buckeye	35 50 50.253	1548.7	140 49 47.0	320 48 46.5	San Martin Top	4099.5	3.612734
1887	121 23 07.075	177.5	199 57 49.7	19 58 24.5	Alder Top	4373.8	3.640858
			277 46 29.3	97 47 17.7	Helam	2093.3	3.320830
			315 55 07.5	135 55 35.4	Soda	1735.8	3.239490
Willow Peak	35 55 32.804	1011.0	348 19 26.3	168 19 48.5	Alder Top	4694.7	3.671607
1888	121 22 45.416	1138.6	29 31 50.9	209 30 37.7	San Martin Top	6355.7	3.803161
			52 16 23.5	232 14 08.7	Fancher	7292.0	3.862848
			69 50 58.0	249 48 54.4	Rock	5633.9	3.750811
Mortar	35 54 20.790	640.7	172 56 34.0	352 56 30.9	Plaskett Hill	981.5	2.991909
1888	121 27 02.696	67.6	314 54 23.0	134 55 40.6	San Martin Top	4689.3	3.671109
			343 00 47.9	163 01 03.9	Fancher	2346.7	3.370456
Corral	35 57 58.489	1802.6	325 52 37.2	145 53 36.4	Gate Pine	4504.7	3.653670
1888	121 27 33.762	846.0	337 44 35.4	157 46 11.5	San Martin Top	10826.3	4.034481
			353 27 07.8	173 27 23.2	Plaskett Hill	5773.2	3.761413
Gonzales	35 46 45.330	1397.0	276 04 48.3	96 05 38.4	Bald Top	2164.5	3.335365
1887	121 19 11.846	297.5	305 13 37.9	125 15 28.4	Pine Top	5810.9	3.764240
			9 34 30.1	189 34 21.2	Ragged Point	2289.6	3.359759
			153 43 54.5	333 43 11.8	Salmon Top	4141.0	3.617105
Soda Point	35 49 44.776	1379.9	296 41 21.5	116 42 45.7	Salmon Top	4044.5	3.606868
1887	121 22 48.786	1224.5	307 08 20.6	127 11 17.3	Bald Top	9535.1	3.979325
			311 02 33.6	131 06 30.8	Pine Top	13520.4	4.130090
			326 56 10.6	146 58 08.6	Ragged Point	9291.4	3.968082
Thorndyke Top	35 47 58.184	1793.1	182 43 20.7	2 43 27.1	Lion Peak	5805.1	3.763809
1887	121 19 24.564	616.8	262 23 33.6	82 25 58.8	Jones Top	6287.2	3.798455
			315 01 56.1	135 02 53.6	Bald Top	3497.6	3.543771
Prize Pine	35 53 13.494	415.9	277 19 17.2	97 20 12.4	Alder Top	2382.8	3.377087
1887	121 23 41.761	1047.4	322 39 19.4	142 40 36.4	Silver Peak	5434.6	3.735171
			339 50 38.1	159 51 26.6	Soda	6030.9	3.780380

Piedras Blancas to Point Sur—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Spur	35 57 41.801	1288.2	314 56 33.2	134 57 48.6	Gate Pine	4550.7	3.658080
1888	121 28 01.449	36.3	345 28 36.2	165 29 07.7	Plaskett Hill	5393.4	3.731863
			10 41 59.8	190 41 55.0	Trail	1095.2	3.039481
			12 35 59.2	192 35 41.7	Mansfield	3425.3	3.534698
Plaskett Point	35 54 55.742	1717.9	158 11 28.1	338 11 11.5	Mansfield	1912.1	3.281515
1888	121 28 02.922	73.3	177 38 31.0	357 38 27.2	Trail	4045.4	3.606959
			239 42 15.1	59 43 31.5	Gate Pine	3773.3	3.576718
			274 14 17.9	94 14 50.4	Plaskett Hill	1393.2	3.144024
Mound	35 56 31.331	965.6	211 03 25.7	31 03 40.0	Trail	1279.2	3.106947
1888	121 28 35.895	899.7	323 59 15.8	144 00 07.7	Plaskett Hill	3769.3	3.576258
			354 19 56.7	174 19 59.4	Mansfield	1176.6	3.070647
Willow Point	35 54 07.939	244.7	168 47 14.0	348 46 48.4	Trail	5622.7	3.749943
1888	121 27 25.936	650.5	198 38 06.9	18 38 17.7	Plaskett Hill	1446.1	3.160194
			325 32 06.9	145 32 36.8	Fancher	2241.5	3.350548
San Carpoforo	35 45 05.647	174.0	358 04 51.2	178 04 53.5	Yellow Hill	2944.7	3.469046
1873	121 18 12.820	322.0	23 38 10.5	203 37 42.7	China Gulch	2984.5	3.474867
			113 36 42.6	293 35 59.3	Ragged Point	2034.0	3.308352
Gillis	35 40 57.199	1762.8	276 59 28.2	97 00 27.2	Fairview	2565.4	3.409155
1872	121 17 11.916	299.7	278 51 42.6	98 52 43.8	Chapparal Hill	2669.1	3.426363
			350 42 11.1	170 42 18.0	Piedra Blanca	1842.9	3.265513
Valenzuela	35 46 27.822	857.4	326 27 12.8	146 27 51.8	San Carpoforo	3038.6	3.482669
1873	121 19 19.654	493.6	342 00 26.7	162 01 08.0	Yellow Hill	5757.1	3.760201
			354 45 32.6	174 45 43.8	China Gulch	5288.9	3.723366
			6 08 11.6	186 08 07.3	Ragged Point	1728.0	3.237548
Brushy Knob	35 42 02.494	76.9	314 21 36.2	134 22 31.3	Fairview	3324.9	3.521774
1873	121 17 05.188	130.4	358 04 43.1	178 04 46.0	Piedra Blanca	3833.2	3.583565
			111 10 32.9	291 10 00.6	La Cruz	1489.7	3.173110
			205 30 46.2	25 30 59.9	Cinnabar	1367.0	3.135773
Sierra Nevada	35 42 50.329	1551.1	176 11 42.4	356 11 40.2	China Gulch	1439.5	3.158200
1873	121 18 56.630	1423.4	224 20 38.8	44 21 06.7	Yellow Hill	1716.4	3.234608
			303 32 09.8	123 32 42.6	La Cruz	1694.4	3.229018
La Cruz Rock	35 42 26.998	832.0	156 26 28	336 26 21	Sierra Nevada	784.4	2.894563
1873	121 18 44.156	1110.0	204 28 43	24 29 04	Yellow Hill	2138.7	3.330154
			261 08 58	81 10 10	Cinnabar	3113.6	3.493265
			281 10 32	101 10 58	La Cruz	1120.0	3.049228
Gillis' house, chimney	35 40 56.374	1737.4	144 10 56	324 10 14	La Cruz	3173.1	3.501487
1873	121 16 46.495	1169.1	182 04 53	2 04 56	Cinnabar	3273.6	3.515029
			278 33 27	98 34 12	Fairview	1928.5	3.285230
White Rock 2	35 49 51.272	1580.1	316 16 42	136 19 58	San Carpoforo	12175.1	4.085472
1873	121 23 47.748	1198.4	320 38 25	140 40 57	Ragged Point	10328.8	4.014049
			327 57 06	147 59 54	China Gulch	13608.1	4.133796
Cone Pine	36 30 11.057	340.8	274 19 42.5	94 20 08.6	Cone Peak	1112.6	3.046337
1890	121 30 28.399	710.8	57 00 26.6	236 58 33.5	Lopez	5737.6	3.758727
			113 41 32.0	293 38 00.1	Dolan	9811.6	3.991739
			133 29 53.9	313 26 36.7	Rock Slide	11532.7	4.061931
Cape San Martin Cone	35 53 21.828	672.7	147 23 14	327 19 36	Lopez Point	17232.4	4.236345
1890	121 27 49.641	1245.0	149 42 10	329 38 44	Lopez	17418.4	4.241009
			170 59 48	350 58 41	Cone Peak	18302.6	4.262512
Dolans Cone Rock	36 05 07.499	231.2	146 27 03.2	326 23 03.0	Castro	18402.8	4.264884
1890	121 37 02.510	62.8	148 20 25.5	328 16 54.4	Timber Top	17041.5	4.231508
			155 21 07.3	335 19 49.0	Anderson Point	7965.0	3.901184
Lopez Lone Tree	36 02 07.26	223.8	356 48 18	176 48 19	Lopez	1161.2	3.06490
1890	121 33 43.18	1081.0	14 28 55	194 28 45	Lopez Point	1739.4	3.24039
Lopez Pine	36 02 17.77	547.7	154 46 52	334 45 06	Rock Slide	10586.7	4.02476
1890	121 33 02.56	64.1	252 34 01	72 35 58	Cone Peak	5206.9	3.71658
Digges Pine	35 58 18.59	572.9	115 51 56	295 47 36	Lopez Point	12311.2	4.09030
1888	121 26 38.14	955.6	152 28 41	332 26 52	Cone Peak	10070.9	4.00307
Post's house*	36 13 45.82	1412.4	175 01 05	355 00 56	Manuel	4508.6	3.65404
1890	121 45 49.53	1237.0	282 08 40	102 09 51	Castro	3060.5	3.48579

* No check on this position.

Piedras Blancas to Point Sur—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Pine Anderson* 1890	36 09 01.43 121 38 09.58	44.1 239.5	312 07 35 339 35 13	132 08 50 159 36 13	Rock Slide Dolan	4270.0 7320.7	3.63043 3.86455
Gamboa Point* 1890	36 03 02.43 121 35 28.31	74.9 708.6	160 35 14 173 58 16	340 34 39 353 57 56	Dolan Rock Slide	4457.4 8245.9	3.64908 3.91624
Little Pyramid Rock* 1890	36 12 38.56 121 45 11.57	1188.6 289.0	117 27 43 136 28 14	297 25 36 316 27 15	Pfeiffers Point Rico	6047.0 3624.6	3.78154 3.55926
Mansfield Pine* 1888	35 56 14.56 121 27 19.38	448.7 485.8	70 03 33 142 03 05	250 02 51 322 02 35	Mansfield Trail	1916.9 2045.3	3.28260 3.31076
Harlan Rock* 1890	36 00 40.61 121 32 04.59	1251.7 114.9	108 46 33 122 09 43	288 45 25 302 08 46	Lopez Point Lopez	3067.0 2839.7	3.48671 3.45327
Deer Pine 1887	35 49 26.94 121 21 50.07	830.2 1256.8	280 52 47 300 38 34	100 56 38 120 39 24	Jones Top Salmon Top	10065.8 2486.9	4.00285 3.39565
Cabin Pine 1888	35 54 54.19 121 26 01.87	1670.1 46.9	300 05 14 337 31 33	120 07 32 157 32 15	Alder Top San Martin Top	6793.0 4697.0	3.83206 3.67182
Salmon Pine 1887	35 48 28.66 121 20 15.19	883.3 381.4	155 21 52 312 21 34	335 21 46 132 23 01	Salmon Top Bald Top	581.6 5065.8	2.76459 3.70465
Lone Oak* 1887	35 47 46.69 121 19 55.51	1438.9 1394.1	350 12 25 157 59 31	170 12 42 337 59 14	Ragged Point Salmon Top	4210.1 1965.4	3.62429 3.29346
Burnett Peak* 1887	35 45 23.95 121 09 34.73	738.1 872.5	100 29 56 110 54 44	280 25 09 290 48 24	Bald Top Salmon Top	12552.8 17472.3	4.09874 4.24235
Lion Cone* 1887	35 50 54.27 121 18 17.31	1672.5 434.3	315 19 38 354 20 34	135 21 24 174 20 52	Jones Top Bald Top	6462.3 7940.5	3.81039 3.89985
Lone Pine 1888	35 55 44.46 121 26 50.32	1370.2 1261.4	141 59 05 254 24 17	321 58 18 74 24 50	Trail Gate Pine	3224.6 1492.9	3.50848 3.17404
Chute Derrick* 1888	36 00 28.00 121 31 07.33	862.9 183.6	324 17 22 335 11 36	144 19 06 155 13 08	Trail Mansfield	7632.6 9325.0	3.88267 3.96965
Ridge Pine* 1888	35 57 01.52 121 25 24.12	46.8 604.5	33 04 52 65 53 02	213 03 52 245 51 12	Plaskett Hill Mansfield	4749.1 5139.7	3.67661 3.71094
Schoolhouse, cupola* 1888	35 55 39.15 121 27 54.84	1206.5 1374.7	320 31 44 115 35 14	140 32 12 295 34 53	Plaskett Hill Mansfield	1866.8 1012.3	3.27110 3.00533
Valenzuela's house, south gable* 1871	35 46 16.12 121 19 17.51	496.8 439.8	323 11 23 9 58 19	143 12 01 189 58 13	San Carpoforo Ragged Point	2712.4 1378.1	3.43336 3.13929
Big Tree 1871	35 44 43.15 121 15 35.22	1329.8 884.9	39 36 16 68 25 34	219 34 51 248 23 34	La Cruz China Gulch	5727.0 5546.0	3.75793 3.74398
Oak Tree on ridge 1871	35 44 39.65 121 17 01.52	1222.0 38.2	359 45 40 18 58 19	179 45 41 198 58 45	Piedra Blanca La Cruz	8674.6 4553.0	3.93825 3.65830
Cone Top Hill 1871	35 43 54.76 121 13 37.09	1687.6 932.1	26 16 32 35 00 20	206 15 26 214 58 22	Fairview Piedra Blanca	6451.0 8899.6	3.80963 3.94937
Phillips' house, chimney* 1871	35 41 36.36 121 17 12.49	1120.6 314.0	300 40 45 354 06 27	120 41 44 174 06 34	Fairview Piedra Blanca	2977.6 3041.8	3.47386 3.48313
Evans' house, chimney* 1871	35 41 24.02 121 17 00.30	740.3 7.5	190 54 08 296 48 17	10 54 19 116 49 10	Cinnabar Fairview	2463.9 2525.7	3.39162 3.40238
Hildebrandt's house, north gable* 1871	35 44 39.76 121 18 28.56	1225.3 717.6	137 40 53 206 21 51	317 40 19 26 22 01	Ragged Point San Carpoforo	2180.9 890.6	3.33863 2.94967
Rocky Butte Lat. Sta. 1885	35 39 56.03 121 03 32.13	1726.6 808.0					
Castle Mount Lat. Sta. 1885	35 56 21.34 120 20 22.84	657.6 572.6					
Hepsedam Lat. Sta. 1885	36 18 53.60 120 49 26.30	1652.2 656.0					

* No check on this position.

Piedras Blancas to Point Sur—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Santa Lucia Lat. Sta. 1885	36 08 45.62 121 25 05.54	1406.3 138.5					
Santa Lucia Lat. Sta. 1880	36 08 47.15 121 25 12.24	1453.3 306.0					
Santa Lucia Eclipse Sta. 1880	36 08 46.50 121 25 12.44	1433.3 311.0					
Santa Lucia, U. S. Naval Observatory Station 1880	36 08 46.85 121 25 12.65	1444.1 316.3					

Point Sur to Monterey Bay.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Point Pinos Light-house 1854	36 38 01.323 121 55 58.888	40.8 1463.0	164 07 32.6 188 32 29.0 244 02 54.3	344 03 09.1 8 35 42.5 64 28 03.4	Santa Cruz Loma Prieta Santa Ana	39768.6 53605.8 69414.3	4.599540 4.729212 4.841449
Sierra Hill 1875	36 20 44.440 121 52 49.993	1369.8 1246.6	295 20 13.9 331 04 21.3 345 18 50.7	115 22 42.1 151 06 29.0 165 19 10.8	Pico Blanco Coopers SE. corner Little River Hill	6905.5 11135.4 3333.8	3.839196 4.046704 3.522939
Bonifacio Hill 1875	36 21 15.876 121 51 24.014	489.3 598.8	313 46 41.2 17 13 03.6 65 41 09.2	133 48 18.5 197 12 32.7 245 40 18.2	Pico Blanco Little River Hill Sierra Hill	5673.7 4390.5 2352.7	3.753863 3.642517 3.371561
Point Sur 1875	36 18 21.512 121 53 57.858	663.1 1443.5	201 00 46.2 215 30 43.9 245 02 56.4 306 46 04.1	21 01 26.4 35 32 15.0 65 03 56.7 126 47 22.2	Sierra Hill Bonifacio Hill Little River Hill Sur River	4719.5 6603.6 2799.4 4107.5	3.673892 3.819778 3.447059 3.613582
Dry Hill 1875	36 18 05.732 121 51 54.178	176.7 1351.7	354 06 03.0 98 58 03.5 161 49 37.7	174 06 07.8 278 56 50.3 341 49 24.7	Sur River Point Sur Little River Hill	1983.4 3123.9 1754.4	3.297410 3.494695 3.244138
False Sur 1875	36 17 45.721 121 52 46.574	1409.3 1162.1	121 48 55.7 244 44 16.2 311 53 47.6	301 48 13.5 64 44 47.2 131 54 23.4	Point Sur Dry Hill Sur River	2093.0 1445.5 2030.5	3.320759 3.160028 3.307612
Oliviers Mount 1875	36 26 11.532 121 53 59.991	355.4 1494.2	336 53 14.7	156 54 47.2	Bonifacio Hill	9907.4	3.995961
Cushings Mount 1875	36 23 29.255 121 53 37.055	901.7 923.5	173 29 03.7 321 05 48.4	353 28 50.1 141 07 07.3	Oliviers Mount Bonifacio Hill	5034.5 5252.1	3.701952 3.722804
Kaslers Point 1875	36 24 35.947 121 54 50.749	1108.0 1264.5	203 13 25.8 318 13 06.9	23 13 55.9 138 13 50.6	Oliviers Mount Cushings Mount	3206.1 2756.5	3.505982 3.440351
Soberanes Point 1875	36 26 55.530 121 55 41.486	1711.6 1033.1	298 12 21.0 343 37 32.7	118 13 21.3 163 38 02.8	Oliviers Mount Kaslers Point	2868.6 4484.2	3.457670 3.651688
Rocky Ridge 1875	36 28 00.613 121 54 50.127	18.9 1248.1	339 37 28.5 32 31 17.6	159 37 58.3 212 30 47.1	Oliviers Mount Soberanes Point	3586.6 2379.1	3.554682 3.376405
Gutres Knoll 1875	36 28 21.024 121 56 00.823	648.0 20.5	289 39 48.0 349 38 40.6	109 40 30.0 169 38 52.1	Rocky Ridge Soberanes Point	1869.1 2678.8	3.271642 3.427947
Waters Ridge 1875	36 29 33.932 121 55 32.640	1045.9 812.4	339 47 49.1 17 20 20.5	159 48 14.4 197 20 03.8	Rocky Ridge Gutres Knoll	3064.9 2354.3	3.486421 3.371853
Yankee Point 1875	36 29 29.954 121 56 37.901	923.3 943.4	265 40 33.8 336 30 57.2	85 41 12.6 156 31 19.3	Waters Ridge Gutres Knoll	1628.9 2316.5	3.211904 3.364825
Whalers Knoll 1875	36 31 14.851 121 56 44.228	457.8 1100.4	330 11 42.9 357 12 42.3	150 12 25.5 177 12 46.1	Waters Ridge Yankee Point	3584.7 3237.2	3.554456 3.510173
Greggs Hill 1875	36 31 30.483 121 54 17.998	939.6 447.8	27 20 44.4 82 28 03.2 171 19 08.8	207 20 00.0 262 26 36.2 351 18 24.9	Waters Ridge Whalers Knoll Point Pinos Lat. Sta.	4044.3 3669.9 12120.5	3.606846 3.564656 4.083522

Point Sur to Monterey Bay—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Pescadero Point	36 33 43.395	1337.6	313 09 08.9	133 10 53.4	Greggs Hill	5988.5	3.777317
1875	121 57 13.601	338.2	350 55 53.2	170 56 10.7	Whalers Knoll	4636.7	3.666205
Monterey Hill	36 34 00.951	29.3	9 44 47.8	189 44 28.7	Greggs Hill	4705.9	3.672645
1875	121 53 45.976	1143.2	84 02 01.0	263 59 57.3	Pescadero Point	5191.2	3.715264
Loma Alta	36 33 45.210	1393.5	30 42 04.2	210 41 05.2	Greggs Hill	4829.4	3.683889
1875	121 52 38.891	967.1	106 13 23.9	286 12 44.0	Monterey Hill	1737.3	3.239871
			151 16 19.3	331 14 36.3	Point Pinos Lat. Sta.	8928.7	3.950790
Sand Hill 2	36 36 07.568	233.3	5 20 57.8	185 20 48.0	Loma Alta	4407.3	3.644170
1875	121 52 22.369	556.0	28 02 40.6	208 01 50.8	Monterey Hill	4421.8	3.645603
			126 12 11.7	306 10 18.8	Point Pinos Lat. Sta.	5827.2	3.765460
Monterey Bay 2	36 37 35.807	1103.7	23 04 55.9	203 03 43.3	Loma Alta	7726.0	3.887955
1875	121 50 37.084	921.4	35 20 58.7	215 19 06.2	Monterey Hill	8118.2	3.909462
			43 53 48.6	223 52 45.9	Sand Hill 2	3774.0	3.576805
			95 38 41.3	275 35 29.3	Point Pinos L. H.	8033.9	3.904926
			95 38 54.0	275 35 58.3	Point Pinos Lat. Sta.	7353.5	3.866497
Luces Point	36 38 11.560	356.3	278 18 50.9	98 21 51.6	Monterey Bay 2	7598.8	3.880745
1875	121 55 39.702	986.3	332 16 36.9	152 16 41.7	Point Pinos Lat. Sta.	430.9	2.634389
			56 29 56.5	236 29 45.0	Point Pinos L. H.	571.6	2.757110
Rocky Point 2	36 36 49.555	1527.5	253 39 14.2	73 41 11.0	Monterey Bay 2	5070.6	3.705060
1875	121 53 52.913	1314.9	299 53 52.7	119 54 46.7	Sand Hill 2	2595.9	3.414287
			342 03 02.3	162 03 46.4	Loma Alta	5972.8	3.776181
			358 05 57.2	178 06 01.5	Monterey Hill	5200.0	3.716002
Mussel Point	36 37 18.160	559.8	123 53 01.7	303 52 16.4	Point Pinos Lat. Sta.	2268.7	3.355772
1875	121 54 15.824	393.2	128 18 40.0	308 17 49.8	Luces Point	2655.6	3.424167
			264 15 59.4	84 18 09.9	Monterey Bay 2	5462.3	3.737372
			307 38 58.8	127 40 06.6	Sand Hill 2	3561.5	3.551636
			327 08 49.3	147 09 03.0	Rocky Point 2	1049.6	3.021008
			339 50 05.7	159 51 03.6	Loma Alta	6992.3	3.844622
White Rock	36 38 19.875	612.6	286 18 38.2	106 18 59.2	Luces Point	912.5	2.960257
1875	121 56 14.956	371.5	325 04 54.4	145 05 04.0	Point Pinos L. H.	697.4	2.843478
Moss Beach	36 36 51.339	1582.4	194 09 17.4	14 09 33.9	White Rock	2814.6	3.449409
1875	121 56 42.662	1060.2	206 45 11.8	26 45 37.9	Point Pinos L. H.	2415.9	3.383080
Pyramid Point	36 36 36.998	1140.4	207 57 52.8	27 58 33.2	White Rock	3590.5	3.555157
1875	121 57 22.731	564.9	218 42 18.8	38 43 08.8	Point Pinos L. H.	3331.1	3.522591
			246 03 31.7	66 03 55.6	Moss Beach	1089.5	3.037212
Timber Ridge	36 33 50.756	1564.5	31 28 44.0	211 27 33.6	Whalers Knoll	5634.2	3.750836
1875	121 54 45.977	1143.2	86 28 34.5	266 27 06.6	Pescadero Point	3677.9	3.565604
			258 05 56.0	78 06 31.7	Monterey Hill	1524.7	3.183194
			273 05 05.7	93 06 21.3	Loma Alta	3164.8	3.500350
			350 51 15.1	170 51 31.8	Greggs Hill	4379.4	3.641412
Carmel River	36 32 27.839	858.1	29 46 08.9	209 45 38.1	Whalers Knoll	2591.7	3.413580
1875	121 55 52.509	1306.1	139 06 56.0	319 06 07.7	Pescadero Point	3080.8	3.488670
			212 54 49.8	32 55 29.4	Timber Ridge	3044.7	3.483543
			227 37 21.4	47 38 36.7	Monterey Hill	4259.1	3.629321
			243 38 09.6	63 40 04.8	Loma Alta	5373.6	3.730265
			306 56 00.6	126 56 56.8	Greggs Hill	2941.6	3.468587
Huckleberry Hill	36 30 44.985	1386.6	12 59 55.1	192 59 43.0	Waters Ridge	2247.7	3.351746
1875	121 55 12.327	306.8	42 38 44.4	222 37 53.5	Yankee Point	3143.9	3.497475
			111 56 12.8	291 55 18.1	Whalers Knoll	2465.0	3.391817
			162 30 08.8	342 29 44.8	Carmel River	2465.0	3.391816
			223 56 30.2	43 57 02.4	Greggs Hill	1947.8	3.289553
Yankee Knoll	36 29 33.422	1030.2	73 54 23.6	253 54 14.7	Yankee Point	385.9	2.586450
1875	121 56 23.005	572.6	170 24 49.1	350 24 36.4	Whalers Knoll	3170.7	3.501157
			218 33 45.0	38 34 27.0	Huckleberry Hill	2821.3	3.450442
			269 16 44.2	89 17 14.1	Waters Ridge	1253.6	3.098176
			346 06 01.2	166 06 14.4	Gutres Knoll	2298.9	3.361522
Point Cypress	36 34 51.855	1598.4	210 00 59.3	30 01 44.2	Pyramid Point	3743.2	3.573241
1875	121 58 38.079	946.6	326 03 42.2	146 05 44.7	Huckleberry Hill	9170.2	3.962380
			341 05 30.0	161 06 50.4	Yankee Knoll	10374.5	4.015968
			343 13 23.2	163 14 34.8	Yankee Point	10362.9	4.015480
Timber Point	36 34 11.160	344.0	301 19 38.8	121 20 12.6	Pescadero Point	1645.8	3.216382
1875	121 58 10.136	252.1	310 36 14.1	130 38 32.4	Greggs Hill	7606.9	3.881208
			312 55 36.0	132 56 58.0	Carmel River	4675.2	3.669804
			325 08 58.7	145 10 44.8	Huckleberry Hill	7742.7	3.888891

Point Sur to Monterey Bay—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters.	
Monterey Mission, cross	36 35 45.594	1405.4	230 27 47	50 29 26	Monterey Bay 2	5338.3	3.727402
1875	121 53 22.781	566.3	245 42 57	65 43 33	Sand Hill 2	1647.3	3.216763
			343 36 38	163 37 04	Loma Alta	3867.9	3.587471
			10 08 19	190 08 04	Monterey Hill	3276.7	3.515436
Vierra's house, west gable	36 30 30.355	935.6	332 10 29	152 10 51	Waters Ridge	1966.5	3.293693
1875	121 56 09.520	236.9	10 49 39	190 49 31	Yankee Knoll	1786.5	3.252040
			20 46 39	200 46 22	Yankee Point	1991.3	3.299137
			147 48 23	327 48 02	Whalers Knoll	1620.8	3.209734
Point Lobos	36 31 03.692	113.8	231 55 27.2	51 55 37.6	Whalers Knoll	557.8	2.746445
1875	121 57 01.875	46.6	258 32 12.6	78 33 49.9	Greggs Hill	4160.1	3.619101
			281 56 07.6	101 57 12.8	Huckleberry Hill	2786.1	3.444998
			321 14 30.6	141 15 23.5	Waters Ridge	3547.7	3.549949
			340 49 38.7	160 50 01.8	Yankee Knoll	2945.8	3.469204
Frank	36 36 23.159	713.8	35 13 28.0	215 12 40.4	Point Cypress	3444.9	3.537178
1875	121 57 18.156	451.2	165 04 36.6	345 04 33.9	Pyramid Point	441.5	2.644900
			203 34 32.7	23 35 10.4	White Rock	3925.5	3.593894
			225 26 15.9	45 26 37.1	Moss Beach	1238.0	3.092712
Pelican Point	36 35 28.933	891.8	46 55 45.1	226 55 15.8	Point Cypress	1673.5	3.223621
1875	121 57 48.906	1215.7	197 13 32.4	17 13 48.0	Pyramid Point	2196.6	3.341750
Lone Rock	36 36 06.410	197.6	24 31 54.6	204 31 41.9	Pelican Point	1269.8	3.103742
1875	121 57 27.696	688.4	37 17 16.3	217 16 34.3	Point Cypress	2888.3	3.460642
			187 27 22.5	7 27 25.3	Pyramid Point	950.9	2.978124
			204 40 00.2	24 40 05.7	Frank	568.1	2.754435
Waters' house, chimney	36 29 35.830	1104.4	77 12 30	257 12 23	Yankee Knoll	335.2	2.525311
1875	121 56 09.872	245.7	154 27 49	334 27 19	Point Lobos	3001.6	3.477346
			273 36 41	93 37 04	Waters Ridge	928.5	2.967786
Towles' house, chimney	36 29 13.073	403.0	124 38 06	304 37 48	Yankee Point	915.5	2.961648
1875	121 56 07.638	190.1	148 37 35	328 37 26	Yankee Knoll	734.7	2.866095
			233 34 01	53 34 22	Waters Ridge	1082.7	3.034497
Carmel Mission, spire	36 32 35.590	1097.0	1 09 11	181 09 09	Huckleberry Hill	3410.0	3.532756
1875	121 55 09.569	238.0	43 25 25	223 24 29	Whalers Knoll	3426.2	3.534814
			77 23 24	257 22 59	Carmel River	1094.5	3.039202
			240 11 25	60 12 54	Loma Alta	4318.3	3.635315
			327 24 26	147 24 57	Greggs Hill	2381.9	3.376924
San Jose Creek house, west gable	36 31 24.356	750.7	148 45 10	328 44 08	Pescadero Point	5013.4	3.700130
1875	121 55 29.021	722.0	163 22 34	343 22 20	Carmel River	2042.1	3.310078
			193 20 36	13 21 02	Timber Ridge	4637.8	3.666315
Whalers Rocks, outer	36 31 01.510	46.6	259 30 20	79 32 15	Greggs Hill	4910.6	3.691136
1875	121 57 32.076	798.1	278 19 19	98 20 42	Huckleberry Hill	3514.4	3.545851
			327 39 29	147 40 10	Yankee Knoll	3213.5	3.506984
			334 27 39	154 28 11	Yankee Point	3127.7	3.495221
St. John's house, chimney	36 32 28.802	887.8	168 34 28	348 34 16	Timber Ridge	2577.2	3.411150
1875	121 54 25.446	633.0	228 21 45	48 22 48	Loma Alta	3545.4	3.549667
			354 06 53	174 06 57	Greggs Hill	1807.1	3.256990
Gregg's house, chimney	36 31 56.550	1743.1	125 17 30	305 16 57	Carmel River	1669.5	3.222599
1875	121 54 57.724	1436.0	184 44 35	4 44 42	Timber Ridge	3532.4	3.548067
			309 06 26	129 06 50	Greggs Hill	1273.7	3.105056
Yankee Point Rock	36 29 27.476	846.9	181 46 56	1 46 58	Whalers Knoll	3311.3	3.520000
1875	121 56 48.367	1203.8	253 48 25	73 48 40	Yankee Knoll	657.3	2.817776
			263 58 03	83 58 48	Waters Ridge	1895.3	3.277676
			329 58 34	149 59 05	Gutres Knoll	2365.7	3.373954
Pescadero Dairy, chimney	36 34 04.634	142.8	325 49 23	145 50 40	Greggs Hill	5742.7	3.759113
1875	121 56 27.664	687.9	343 03 29	163 04 14	Huckleberry Hill	6433.0	3.808413
			343 39 55	163 40 16	Carmel River	3109.1	3.492634
			4 30 10	184 30 00	Whalers Knoll	5249.6	3.720126
Point Sur Light-house	36 18 23.918	737.2	202 51 18.1	22 52 01.4	Sierra Hill	4700.5	3.672148
1890	131 54 03.207	80.0	247 29 46.1	67 30 49.5	Little River Hill	2891.7	3.461160
			260 18 34.2	80 21 45.7	Pico Blanco	8184.3	3.912983
Point Sur, light-keeper's house, SE. chimney	36 18 19.255	593.5	242 50 00.7	62 50 58.5	Little River Hill	2738.7	3.437548
	121 53 53.789	1342.0	259 00 35.0	79 03 40.9	Pico Blanco	7978.9	3.901945
			288 34 02.3	108 38 39.7	Manuel	12338.1	4.091248
			306 50 26.6	126 51 42.2	Sur River	3984.6	3.600382
			307 03 26.8	127 06 12.3	Coopers SE. corner	8745.0	3.941759

Point Sur to Monterey Bay—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Point Sur, light-keeper's house, NW. chimney	36 18 19.600	604.1	243 04 46.5	63 05 44.6	Little River Hill	2738.4	3.437490
1890	121 53 53.991	1347.0	259 05 29.6	79 08 35.7	Pico Blanco	7981.9	3.902104
			288 36 23.8	108 41 01.4	Manuel	12346.3	4.091536
			306 55 10.6	126 56 26.4	Sur River	3994.9	3.601516
			307 05 35.5	127 08 21.2	Coopers SE. corner	8755.4	3.942277
Black Ridge	36 19 03.966	122.2	44 22 34.5	224 22 04.2	Point Sur	1830.6	3.262604
1875	121 53 06.542	163.2	187 35 22.7	7 35 32.5	Sierra Hill	3124.3	3.494746
			212 09 24.5	32 10 25.3	Bonifacio Hill	4803.0	3.681514
			275 48 28.4	95 48 58.3	Little River Hill	1264.5	3.101908
Cooper	36 18 37.524	1156.6	2 13 04.5	182 13 03.0	False Sur	1597.9	3.203551
1875	111 52 44.095	1100.1	74 59 37.8	254 58 54.1	Point Sur	1905.3	3.279961
			145 30 41.5	325 30 28.2	Black Ridge	988.9	2.995140
			308 11 34.1	128 12 03.6	Dry Hill	1584.7	3.199941
Point Sur South Base	36 18 16.335	503.5	98 06 23.8	278 05 57.2	Point Sur	1132.1	3.053905
1875	121 53 12.933	322.7	227 45 56.9	47 46 14.0	Cooper	971.7	2.987524
			279 26 12.0	99 26 58.8	Dry Hill	1991.9	3.299274
			325 07 17.2	145 07 32.9	False Sur	1150.2	3.060774
Point Sur North Base	36 18 40.175	1238.3	274 29 56.3	94 30 21.0	Cooper	1041.1	3.017482
1875	121 53 25.697	641.0	336 34 08.3	156 34 15.9	Point Sur S. Base	800.9	2.903554
			54 21 52.5	234 21 33.5	Point Sur	987.3	2.994434
Vierra Knoll	36 30 31.696	977.0	3 19 01.4	183 18 58.9	Yankee Knoll	1799.2	3.255090
1875	121 56 18.822	468.4	14 00 35.2	194 00 23.7	Yankee Point	1961.5	3.292596
			132 38 13.4	312 37 47.8	Point Lobos	1456.1	3.163197
			154 35 01.2	334 34 46.0	Whalers Knoll	1472.8	3.168134
Brushy Ridge	36 28 41.469	1278.2	324 09 24.2	144 09 45.9	Rocky Ridge	1553.5	3.191298
1875	121 55 26.663	663.7	6 26 59.8	186 26 51.0	Soberanes Point	3286.2	3.516693
			53 27 46.5	233 27 26.2	Gutres Knoll	1058.4	3.024667
			130 07 46.4	310 07 04.0	Yankee Point	2319.0	3 365302
			138 47 40.4	318 47 06.9	Yankee Knoll	2128.7	3.328118
			174 44 38.5	354 44 35.0	Waters Ridge	1624.0	3.210573
Soberanes Ridge	36 26 59.624	1837.8	309 33 00.9	129 33 43.7	Oliviers Mount	2327.7	3.366930
1875	121 55 12.051	300.1	353 09 57.7	173 10 10.4	Kaslers Point	4460.3	3.649364
			80 14 06.0	260 13 48.5	Soberanes Point	743.8	2.871457
			154 10 38.0	334 10 09.1	Gutres Knoll	2787.5	3.445209
			173 23 26.6	353 23 17.9	Brushy Ridge	3160.2	3.499717
			196 11 29.8	16 11 42.8	Rocky Ridge	1957.6	3.291717
Soberanes' house, chimney	36 27 17.184	529.7	152 30 03	332 29 39	Gutres Knoll	2218.4	3.346049
1875	121 55 19.680	490.0	176 10 14	356 10 10	Brushy Ridge	2603.7	3.415598
			208 47 37	28 47 55	Rocky Ridge	1527.5	3.183984
Portuguese Ridge	36 25 51.714	1594.0	234 20 15.1	54 20 35.4	Oliviers Mount	1047.8	3.020293
1875	121 54 34.171	851.1	342 02 18.9	162 02 52.9	Cushings Mount	4615.9	3.664256
			10 01 49.2	190 01 39.5	Kaslers Point	2371.6	3.375049
			139 33 49.3	319 33 09.2	Soberanes Point	2584.6	3.412391
			155 44 29.0	335 44 06.5	Soberanes Ridge	2296.0	3.360974
Palo Colorado Ridge	36 24 21.207	653.7	333 10 53.0	153 11 12.3	Cushings Mount	1794.3	3.253889
1875	121 54 09.537	237.6	113 52 13.9	293 51 49.5	Kaslers Point	1122.9	3.050336
			162 19 01.9	342 18 24.8	Soberanes Ridge	5125.3	3.709716
			167 35 43.4	347 35 28.7	Portuguese Ridge	2856.4	3.455826
			183 59 58.6	4 00 04.3	Oliviers Mount	3408.9	3.532614
Division Knoll	36 22 29.844	919.9	164 24 16.0	344 23 50.2	Kaslers Point	4035.6	3.605903
1875	121 54 07.205	179.6	179 01 48.7	359 01 47.3	Palo Colorado Ridge	3433.1	3.535681
			202 18 33.0	22 18 50.9	Cushings Mount	1979.4	3.296542
			299 15 10.6	119 16 47.4	Bonifacio Hill	4663.7	3.668729
Algers Ridge	36 22 40.288	1241.8	340 16 33.5	160 16 55.7	Bonifacio Hill	2764.0	3.441531
1875	121 52 01.426	35.6	18 44 07.4	198 43 38.6	Sierra Hill	3770.5	3.576399
			84 08 53.7	264 07 39.1	Division Knoll	3151.7	3.498548
			134 15 52.4	314 14 36.4	Palo Colorado Ridge	4457.6	3.649097
			155 36 19.0	335 35 08.6	Oliviers Mount	7150.1	3.854313
Las Piedras Ridge	36 22 18.991	585.4	102 44 12.7	282 43 37.4	Division Knoll	1517.9	3.181248
1875	121 53 07.809	194.7	148 43 16.2	328 42 12.7	Kaslers Point	4939.9	3.693715
			161 24 02.2	341 23 44.8	Cushings Mount	2285.2	3.358916
			248 21 22.8	68 22 02.2	Algers Ridge	1780.2	3.250465
			306 55 37.5	126 56 39.0	Bonifacio Hill	3237.4	3.510196
			351 19 56.4	171 20 06.9	Sierra Hill	2948.0	3.469530

Point Sur to Monterey Bay—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Widow Heaths Hill	36 21 27.002	832.3	349 53 19.5	169 53 38.2	Black Ridge	4478.3	3.651113
1875	121 53 38.058	948.9	4 56 16.7	184 56 05.0	Point Sur	5738.6	3.758808
			159 26 22.5	339 26 05.2	Division Knoll	2068.8	3.315718
			180 22 48.7	0 22 49.3	Cushings Mount	3768.3	3.576147
			226 50 00.7	46 50 58.0	Algers Ridge	3302.4	3.518827
			275 50 52.1	95 52 11.6	Bonifacio Hill	3359.7	3.526297
Point Sur 2	36 18 21.624	666.4	245 09 14.3	65 10 14.7	Little River Hill	2802.2	3.447506
1890	121 53 58.050	1448.3	259 39 42.9	79 42 51.3	Pico Blanco	8069.9	3.906868
			307 01 10.1	127 03 58.1	Coopers SE. Corner	8873.8	3.948111
Ventura Rock	36 20 36.470	1124.2	174 56 24	354 56 08	Kaslers Point	7410.3	3.869835
1875	121 54 24.518	611.4	187 02 24	7 02 34	Division Knoll	3521.1	3.546675
			216 38 15	36 38 42	Widow Heaths Hill	1941.1	3.288052
			350 53 35	170 54 51	Point Sur	4213.0	3.624595
Bixbys Mount	36 21 20.078	618.9	72 24 32.5	252 23 09.7	Sierra Hill	3632.4	3.560188
1875	121 50 31.139	776.4	84 23 37	264 23 06	Bonifacio Hill	1324.7	3.122117
			114 56 50	294 55 18	Las Piedras Ridge	4307.3	3.634210
			137 41 33	317 40 40	Algers Ridge	3343.4	3.524193
Boulder Peak	36 23 10.200	314.4	60 21 11	240 18 44	Bonifacio Hill	7119.3	3.852440
1875	121 47 15.862	395.4	61 41 14	241 37 55	Sierra Hill	9464.2	3.976086
			71 34 08	251 30 22	Widow Heaths Hill	10044.3	4.001920
			82 38 34	262 35 44	Algers Ridge	7177.1	3.855946
Flat Point	36 21 24.274	748.2	325 14 59	145 16 13	Little River Hill	5418.6	3.733889
1875	121 54 19.925	496.8	337 03 23	157 04 06	Black Ridge	4696.0	3.671728
			354 25 03	174 25 16	Point Sur	5660.1	3.752824
Twin Peaks North	36 24 07.112	219.2	28 23 14	208 22 06	Bonifacio Hill	5998.9	3.778075
1875	121 49 29.630	738.4	54 44 12	234 42 41	Algers Ridge	4634.0	3.665956
			66 35 31	246 32 46	Division Knoll	7539.6	3.877351
			93 35 16	273 32 29	Palo Colorado Ridge	6988.2	3.844363
Palo Corona	36 27 04.264	131.4	353 46 34	173 47 02	Bonifacio Hill	10802.0	4.033506
1875	121 52 10.982	273.4	358 19 23	178 19 30	Algers Ridge	8140.2	3.910637
			17 56 10	197 55 19	Cushings Mount	6965.5	3.842954
Castle Rock	36 22 31.467	969.9	187 53 31	7 53 43	Palo Colorado Ridge	3414.9	3.533375
1875	121 54 28.356	706.8	215 40 06	35 40 36	Cushings Mount	2192.6	3.340964
			327 44 31	147 45 01	Widow Heaths Hill	2349.6	3.370989
Awash Rock	36 16 50.857	1567.6	152 39 36	332 39 01	Point Sur	3145.7	3.497724
1875	121 52 59.950	1496.2	177 42 18	357 42 13	Black Ridge	4106.1	3.613430
			195 22 57	15 23 23	Little River Hill	4122.5	3.615161
Big Mountain	36 25 44.478	1371.0	10 37 24	190 36 58	Algers Ridge	5776.3	3.761649
1875	121 51 18.704	465.9	23 14 25	203 13 20	Las Piedras Ridge	6892.6	3.838386
			39 36 12	219 34 50	Cushings Mount	5408.8	3.733099
Piedra de Lobos, outer	36 27 21.467	661.7	239 21 40	59 22 29	Rocky Ridge	2368.1	3.374406
1875	121 56 11.963	297.9	294 17 02	114 17 38	Soberanes Ridge	1636.8	3.214000
			316 29 12	136 29 30	Soberanes Point	1102.3	3.042312
			318 37 57	138 38 55	Portuguese Ridge	3685.8	3.566536
			338 21 54	158 22 42	Kaslers Point	5488.3	3.739439
Sandstone Cliff	36 19 02.501	77.1	320 44 35	140 44 50	Cooper	994.2	2.997482
1875	121 53 09.313	232.3	30 42 32	210 42 22	Point Sur N. Base	800.4	2.903285
			43 47 33	223 47 04	Point Sur	1750.1	3.243057
Cushings Point	36 24 11.350	349.8	178 49 41	358 49 40	Kaslers Point	758.3	2.879862
1875	121 54 50.126	1249.0	305 27 55	125 28 38	Cushings Mount	2235.9	3.349454
			341 07 16	161 07 41	Division Knoll	3306.5	3.519374
Throp's house, chimney	36 28 39.238	1209.5	151 00 18	330 59 57	Yankee Point	1787.3	3.252189
1875	121 56 03.093	77.0	204 12 30	24 12 48	Waters Ridge	1848.5	3.266808
			303 14 06	123 14 48	Rocky Ridge	2171.9	3.336848
			354 15 00	174 15 01	Gutres Knoll	564.3	2.751486
Point Cypress Rock	36 35 01.354	41.7	216 09 54	36 10 45	Pyramid Point	3652.1	3.562541
1875	121 58 49.451	1229.3	225 22 30	45 23 19	Lone Rock	2855.0	3.455612
			240 32 11	60 32 47	Pelican Point	1728.6	3.237686
			316 00 14	136 00 21	Point Cypress	407.0	2.609613
Double tree north	36 29 42.150	1299.2	150 52 25	330 50 45	Pescadero Point	8513.7	3.93012
1875	121 54 26.958	670.9	187 16 47	7 17 11	Monterey Hill	8042.1	3.90537
White house, chimney*	36 33 20.48	631.3	329 54 01	149 54 48	Greggs Hill	3918.7	3.59314
1875	121 55 36.99	919.9	23 21 54	203 21 14	Whalers Knoll	4218.1	3.62512

* No check on this position.

int Sur to Monterey Bay—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Yankee Point Breaker	36 29 06.53	201.2	246 32 40	66 33 26	Waters Ridge	2122.8	3.32690
1875	121 56 50.88	1266.6	318 22 36	138 23 06	Gutres Knoll	1876.2	3.27327
Bixby's barn, north gable*	36 21 21.88	674.4	132 26 57	312 26 11	Las Piedras Ridge	2608.7	3.41642
1875	121 51 50.59	1261.6	173 37 34	353 37 27	Algers Ridge	2432.0	3.38596
Gutres' barn, west gable*	36 28 10.65	328.3	283 44 50	103 45 21	Rocky Ridge	1301.8	3.11456
1875	121 55 40.92	1018.5	0 21 00	180 21 00	Soberanes Point	2315.6	3.36466
Double tree south	36 29 42.17	1299.8	12 36 53	192 36 27	Soberanes Ridge	5134.2	3.71047
1875	121 54 27.02	672.4	38 26 09	218 25 34	Brushy Ridge	2388.3	2.37808
Mount Toro Lat. Station	36 31 35.17	1084.2					
1885	121 36 32.83	816.8					
Santa Ana Lat. Station	36 54 19.60	604.2					
1885	121 13 58.10	1438.3					

Inland peaks.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Santa Inez Peak, top	34 31 38.382	1182.7	82 10 28.9	262 02 59.6	Gaviota	20417.3	4.309998
	119 58 40.547	1034.1	96 45 17.9	276 25 27.7	Arguello	53855.7	4.731232
			125 27 27.8	305 06 01.3	Lospe	70430.2	4.847759
			147 32 47.9	327 12 46.5	San Luis	98882.2	4.995118
			155 54 02.6	335 46 56.0	Tepusquet	46573.8	4.668142
Dome Mountain, top of peak	35 16 44.806	1380.9	354 21 00.8	174 22 32.4	Tepusquet	41103.8	4.613882
	120 13 49.054	1239.7	38 48 10.1	218 35 13.6	Lospe	54737.4	4.738284
			138 55 16.0	318 53 55.6	San Jose	5350.1	3.728364
San Rafael Mtn. or McKinley, U. S. G. S.	34 42 09.686	298.5	107 10 13.2	286 44 10.1	Lospe	72789.0	4.862066
	119 50 40.971	1042.7	126 31 01.3	306 19 20.0	Tepusquet	38810.7	4.588951
			150 27 12.2	330 12 36.1	San Jose	78234.8	4.893400
Zaca Peak, top of highest tree	34 46 05.771	177.8	67 31 16.3	247 12 55.0	Arguello	53395.8	4.727507
	120 01 23.119	587.9	104 50 17.7	284 30 20.1	Lospe	55077.0	4.740970
			136 39 39.8	316 34 04.7	Tepusquet	21695.4	4.336367
			139 11 20.4	318 52 48.6	San Luis	74900.4	4.874484
			159 47 19.0	339 38 50.8	San Jose	64716.9	4.811018
Fremont Peak	36 45 27.126	836.1	235 43 51.2	55 53 35.5	Santa Ana	29198.0	4.465353
	121 30 12.397	307.5	353 33 31.6	173 36 33.7	Santa Lucia	68294.9	4.834388
			20 13 26.5	200 09 39.8	Mount Toro	27339.0	4.436783
Cuyama Peak, top	34 56 07.012	216.1	82 42 56.2	262 34 53.8	Tepusquet	21575.7	4.333964
	119 57 06.603	167.6	85 48 20.4	265 25 53.5	Lospe	59914.0	4.777528
			145 40 00.0	325 29 03.1	San Jose	51131.2	4.708686
San Luis Obispo 2	35 18 09.330	287.5	282 21 14.6	102 25 57.5	San Luis	12668.7	4.102732
	120 41 49.766	1257.3	349 31 52.0	169 35 01.6	Lospe	46089.9	4.663606
			140 55 04.2	320 42 28.2	Rocky Butte	51955.9	4.715635
Santa Cruz Peak, top†	34 44 06.18	190.4	101 37 28	281 04 38	Lospe	89599	4.952305
	119 38 43.51	1106.9	111 37 25	291 18 54	Tepusquet	53145	4.725464
Chalone Peak, northwest peak†	36 26 52.72	1625.0	293 49 02	114 02 14	Hepsedam	36412	4.561243
	121 11 41.68	1037.9	351 55 32	172 00 20	Rocky Butte	87675	4.942877
Estrella Mountain, highest knob†	35 44 13.45	414.5	84 52 05	264 19 38	Rocky Butte	84265	4.925648
	120 07 55.13	1385.3	140 08 46	320 01 28	Castle Mount	29248	4.466104
Chiches Mountain, highest part†	35 23 34.29	1056.8	344 12 56	164 18 39	Tepusquet	55609	4.745143
	120 21 05.51	139.1	115 27 10	295 02 31	Rocky Butte	70934	4.850854
Centre Peak	36 12 09.43	290.7	112 22 52	291 47 47	Mount Toro	95512	4.980058
	120 37 22.34	558.1	124 38 04	304 30 56	Hepsedam	21952	4.341479
			145 11 01	324 49 13	Santa Ana	95196	4.978619

* No check on this position.

† Checked only by vertical angles.

Inland peaks—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Otay Mountain	32 35 40.73	1254.6	125 30 46.6	305 19 33.1	Soledad	46924.1	4.6713958
	116 50 39.15	1020.9	141 01 39.8	320 32 33.3	Niguel	131396.9	5.1185850
			142 43 21.1	322 40 23.0	San Miguel	14201.4	4.1523321
			209 39 16.4	29 47 00.1	Cuyamaca	44972.8	4.6529501
			276 31 52.7	96 36 54.9	Tecate	14730.1	4.1682046
Table Mountain, north end, Mex.	32 20 36.958	1138.5	178 56 21.3	358 56 06.3	San Miguel	39142.3	4.5926467
	116 55 41.544	1086.3	204 13 55.0	24 23 20.1	Cuyamaca	48495.2	4.6856988
			220 42 22.1	40 50 05.6	Tecate	34532.8	4.5382323
Table Mountain, south end, Mex.	32 19 58.10	1789.7	177 34 23.8	357 33 48.5	San Miguel	40369.1	4.6060494
	116 55 03.74	97.8	203 08 38.4	23 18 43.1	Cuyamaca	74099.9	4.8698175
			218 11 37.5	38 19 00.6	Tecate	34829.2	4.5419436
Round Table Mountain, Mex.	32 18 31.29	963.8	159 16 58	339 11 22	San Miguel	45994.2	4.662703
	116 45 44.73	1170.1	191 39 29	11 44 32	Cuyamaca	72269.2	4.858953
			193 01 31	13 04 54	Tecate	30821.5	4.488854
Laguna Mountain, cairn	32 53 32.772	1009.4	65 55 08.8	245 38 23.4	San Miguel	52960.0	4.7239482
	116 25 13.150	341.8	85 57 07.4	265 30 02.4	Soledad	78059.4	4.8924252
			109 11 00.8	289 04 57.0	Cuyamaca	18409.4	4.2650404
			166 49 46.9	346 41 15.0	San Jacinto	105096.4	5.0215879
Cajon Mountain	32 54 53.95	1661.8	24 14 47.4	204 11 00.5	San Miguel	26565.3	4.4243140
	116 49 10.55	274.1	78 48 52.2	258 04 47.0	Soledad	41124.2	4.6140978
			259 54 03.2	80 01 00.7	Cuyamaca	20263.6	4.3067166
			341 40 20.4	161 44 36.0	Tecate	39191.0	4.5931863
North Peak	33 00 23.25	716.3	43 48 27.7	223 37 02.2	San Miguel	47553.1	4.6771786
	116 35 05.63	146.2	73 41 57.3	253 20 12.0	Soledad	65072.7	4.8133988
			117 59 19.2	297 21 31.1	Niguel	120867.5	5.0823097
Middle Peak	32 58 49.52	1525.4	45 04 47.9	224 53 51.7	San Miguel	44517.0	4.6485261
	116 35 59.22	1537.6	75 51 28.5	255 30 12.8	Soledad	62971.7	4.7991452
			119 29 48.3	298 52 30.4	Niguel	121036.3	5.0829157
San Onofre Mountain	33 21 51.22	1578.0	126 33 26.3	306 25 31.6	Niguel	27676.3	4.4421087
	117 29 39.74	1027.4	174 35 07.9	354 33 49.7	Santiago	38600.2	4.5865896
			298 56 54.3	119 26 02.8	Cuyamaca	94906.5	4.9772961
			338 40 16.5	158 48 13.0	Soledad	62387.2	4.7950955
San Gabriel Peak	34 14 36.51	1125.0	21 45 07.9	201 37 10.1	San Pedro	59349.6	4.7734177
	118 05 52.90	1353.7	289 32 26.0	109 57 11.9	San Jacinto	139414.9	5.1443093
			302 27 34.6	122 28 49.6	Wilson Peak	4034.1	3.6057496
			317 35 29.0	137 47 36.3	San Juan	49427.3	4.6939668
			318 24 44.1	138 43 39.7	Santiago	78817.2	4.8966208
			337 19 01.9	157 31 13.1	Niguel	87793.3	4.9434614
Lions Head	34 07 14.25	439.1	232 37 03.8	52 48 14.0	San Fernando	38334.0	4.5835842
	118 55 53.01	1358.5	261 37 37.4	82 06 57.2	Wilson Peak	81056.4	4.9087875
			285 53 07.8	105 58 03.1	Castro	14036.1	4.1472458
			306 49 53.1	127 09 50.8	San Pedro	68997.9	4.8388356
San Bernardino Meridian	34 07 20.902	644.0	326 35 19.1	146 43 27.8	San Jacinto	40844.5	4.6111339
	116 55 18.684	478.7	51 15 31.2	230 55 02.2	Santiago	72712.2	4.8616075
			96 26 11.4	275 47 47.8	Wilson Peak	105636.5	5.0238142
San Bernardino East Peak, cairn	34 07 29.317	903.4	329 55 41.6	150 02 53.8	San Jacinto	39703.8	4.5988321
	116 53 37.748	967.4	348 21 56.7	168 31 28.7	Cuyamaca	133351.3	5.1249971
			13 14 55.9	193 03 04.4	Soledad	146336.8	5.1653537
			52 21 27.5	232 00 02.2	Santiago	74905.5	4.8745139
			73 31 47.4	253 03 28.1	San Juan	81368.8	4.9104578
			89 06 49.4	268 03 11.4	Castro	174566.0	5.2419597
			96 09 43.3	275 30 22.9	Wilson Peak	108179.0	5.0341430
Old Baldy Peak, cairn	34 17 21.664	667.4	300 15 03.1	120 47 32.1	San Jacinto	103631.0	5.0154898
	117 38 44.930	1149.1	326 46 21.5	147 20 53.8	Cuyamaca	177416.2	5.2489934
			350 47 54.4	170 51 40.2	Santiago	65014.4	4.8130099
			5 24 41.7	185 21 45.5	Niguel	86533.9	4.9371862
			11 31 10.5	191 28 05.5	San Juan	42494.6	4.6283335
			46 47 27.4	226 24 18.7	San Pedro	87667.0	4.9428360
			93 12 22.4	272 40 05.6	San Fernando	87985.6	4.9444114
Old Grizzly Mountain, cairn	34 05 57.699	1777.9	336 52 54.7	156 57 47.2	San Jacinto	34302.6	4.5353273
	116 49 27.863	714.2	350 55 50.6	171 03 04.4	Cuyamaca	129422.6	5.1120100
			16 01 11.7	195 46 02.7	Soledad	145222.2	5.1620331
			56 53 12.1	236 29 27.8	Santiago	78495.8	4.8948464
			74 45 51.9	253 55 16.1	San Pedro	145104.3	5.1616803
			76 33 11.5	256 02 32.9	San Juan	86829.4	4.9386665
			97 15 24.5	276 33 44.5	Wilson Peak	114869.7	5.0602053

Inland peaks—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	*m.*	° ′ ″	° ′ ″		*meters*	
Waterman Mountain	34 18 57.41	1769.0	295 25 16	116 07 11	San Jacinto	127837	5.106656
	117 55 33.59	858.8	338 38 57	158 45 18	San Juan	47861	4.679984
			1 26 28	181 25 57	Los Angeles SE. B.	58028	4.763641
			15 18 52	195 14 28	Los Angeles NW. B.	45731	4.660209
			20 59 12	200 51 14	Los Cerritos	61275	4.787281
			29 55 32	209 45 06	Dominguez Hill	57592	4.760364
			41 46 16	221 30 30	West Beach	65065	4.813348
Peak D	34 14 35.45	1092.3	6 57 04	186 54 54	Los Cerritos	49526	4.694832
	118 05 53.71	1374.4	16 59 23	196 54 44	Dominguez Hill	43800	4.641475
			34 04 36	213 54 39	West Beach	48913	4.689426
Old Baldy Southwest Peak	34 17 12.99	400.3	10 36 18	190 33 29	San Juan	42091	4.624188
	117 39 13.73	351.2	46 34 57	226 12 04	San Pedro	86947	4.939257
			93 24 14	272 52 14	San Fernando	87265	4.940842
Mount Lowe	34 13 55.23	1701.8	282 19 18	102 20 48	Wilson Peak	4184	3.621558
	118 06 19.60	501.6	288 57 03	109 44 56	San Jacinto	139641	5.145013
			315 59 34	136 11 56	San Juan	48968	4.689912
			317 25 00	137 44 10	Santiago	78331	4.893934
Toro Mount	33 31 25.05	771.8	14 49 31	194 43 34	Cuyamaca	66155	4.820565
	116 25 30.87	796.6	27 35 56	207 19 12	San Miguel	103374	5.014413
			101 42 39	281 05 51	Santiago	104932	5.020910
			143 59 55	323 51 30	San Jacinto	39962	4.601651
Smith Mountain, high peak	33 21 46.69	1438.4	335 02 38	155 10 10	Cuyamaca	50876	4.706515
	116 50 08.92	230.6	7 14 25	187 11 08	San Miguel	74500	4.872157
			120 56 38	300 33 31	Santiago	75426	4.877523
Cobble Back Mountain or Woodson Mountain	33 00 30.73	946.7	35 16 45	215 09 44	Old Town	34967	4.543656
	116 58 12.85	333.6	54 43 48	234 34 37	Soledad	32311	4.509356
			70 06 09	249 56 53	Pine	28206	4.450336
			76 25 05	256 15 59	Town	26811	4.428317
Long Range Mountain or Cowles Mountain	32 48 46.50	1432.4	64 37 48	244 32 47	Old Town	16012	4.204457
	117 01 42.86	1115.0	98 19 31	278 12 20	Soledad	20879	4.319706
			120 08 32	300 01 18	Pine	24059	4.381272
			127 05 36	306 58 30	Town	25509	4.406688
Coast Range Double Peak or Cerro de las Posas	33 06 34.46	1061.6	1 10 12	181 09 55	Old Town	39779	4.599652
	117 10 37.43	970.5	13 12 30	193 10 04	Soledad	30708	4.487246
			20 58 32	200 56 11	Town	18778	4.273641
			113 56 23	293 51 38	Kelly	14773	4.169466
			118 51 46	298 45 11	San Luis	21349	4.329376
			126 27 32	306 21 19	Wire	21975	4.341922
Telegraph Peak	34 13 22.95	707.2	355 14 54	175 16 36	Santiago	57023	4.756052
	117 35 04.64	118.8	9 58 04	189 53 05	Niguel	79994	4.903056
			22 25 31	202 20 22	San Juan	37081	4.569148
			34 46 00	214 34 01	Los Angeles SE. B.	58002	4.763439
			52 53 33	232 28 22	San Pedro	87231	4.940669
Ontario Peak	34 13 39.99	1232.2	31 26 31	211 15 50	Los Angeles SE. B.	56476	4.751866
	117 37 25.14	643.5	46 32 36	226 14 29	Los Cerritos	68803	4.837607
			49 27 19	229 12 46	Los Angeles NW. B.	52688	4.721713
			54 47 34	234 26 59	Dominguez Hill	69412	4.841434
			61 35 24	241 09 30	West Beach	81081	4.908917
			89 31 12	269 16 26	Wilson Peak	40308	4.605393
Mount Islip	34 20 42.63	1313.6	348 51 38	168 55 04	San Juan	48748	4.687960
	117 50 21.90	559.7	8 47 48	188 44 22	Los Angeles SE. B.	61977	4.792228
			26 22 26	206 11 33	Los Cerritos	67451	4.828987
			34 39 59	214 26 38	Dominguez Hill	64609	4.810294
			44 47 31	224 28 51	West Beach	72891	4.862672
			49 15 08	229 01 32	Buenavista	49170	4.691704
Cloud Peak	32 56 49.48	1524.2	68 19 07	248 00 15	Old Town	58468	4.766916
	116 36 21.56	560.0	79 03 33	258 42 30	Soledad	61602	4.789595
			90 38 14	270 17 15	Town	60125	4.779053
			111 39 36	291 14 20	San Luis	77412	4.888805
			113 49 52	293 24 57	Wire	77516	4.889393
Mount Disappointment	34 14 48.01	1479.4	343 19 07	163 24 34	Los Angeles SE. B.	52524	4.720357
	118 06 16.41	419.9	353 03 36	173 05 13	Los Angeles NW. B.	36698	4.564640
			16 06 59	196 02 33	Dominguez Hill	44006	4.643511
			31 01 36	210 56 56	Buenavista	24778	4.394071
			33 15 22	213 05 37	West Beach	48914	4.689430
Cucamonga Peak	34 13 20.00	616.3	48 50 54	228 31 32	Los Cerritos	70949	4.850947
	117 35 09.90	253.4	56 48 16	236 26 25	Dominguez Hill	71929	4.856904
			63 06 23	242 39 13	West Beach	83861	4.923561

Inland peaks—Continued.

Station	Latitude and longitude	Seconds in meters	Azimuth	Back azimuth	To station	Distance	Logarithms
	° ′ ″	m.	° ′ ″	° ′ ″		meters	
Peak 26	34 20 47.65	1468.3	290 30 00	111 26 04	San Jacinto	164809	5.216980
	118 20 46.71	1193.8	297 17 57	117 27 35	Wilson Peak	29576	4.470936
			310 20 48	130 41 17	San Juan	73865	4.868441
High Knob Mountain	33 12 44.66	1375.9	67 13 54	247 09 21	Kelly	13982	4.145554
	117 11 00.97	25.1	80 31 47	260 26 43	Fire	14603	4.164454
			86 31 08	266 24 46	San Luis	18121	4.258173
			95 31 55	275 25 54	Wire	17144	4.234116
Pola Mountain or Morgan Hill	33 22 13.43	413.8	25 51 03	205 41 05	Soledad	65320	4.815045
	116 56 52.08	1346.3	31 14 28	211 04 35	Town	54295	4.734763
			56 44 36	236 32 17	Kelly	41721	4.620351
			61 22 09	241 09 18	Fire	41463	4.617663
			65 09 09	244 55 00	San Luis	44162	4.645045
			67 57 38	247 43 50	Wire	42123	4.624517
Santa Maria Mountain or Black Mountain	32 58 53.99	1663.1	14 22 43	194 20 27	Old Town	26410	4.421776
	117 06 56.69	1471.9	62 45 39	242 41 08	Pine	14521	4.162004
			74 58 40	254 54 19	Town	12896	4.110450
			135 06 16	314 57 41	San Luis	34590	4.538947
			136 24 23	316 17 38	Kelly	27876	4.445231
			139 21 56	319 13 42	Wire	35915	4.555280
Ragged Peak or Lyons Peak	32 42 07.41	228.2	87 52 38	267 47 02	San Miguel	16230	4.210327
	116 45 46.71	1216.7	97 54 20	277 40 38	Old Town	39999	4.602054
			108 35 31	288 19 38	Soledad	48306	4.684000
			121 25 20	301 09 31	Town	53251	4 726329
			208 21 09	28 26 15	Cuyamaca	30859	4.489385
			332 44 02	152 46 26	Tecate	15294	4.184529
Santiago Northwest Peak	33 43 11.26	346.9	262 15 40	82 44 30	San Jacinto	80787	4.907339
	117 32 36.79	947.2	317 44 00	137 44 19	Santiago	1363	3.134524
			37 31 46	217 27 48	Niguel	28969	4.461929
			65 18 49	244 52 45	Catalina Peak	87721	4.943102
			92 28 19	272 04 17	San Pedro	73443	4.865948
Sharp Peak or Strawberry Peak	34 17 00.70	21.6	290 57 37	111 45 58	San Jacinto	142701	5.154426
	118 07 05.70	145.8	321 26 16	141 28 12	Wilson Peak	8450	3.926847
			96 45 36	276 29 18	San Fernando	44682	4.650135
Saddle Mountain 1	34 04 33.70	1038.4	95 22 48	275 18 32	Castro	11758	4.070336
	118 39 29.82	764.6	190 42 23	10 44 20	San Fernando	28672	4.457453
			253 14 35	73 34 42	Wilson Peak	57468	4.759427
			320 40 47	140 51 36	San Pedro	47218	4.674103
Saddle Mountain 2	34 04 42.26	1302.2	93 59 30	273 55 07	Castro	12054	4.081139
	118 39 17.39	445.9	127 55 24	307 42 28	Santa Clara	44775	4.651036
			190 10 28	10 12 18	San Fernando	28354	4.452622
			321 11 02	141 21 43	San Pedro	47222	4.674140
San Antonio Mountain, north peak	34 21 02.62	80.7	353 21 00	173 23 03	San Juan	48777	4.688215
	117 47 55.16	1409.8	12 05 32	192 00 44	Los Angeles SE. B.	63262	4.801145
			26 27 11	206 18 30	Los Angeles NW. B.	53549	4.728751
			28 55 58	208 43 44	Los Cerritos	69737	4.843462
			37 01 02	216 46 18	Dominguez Hill	67301	4.828023
			53 42 14	233 23 13	De Camp	64610	4.810301
White Cone (San Antonio) or North Baldy	34 21 32.66	1006.4	357 12 49	177 13 42	San Juan	49435	4.694030
	117 45 48.82	1247.6	14 43 41	194 37 42	Los Angeles SE. B.	64912	4.812327
			29 00 52	208 51 00	Los Angeles NW. B.	55872	4.747191
Black Knob or Iron Mountain	34 17 19.32	595.3	3 08 36	183 07 46	San Juan	41632	4.619431
	117 42 46.41	1187.0	21 05 16	200 57 35	Los Angeles SE. B.	58909	4.770182
			37 45 30	217 33 56	Los Angeles NW. B.	51908	4.715236
Wilson Peak, Harvard Observatory Station	34 13 26.79	825.5	346 50 11	166 54 14	Los Angeles SE. B.	49107	4.691141
	118 03 45.03	1152.6	359 04 41	179 04 52	Los Angeles NW. B.	33932	4.530609
Margarita Peak	33 26 40.92	1260.7	348 24 44	168 27 00	Kelly	31829	4.502824
	117 23 25.24	651.9	350 11 00	170 12 43	Fire	28594	4.456277
			357 27 56	177 28 22	San Luis	26906	4.429854
			103 22 45	283 11 24	Niguel	32786	4.515688
			144 29 42	324 07 17	Wilson Peak	106419	5.027021
Boundary Mon. 245*	32 34 25.77	793.8	102 29 41	282 28 43	Tecate	2880	3.45944
	116 39 30.24	788.8					
Boundary Mon. 246*	32 34 16.16	497.8	192 18 37	12 18 41	Tecate	941	2.97341
	116 41 25.76	671.9	264 22 48	84 23 50	Bound. Mon. 245	3028	3.48116

*No check on this position.

DESCRIPTIONS OF STATIONS.

This list may be conveniently consulted by reference to the illustrations at the end of this appendix and to the index.

In each description the tense used is appropriate to the date at which the description was written.

All directions in the descriptions are given in the form of azimuths reckoned continuously from south around by west to 360°, west being 90°, north 180°, and east 270°. The azimuths are true, not magnetic.

In general the surface and underground marks described are not in contact, so that a disturbance of the surface mark will not, in general, affect the underground mark. The underground mark should be resorted to only when there is evidence that the surface mark has been disturbed.

Any person who finds that one of the stations here described is disturbed, or that the description no longer fits the facts, is requested to send such information to

SUPERINTENDENT,
COAST AND GEODETIC SURVEY,
Washington, D. C.

GENERAL NOTES IN REGARD TO STATION MARKS.

NOTE 1.—The method of marking each station referred to this note was as follows: A glass bottle buried neck up with its top about 20 inches below the surface of the ground was the underground mark. A redwood stub 2 by 3 inches in cross section, with several inches left protruding and having a nail driven in its top, marked the station at the surface. Coal cinders were placed in the hole with the earth in filling it and placed on the surface around the center mark. As witness marks the three stubs, 2 by 3 inches in cross section, which supported the theodolite stand were left in position.

NOTE 2.—The station was marked by the center of the upper end of a 4-inch earthenware pipe buried in the ground and filled with coal cinders and ashes. Three stubs, each with a fencing staple in the top, were driven around the center.

NOTE 3.—A station referred to this note was marked in 1860 by a redwood stub with a composition nail in the top, surrounded by four similar stubs. In 1878 the center was re-marked by a stone, usually 6 inches long by 3 inches in diameter, with a leaden bolt and copper nail in the top, the nail marking the center of the station, and buried from 1 to 3 feet under the ground. Above this was set even with the surface a stone about 8 inches square, with a drill hole marking the center of station, surrounded by three redwood stakes, each 1 foot from the drill hole, and by three large stones with drill holes in the top buried even with the surface of the ground, ranging approximately north, southeast, and southwest, and distant 15 feet, each surrounded by three redwood stakes, distant 1 foot from the drill hole.

NOTE 4.—A station referred to this note was marked by a flat stone, in which a hole was drilled, buried 3 feet below the surface of the ground. Over this was a pine stub projecting 6 inches above the surface and having a copper tack in the top. Three stubs, each with a copper tack in the top, were driven in the ground, each 6 feet from the center, and three bottles were buried 1 foot deep, each pointing to the center.

NOTE 5.—A station referred to this note was marked at the center by a stone, with a ¾-inch drill hole in the top, buried 10 to 14 inches below the surface. The reference marks were on similar stones or in the solid rock, each a ¾-inch drill hole filled with a lead bolt and copper tack, with an arrowhead pointing to the center of the station.

NOTE 6.—The underground mark was a glass bottle buried 3 feet below the surface. A pine or redwood stub, projecting from 6 inches to 1 foot, with a copper tack in the top, marked the center of the station. Three witness stubs were driven into the ground to the north, south, and east, each with a copper tack in the top, exactly 6 feet from the center of the station.

NOTE 7.—The center of the station was marked by a drill hole in a flat stone buried 3 feet below the surface. Over this was a redwood stub, with copper tack in the top, driven even with the surface of the ground. One foot below the surface and 6 feet from the center, three glass bottles were buried, with their necks pointing toward the center. Three redwood stubs were driven even with the surface, each with copper nail in top, 4 feet from the center, approximately north, south, and east.

NOTE 8.—The underground mark was a bottle buried 3 feet below the surface, and the surface mark a redwood stub over the center. Where the station was on rock the center was marked by a drilled hole filled with lead. Two stubs were placed in line and one at right angles thereto, each 6 feet distant from center.

NOTE 9.—The underground mark was a glass bottle, buried 3 feet beneath the surface. A pine or redwood stub, projecting 1 foot or more, with a copper tack in the top, marked the center of the station. Three witness stubs were driven even with the surface of the ground, to the north, south, and east, each with a copper tack in the top, 6 feet from the center of station. Three bottles, with the necks pointing to the center of station, were buried 1 foot deep.

NOTE 10.—A stone bottle was buried, neck up, from 2½ to 4 feet underground. A redwood stub was driven 20 inches in the ground, and the center of the top marked the station. The three redwood theodolite stubs, their tops even with the center, sometimes with a fencing staple driven in each, were left as reference marks.

NOTE 11.—A glass bottle was buried 3 feet below the surface, and three stubs, each with a copper tack in the top, were placed to the north, south, and east.

NOTE 12.—A copper tack in the top of a redwood stub, 2 feet in the ground, marked the center. Three or four similar stubs were placed 3 feet from the center.

NOTE 13.—A copper tack in the top of a redwood stub, 2 feet in the ground, marked the center. Three similar stubs were placed 3 feet from the center to the north, south, and west, and sometimes a fourth stub at the same distance to the east.

NOTE 14.—A stone with a drill hole to mark the station was placed with the top 3 inches below the surface of the ground, and three similar stones were placed 3 feet from the center to the north, south, and west. Three redwood stubs, each with a copper tack in the top, were placed 3 feet from the center to the east, west, and north.

NOTE 15.—A copper tack in the top of a redwood stub, driven 2 feet in the ground, marked the center. Three similar stubs were placed 3 feet to the north, east, and west of the center.

NOTE 16.—The center was marked by a redwood stub projecting a few inches above the ground, with a copper tack in the top. Similar stubs were placed 6 feet from the center.

NOTE 17.—The station was marked usually by a hole in the bottom of a stone bottle set in the ground, neck down, even with the surface, and by four similar bottles placed 2 feet from the center to the north, east, south, and west; sometimes (as stated in description) by the center bottle only or by reference bottles only.

NOTE 18.—A glass bottle was buried 3 feet deep, and three stubs, each with a copper nail in the top, were placed 3 feet from the center to the north, south, and east.

NOTE 19.—A stone 6 inches square, or less, and 6 to 12 inches long, was buried 8 to 18 inches beneath the surface of the ground. In the top of it was a drill hole, in which a copper tack was leaded. Above this was placed, even with the surface, another stone, in the top of which a copper tack was leaded. Three or four redwood stakes were driven in the ground, each 1 foot from the center, and three stones, each with a drill hole in the top, were placed to the north, south, and west, 15 feet from the center, and each surrounded by three redwood stakes driven in the ground 1 foot from the drill hole in the stone.

NOTE 20.—A brickbat was buried even with the surface of the ground, and an iron spike driven in a lead bolt in the top marked the center. Four redwood stubs, each with a copper tack in the top, were placed to the north, south, east, and west, 2 feet from the center. Sometimes the three theodolite stubs were left, but these had no copper tacks in the tops and had no reference to the center.

NOTE 21.—Four redwood stubs, each with a copper tack in the top, were placed approximately north, south, east, and west, and equally distant from the center. Lines joining them diagonally intersect at the center.

NOTE 22.—A stone with a hole drilled in the top, in which a copper tack was driven, with or without a lead bolt, was buried 3 feet below the surface of the ground. On it rested a redwood stub, projecting 1 foot above the surface, with a tack in the top marking the center.

NOTE 23.—The center was marked by a tack in the top of a redwood stub 3 feet long driven in the ground. Similar stubs were placed 6 feet from the center to the north, south, and west. Stones were piled around the stubs.

NOTE 24.—The center was marked by a glass bottle, sometimes stated to be buried 3 feet deep, and by four redwood stubs, each with a tack in the top driven in the ground to the north, south, east, and west.

NOTE 25.—The center was marked by a cider bottle, buried neck up, 3 or 4 feet below the surface of the ground. Four stubs were driven in the ground to the north, south, east, and west, each 6 feet from the center.

NOTE 26.—The station was marked by a nail in the top of a redwood stub 1½ feet long driven about 3 inches below the surface of the ground. The reference marks were four redwood stubs, each with a nail in the top, placed 3 feet from the center to the north, south, east, and west.

NOTE 27.—The station was marked by a copper tack in the top of a stub about 2 feet long, projecting a few inches above the ground. Similar stubs were placed 6 feet from the center to the north, south, and west.

NOTE 28.—The station was marked by a copper tack in the top of a 2 by 3 inch stub, 3 feet long driven in the ground. Three similar stubs were placed to the north, south, and west, each with three copper tacks in the top, the center one of each being 6 feet from the center of the station. Usually rocks were piled around the stubs.

NOTE 29.—The station was marked by a bottle buried 3 feet underground, with a redwood stub resting on the neck of the bottle, the top of the stub even with the surface of the ground. Three witness stubs were placed, each 6 feet from the center, to the north, south, and east.

NOTE 30.—The center of station was marked by a stone bottle buried 4 feet below the surface of the ground, neck up. On top of this was placed a redwood stub, 2 by 2 inches, with the top even with the surface of the ground. . The witness marks were stubs with copper tacks in top, buried even with the surface of the ground, approximately to the north, south, east, and west, and distant 2 feet from the center of the station.

NOTE 31.—The center of the station was marked by a stone bottle, buried 3 feet below the surface of the ground, neck up. Over this was placed a redwood stub, 2 feet long, with the top even with the surface of the ground, and with a copper tack in the top marking the center of station. Three redwood stubs, each with a copper tack in the top, were placed even with the surface of the ground at the distances given in the description.

NOTE 32.—A flat stone, in which a hole was drilled, was buried 3 feet below the surface. Over this was a pine stub, projecting 6 inches above the surface of the ground and having a copper tack in the top. Three stubs, each with a copper tack in the top, were driven in the ground, 6 feet from the center to the north, south, and east. Three bottles were buried around the station 1 foot deep, pointing to the center.

NOTE 33.—A stone with a hole drilled in the top was buried 3 feet below the surface. On it rested a redwood stub projecting 1 foot above the surface with a tack in the top marking the center.

NOTE 34.—A stone bottle was buried, neck up, from 2½ to 4 feet underground. A redwood stub was driven 20 inches in the ground and the center of the top marked the station. Four small stubs were placed each 20 inches from the station. Three redwood stubs, with their tops even with the surface, sometimes with a fencing staple driven in each, were also placed around the station.

NOTE 35.—The station was marked by the intersection of the diagonals drawn from composition tacks in the tops of four redwood stubs, placed 2 feet from the center.

NOTE 36.—The station was marked by a redwood stub. Four similar stubs, with a composition nail marked with a cross in the top of each, were placed to the north, south, east, and west, 2 feet from the center.

NOTE 37.—The station was marked by four redwood stubs, sometimes 2 by 3 inches, each with a copper nail in the top, placed to the north, south, east, and west 2 feet from the center. There were also three or four other stubs around the center, sometimes with a copper nail in the top.

NOTE 38.—The center of the station was marked by a redwood stub. Four redwood stubs, each with a copper tack in the top, were placed approximately north, east, south, and west and equally distant from the center. Lines joining them diagonally intersect at the center.

PRIMARIES.

Pah Rah (Washoe County, Nev., W. Eimbeck, 1874, 1878).—On the northernmost of the three principal summits of the Virginia Mountains, the middle one, about 3 miles south, being the highest; just south of Pyramid Lake, in the great bend of the

Truckee River, 26 miles north 44° east from Reno, and 12 miles north 44° west from Wadsworth. It is visible from both places and may be reached from either place by road and trail—35 miles from the former and 20 miles from the latter place. The center was marked by a half-inch copper bolt cemented into the bed rock as a subsurface mark, over which a stone slab, with a ¾-inch drill hole in the center, was firmly cemented in position as a surface mark. Around the station was built to serve as a wind-break a rough stone circular wall, about 8 feet interior diameter, with an opening to the northeast. A stone pier, bearing north 37°.26 east and distant 8.5 feet from the station, was left standing as a reference mark.

Mount Como (Douglas County, Nev., W. Eimbeck, 1879).—On a sharp conical peak of the Como range of mountains, lying between Carson and Mason valleys, about 20 miles nearly due east from the town of Genoa, about 20 miles southeast from Carson City, and about 17 miles southeast from Dayton. The subsurface mark was a ½ by 4 inch copper bolt, leaded into a large and well-bedded granite rock. The surface mark was a ½-inch drill hole in the center of a large flat stone, 19 by 22 inches square and 5 inches thick, firmly cemented to the top of a stone and brick pier built over and around the lower mark to a height of 9 inches above the bolt. A ring wall of stone, resembling the figure 6, built to serve as a wind-break, was left standing. Lieutenant Wheeler's monument, about 35° west of south and 10 feet distant from the station, forms part of the wall. Two piers, one north and one south, were left standing as reference marks. Drill holes were made in the rock—one in line to Round Top, distant 6.25 meters; one in line to north pier, distant 10.6 meters, and one in line to south pier, distant 7.24 meters from the station. The angle at the center between the south pier and Round Top is 71° 01′, and between Round Top and the north pier is 129° 51′.

Mount Grant (Esmeralda County, Nev., A. F. Rodgers, 1878; W. Eimbeck, 1879).—On a high peak on the Wassuck Range, about 7 or 8 miles west of the southern end of Walker Lake. The mountain can be easily recognized by its three sharp peaks, one of which, King Peak, stands high above the others. The station is on the central peak, about 200 meters north of King Peak. The nearest railroad station (1882) is Hawthorne, just south of Walker Lake, on the Centralia and Chester Railroad, and distant about 10 miles from the mountain. The center of station was marked by a copper bolt sunk in a rock embedded in a stone and brick foundation pier, the top of which extends about 8 inches above the bolt, with a center pit in which a notice of approximate height and geographic positon was embedded in cement. A stone ring wall 15.5 feet interior diameter, with a long wing projecting to the southward and curving around the vertical circle pier (distant 32.5 feet from the center) was left standing. The wall and piers will serve as good reference marks for identifying the station.

Round Top (Alpine County, Cal., W. Eimbeck, 1876; G. Davidson, 1879; W. B. Fairfield, 1893).—On the crest of the Sierra Nevada Range of mountains on the highest and most easterly pinnacle, popularly known as Round Top, about 1 mile south of Carson Pass or the main summit of the Amador Grada. It can be reached via Carson City, thence by stage via Genoa to Woodfords, 32 miles distant, thence by wagon or horseback up Hope Valley to the summit of the Amador Grada. The ascent to the top of the peak must be from west or northwest. The station was marked by a copper bolt ⅝ inch in diameter, set in a drill hole in the rock. Above this was built a pier of rough stone masonry. Three other piers were built—one a little east of north and the other two nearly west of the station, and all were left standing to serve as reference marks. No difficulty was experienced in finding the point when it was visited in 1893.

Mount Conness (Tuolumne County, Cal., L. A. Sengteller, 1879; R. A. Marr, 1879; P. A. Welker, 1887; G. Davidson, 1890).—On a lofty peak of the Sierra Nevada Range, about 25 miles a little east of north from the Yosemite Valley, about 10 miles north of Soda Springs in the Tuolumne Meadows, and about 30 miles southwest of the California and Nevada boundary; on the highest pinnacle of the summit, which is a very small irregular crag. The sheer descent around four-fifths of the summit is over 1 000 feet to the talus. The station was marked by a cross cut on top of a copper bolt, ⅝ inch in diameter by 6 inches long, projecting 3½ inches above the solid rock. Above this was built a solid concrete pier 26 inches in diameter and about 40 inches high. In its upper surface was embedded a copper bolt ⅝ inch in diameter by 4 inches long, having a broad spherical head with a small silver pin in the center. A cross cut on the head of the bolt, a little to one side of the silver pin, marked the station.

Mount Lola (Nevada County, Cal., W. Eimbeck, 1876; G. Davidson, 1879; W. B. Fairfield, 1893).—About 25 feet northwest from the highest part of the southernmost summit of the high ridge between Weber and Independence lakes and the town of Meadow Lake. Independence Lake lies at the southeast base of this ridge and Browns Valley is on the opposite side. The best route to the station from Truckee is by way of Jansen's hotel at the east end of Independence Lake, thence up the eastern slope of the mountain to the station. The station was marked by a cross cut on the top of a ⅝-inch copper bolt set in a heavy capstone firmly embedded in a rough stone pier laid in cement. This capstone was about 15 inches above the natural surface of the ground and 3 feet 9 inches above the base of the pier. The pier was then built higher, and surmounted with another capstone 24 inches square with a hole drilled through it, marking the point. The pier was surrounded by a stone wall, about 6 feet distant, to serve as a wind-break. Three brick piers on stone foundations—one north 36°.5 east, distant 27 feet 9½ inches; one north 44°.8 east, distant 31 feet 3 inches, and the other north 27°.75 west—were left standing as reference marks. No difficulty was experienced in finding the point when visited in 1893.

Mount Diablo (Contra Costa County, Cal., R. D. Cutts, 1852; George Davidson, 1858; W. Eimbeck, 1876; J. J. Gilbert, 1880; George Davidson, 1884; George Davidson, 1892).—Close beside the highest rock on the summit of Mount Diablo. In all directions, except by the crooked approach along the ridge, the summit falls off rapidly. The second peak of Mount Diablo stands to the eastward. The subsurface mark was a cross in the top of a copper bolt sunk and cemented into the solid rock. Over this was a pier, and the center of the station was marked by the intersection of cross lines on the top of a ¾-inch copper bolt cemented in flush with the top of the pier. On the top of the bolt are also two other lines, and in the west angle of their intersection a hole. The intersection of cross lines, which marks the station, is three-sixteenths of an inch to the southeast of this hole. The pier from which vertical angles were observed (later reported as in ruins) was 144.74 feet west of the station, and inside the curve of the wagon road. The latitude pier was 27.7 feet southwest of the vertical angle pier and 167.84 feet west of the station; the transit pier was 32.5 feet southwest of the vertical angle pier.

Mocho (Santa Clara County, Cal., W. Eimbeck, 1875; L. A. Sengteller, 1879; E. F. Dickins, 1886; J. S. Lawson, 1887).—On the summit of the highest peak of the group of mountains lying to the eastward of Santa Clara Valley, on the eastern flank of the Mount Diablo Range and overlooking the San Joaquin Valley; about 11½ miles northeast from the Lick Observatory on Mount Hamilton and about 30 miles southeast of the town of Livermore. The station was marked in 1879 by a copper bolt sunk in the rock, over which, in 1887, was built a concrete pier 45 inches high by 24 inches square, enlarged at the top to 26 inches, to receive the theodolite.

Mount Helena (Napa County, Cal., W. Eimbeck, 1876; B. A. Colonna, 1879; E. F. Dickins, 1891).—On the summit of Mount Helena, about 12 miles to northward of Calistoga. The station was marked by a fine drill hole and a cross cut in the top of a ½-inch copper bolt 5 inches long, cemented into a ½-inch hole in the bed rock and projecting ¼ inch. Over this was built a pier 3 bricks square, 43 inches above the ground, with a drill hole in the center brick to mark the station. The collimator pier was 7.45 feet northwest of the station, 61 inches high, and 2 bricks square. The transit pier was 55 feet 11 inches southwest of the station, 3.25 feet high, and 2 bricks by 3 bricks. East of the transit pier and 58 feet 2½ inches from the station was the latitude pier, 3.05 feet high and 2 bricks by 2½ bricks, and with a space of 3.5 feet between the adjacent sides of the two piers. Fifty-five and one-half feet from and a little south of east of the latitude pier and 109 feet 3½ inches from the station was the vertical angle pier, 3.65 feet high and 2 bricks square. Seven feet 1¾ inches northwest of the station is a mark on the boundary of Lake and Napa counties, a basaltic rock with a large drill hole.

Mount Tamalpais (Marion County, Cal., George Davidson, 1859–60; E. F. Dickins, 1881; J. F. Pratt, 1882; George Davidson, 1882).—On a bold ridge running east and west, about 10 miles north of the Golden Gate, on the top of the western and highest of three peaks. The center of the station was marked by a stone bottle set in concrete, with the neck 20 inches below the surface of the ground. Over this was built a stone and concrete pier about 36 inches in diameter at the base and 26 inches at the surface. Here there was placed an irregular-shaped stone, the top even with the ground, with a copper bolt to mark the center of the station. Upon this was built a pier with the same diameter to a height of 24 inches from the ground, where a stone bottle was placed and the pier continued 29 inches higher. In the top was put a ⅝-inch copper bolt, with a hole marking the center of station. The reference marks were three stones, with drill holes in the top, on the surface of the ground, each 6 feet from the center, one along the ridge to the east, one to the south, and the other to the west. In a rock 18 feet 9¼ inches distant from the center was a mass of lead. There were three other concrete piers—one bearing north 76° 47′ west (true), distant 18.36 feet; one north 79° 48′ west (true), distant 23.20 feet, and one north 5° 54′ east (true), distant 41.12 feet from the center.

Vaca (Napa-Solano County, Cal., W. Eimbeck, 1876; G. Davidson, 1880).—About 7 miles west of Vacaville on the top of the first summit to the south of the culminating ridge of the Vaca range of mountains bordering on the Sacramento Valley and Putah Creek, on a bold escarpment of sandstone whose western front is quite steep for some distance. The underground mark was a soda-water bottle of flint glass, filled with sand and buried neck up, with the top 1.18 feet below the surface, a copper nail in the center of the neck marking the station. Over this was built a rough stone pier laid in Portland cement. The center mark at the surface was a copper bolt ⅝-inch in diameter and 5 inches long, projecting about one-fourth inch and having a silver pin in it, set in cement in a large stone in the center of the pier. The top of the pier was 3.44 feet above the underground mark. The astronomic piers, built of concrete, situated as follows, serve as reference marks: vertical circle pier south 6° 02′ east (true), distant 15.9 meters, and zenith telescope pier south 58° 42′ east (true), distant 72.1 feet from the station.

Monticello (Yolo County, Cal., W. Eimbeck, 1876).—In the extreme northeast corner of section 4, township 9 north, range 3 west of the Diablo meridian, on the highest summit of the mountain range lying between the Sacramento and Berryessa valleys, about 5 miles northward from the town of Monticello in the lower portion of Berryessa Valley. It may be most readily approached from this town, from which it is visible. The lower underground mark was a loaded metallic cartridge placed ball downward in a half-inch hole, 1½ inches deep, drilled in the bottom of a 6-inch round hole 1 foot deep excavated in the sandstone rock, the top of the cartridge being 2.5 feet below the surface. Over this was placed a stone about 4 inches square and 1 foot long, with a copper bolt in the top, its top being 1.1 feet below the surface. A rough stone foundation was laid over this and crowned with a large stone coming even with the surface. As a surface mark, a copper bolt ⅝ by 5 inches, with a silver pin in it, was set in cement in a hole drilled in this stone. The bolt projects about one-fourth inch above the stone. A rough stone theodolite pier was then built to a height of 3.84 feet and capped with a flat stone 32 inches square, having cross lines on it. The reference marks were the transit pier, 31.288 feet north and 3.687 feet east of the station; the latitude pier, 31.413 feet north and 8.823 feet east of the station, and the vertical circle pier bearing south 38° 17′ east (true) and distant 19.786 meters from the station.

Yolo Southeast Base (Yolo County, Cal., G. Davidson, 1876, 1880).—In the northwest quarter of section 19, township 8 north, range 2 east, Diablo meridian, 3⅛ miles west and 1⅛ miles south of Davisville and about 25 meters from the left bank of Putah Creek. The subsurface mark was a fine needle hole in a German-silver plug inserted in a copper bolt in the top of a granite block 35 inches long by 20 inches square at the base and dressed to 12 inches square at the top and having the letters U. S. C. G. S. deeply cut on it. The top of the block was 4½ feet below the surface and a glass hemisphere was placed over the copper bolt. The surface mark was a fine needle hole in a copper bolt set in lead on the top of a granite block 25 inches square by 26 inches deep having the letters U. S. C. S. S. E. YOLO BASE cut on it. The top of this block was even with the surface of the ground and the block itself was in the center of a solid brickwork pier, having a base of 70 inches square at a depth of 50 inches below the surface, battering to 54 inches square at the surface. This brickwork was carried up as a hollow pier to a height of 33¼ feet above the ground and capped with a granite slab 40 inches square by 8 inches thick with a 1¼-inch hole in the center. Charcoal and charcoal dust were mixed with the earth in filling in around the subsurface part of the structure. Four reference marks were set, consisting of granite blocks 1 foot square and 1¼ feet high, with copper bolts and drill holes in the top. They were incased in brickwork with their tops 18 inches below the surface. Two were set in a line to Yolo Northwest Base at distances of 18 feet 11$\frac{1}{16}$ inches and 327 feet 10 inches from the center and two at right angles thereto eastwardly at distances of 20 feet ⅝ inch and 328 feet 5$\frac{5}{16}$ inches from the center.

Yolo Northwest Base (Yolo County, Cal., G. Davidson, 1876, 1880).—In the extreme southeast corner of the southeast quarter of section 28, township 10 north, range 1 east, Diablo meridian, 4⅓ miles west of the railroad passing through Woodland, and immediately on the north side of the country road running west toward Madison and Copay Valley. The marking at this station was practically identical with that at Yolo Southeast Base, with the exception that the hollow brick pier was carried to a height of only about 12 feet above the surface, and the letters N.W. were substituted for S.E. on the granite blocks. No reference marks were established.

Ross Mountain (Sonora County, Cal., R. D. Cutts 1855; G. Davidson, 1860; J. F. Pratt, 1881; E. F. Dickins, 1891).—On the mountain locally known as Pole Mountain, on land belonging to Baker & Sons. It may be reached from Cazadero by a wagon road for about 3 miles to the ranch of W. H. Knowles and then about 2 miles by a good trail to the station. A good camping place with a fine spring of water is about ¼ mile southeast and about 250 feet below the station. The station was marked by a copper bolt in the top of a concrete pier. The reference marks were three stones, each with a half-inch drill hole in the top, placed level with the surface of the ground and 6 feet from the station, one nearly in line to Tomales Bay, one toward Mount Helena, and the third toward Walalla. A charred oak stump with a wrought-iron nail in the top was 20 feet 4 inches N. 54° 01′ W. (true) from the station.

Snow Mountain West (Colusa County, Cal., E. F. Dickins, 1892; also given as *Gleen*, Lake County).—On the highest point of the southwestern summit of Snow Mountain, a ridge about 200 yards long sloping slightly to the southeast; at a point where the ridge is about 50 yards wide, bare of grass and covered with small broken stones. The center of the station was marked by a half-inch drill hole 3½ inches deep, into which was driven a brass bolt 3 inches long. Over this was placed a spruce stump 6 inches in diameter and 3 feet long, with a brass bolt in the lower end resting on the brass bolt in the stone and surrounded with a pile of stones.

The best route to take in going to the station is via Colusa Junction, Sites, Stony Ford, and Fouts Springs to Caldwells Ranch, at the head of Paradise Valley, and from there, 6 miles by the trail up the east side of the mountain. The trail up the east side of the mountain is considered better, being less rugged and of easier slope than the one on the south side of the mountain.

Mount Sanhedrin (Mendocino County, Cal., B. A. Colonna, 1878; A. F. Rodgers, 1880; E. F. Dickins, 1891).—On the top of a sharp peak at the east end of Mount Sanhedrin. The best route in 1891 for reaching this station was from Ukiah by the Round Valley wagon road to Watsons (Hearst post-office), on the South Fork of Eel River (about 30 miles), thence by a private road to Ames and Garcy's ranch house (about 2½ miles), and then by a very poor trail, past the old Garcy cabin and round the southwest flank of the mountain up to the station (about 8 miles); this trail is very seldom used, and it would be almost impossible for a stranger to follow it without a guide. The nearest town is Centerville in Potter Valley (about 20 miles from Watsons). The center of the station was marked by a glass bottle embedded in the base of a concrete pier and by a screw in the wooden core in the top of the pier. The top of the bottle was 3.60 feet below the top of the pier. Nails were driven in stumps, as follows: One, 5 feet 1 inch from the station, azimuth 101° 00′; one, 7 feet 1½ inches, azimuth 155° 30′; one, 5 feet, azimuth 225° 30′.

Cold Spring (Mendocino County, Cal., B. A. Colonna, 1878; E. F. Dickins, 1891).—On a conspicuous bowlder 20 feet in diameter at the base and about 15 feet higher than the surrounding ridge, on the southwest end of the summit of Cold Spring Mountain, locally known as Signal Ridge. It is about 3 miles from Clay's ranch, and about 3 miles from Smally's house, and about 1 mile from Cold Spring ranch. The best approach in 1891 was by the Greenville and Booneville road to Clows ranch, about 15 miles from either place, then about 5 miles to Cold Spring ranch.

The center was marked by a drill hole in the rock. This drill hole was 13½ inches deep, and for a depth of 4 inches was 2 inches in diameter; below a depth of 4 inches its diameter was 1¼ inches. This drill hole was filled with cement, and a brass cartridge shell inserted in its mouth marked the center of the station. Above this was built a concrete pier 26 inches square, in the top of which, 3 feet 11 inches above the lower mark, was placed a copper bolt to mark the station. The reference marks were eyebolts in the rock, numbered in their azimuthal order, as follows: No. 1, a little to the right of the line to Paxton △, distant 10 feet 1 inch; No. 2, distant 9 feet 4 inches; No. 3, distant 12 feet.

Great Caspar (Mendocino County, Cal., B. A. Colonna, 1878; A. F. Rodgers, 1879).—On a knoll on the highest part of the ridge between Russian Gulch and Caspar Creek, about 7 miles from Mendocino City and ⅛ mile north from the road from Mendocino City to Little Lake. At the point where the road to the signal left this road there was cut a triangle in a redwood tree, and on another redwood was placed a signboard marked "U. S. C. S. Great Caspar Station 1878." At the center of the station was a redwood tree, and therefore the center of the station was fixed by four stone reference marks, each a granite block, from 15 to 22 inches long, buried even with the surface, the top dressed to 6 by 6 inches.

Stones Nos. 1, 2, and 4 are marked on top $\overset{\text{U S}}{\underset{\text{C S}}{\triangle}}$, and stone No. 3, $\overset{\text{C S}}{\underset{\text{U S}}{\triangle}}$. Beneath each stone a bottle was buried, with its top from 25 to 28 inches below the surface. Three trees were blazed with a triangle, about 2 feet on a side, and with a border of wrought-iron spikes driven around the edge. The distance and true azimuth to these reference marks were as follows: Stone No. 1, 32°, 10 feet; stone No. 2, 32°, 50 feet; redwood tree, 48°, 60.5 feet; pine tree, 98°, 48 feet; redwood tree, 284°, 85.5 feet; stone No. 3, 297°, 10 feet; stone No. 4, 297°, 50 feet.

Two Rock (Mendocino County, Cal., C. Rockwell, 1877–78; B. A. Colonna, 1878; A. F. Rodgers, 1879; E. F. Dickins, 1892).—On the most western of the bare peaks west of the Russian River Valley. The mountain has three summits, the most westerly of which is crowned on the northwest side by a conspicuous sandstone ledge, 200 feet long and 6 to 20 feet wide, precipitous on three sides. The station was on the summit of this rock. The center of station was marked by a drill hole, 1½ inches in diameter and about 3 inches deep, in the bare rock. There were no reference marks.

Paxton (Mendocino County, Cal., C. Rockwell, 1877–78; B. A. Colonna, 1878; C. H. Sinclair, 1897).—On Pine Ridge, west of Ukiah, on the highest hill in the vicinity. This hill is wooded on the sides and clear on the top, and has been known as "Bald Mountain." The station is on the ranch of Mr. Paxton and 2⅔ miles from the house of Mr. John Remstead. The center was marked by a 1-inch drill hole, 2 inches deep, in the top of an irregular shaped stone, about 16 by 18 by 26 inches. The stone had a roof-like top and the part corresponding to the ridge of the roof was placed in the direction of Mount Sanhedrin. The top of the stone was flush with the ground. Broken glass was mixed with the earth around the stone. A white earthenware bottle was buried with its top 22½ inches below the stone. Over the stone was built a hexagonal concrete pier 26 inches in diameter and 50 inches high, with an iron rod running through the center, carefully plumbed over the mark in the stone and bent at right angles at the foot to prevent its being pulled out. The reference marks were: A stone with a triangular flat top and a somewhat pointed bottom, having a drill hole in its top, 6 feet from the center in the direction of Mount Sanhedrin; a stone in the direction away from Mount Sanhedrin, buried big end down, with a pointed top in which was a 1-inch drill hole 1 inch deep; and a stone at right angles to these stones, in the direction of Great Caspar station, somewhat square, and with a 1-inch drill hole 1 inch deep. An oak stump, marked with a triangle 7 feet high and 1 foot in diameter stood a little to the right of the line to Mount Sanhedrin △, and 54.82 feet from the station, and a large oak tree marked with a triangle stood a little to the right of the line to Cold Spring △ and 103.3 feet from the station.

Fisher (Mendocino County, Cal., B. A. Colonna, 1878; E. F. Dickins, 1891–92).—On the highest part of the open grassy hill locally known as Cliffs Ridge, which is the divide between Greenwood and Elk creeks, on the ranch owned in 1878 by Mr. Fisher, and in 1891 by Mr. Bishop, about 2 miles northwest of Bishop's house. The center of the station was marked by a bottle 7 inches long, resting on the rock 20½ inches below the surface, the center of its mouth marking the station. On top of the bottle was a little earth and on this a stone projecting 1 inch at the surface in the top of which was a ½-inch drill hole about 1 inch deep marking the center. There were also three reference stones on the surface, one in line to Cold Spring △, one on the opposite side, and one at right angles toward the southwest, each with a ½-inch drill hole, and each 6 feet from the center. There was a natural outcropping of rock about 18 feet to the northwest of the station, and another 45 feet to the southwest.

Marysville Butte (Sutter County, Cal., George Davidson, 1876; B. A. Colonna, 1879; C. H. Sinclair, 1898).—On the south and highest butte of the Marysville Buttes, a chain of several conical peaks extending north and south, rising abruptly from the plain about 15 miles west of Marysville; near the edge of the summit, 4 feet 6 inches from the brow of the hill on the northeast side and 9 feet on the south side. The center was marked by a drill hole in the top of a fast rock. The reference marks were: a half-inch drill hole in the rock in the direction of Mount Diablo, 8 feet 6 inches; a similar one 8 feet distant toward Downieville Buttes, and a third, 9 feet 8 inches distant, toward Snow Mountain.

Pine Hill (Eldorado County, Cal., W. Eimbeck, 1876; J. F. Pratt, 1879).—In the foothills of the Sierra Nevada, upon the prominent summit locally known as Pine Hill, on the outcropping rock forming the summit. The center was marked by a ½-inch drill hole, in which was put a copper bolt projecting 1½ inches from the rock. The reference marks were a cross cut in a large projecting rock in the direction of Marysville Butte, 12.5 feet distant from the center, and a cross cut in a large rock in the direction of Pyramid Rock, 12.4 feet distant.

Sierra Morena (San Mateo County, Cal., George Davidson, 1883).—On the range of mountains extending northwest and southeast along the San Francisco Peninsula, about 50 yards from an old wood road following along the ridge to the southward from the "Mountain Brow House," which is about 4 miles west of Woodside. The station is 2½ miles from "Mountain Brow House," and is on the highest knoll in the vicinity. The station was marked by a copper bolt in a stone placed 2 feet below the surface of the ground. Over this was built a pier 26 inches in diameter, 4.07 feet above the ground, in the top of which was a copper bolt shaped like a key, with hole in top, marking the station.

Loma Prieta (Santa Clara and Santa Cruz counties, Cal., George Davidson (E. F. Dickins), 1884).—This station was formerly known as Mount Bache, and is on the highest peak of the range of mountains forming the boundary line between the counties of Santa Clara and Santa Cruz. It may be reached from Wrights, on the Southern Pacific, by a wagon road for about 4 miles to D. H. Montgomery's ranch, and then by a fair trail for about 6 or 7 miles to the top of the mountain. The underground mark was a 2 by 3 inch brown stone with a copper bolt in the center, 3 feet 2 inches below the surface. A rock with a drill hole filled with lead, having cross lines on the top, was placed 24⅜ inches below the surface and ⅜ inch to the west of the copper bolt in the brown stone. A concrete foundation 3½ feet square and 9 inches deep was laid around this stone, and upon it was built a hexagonal pier, 30 inches in diameter at the base and 26 inches at the top. An 8 by ½ inch copper bolt in top of pier marked the center.

Santa Ana (San Benito County, Cal., R. D. Cutts, 1852; George Davidson, 1885).—On the western summit of a double-topped peak, very rocky and covered with oaks, locally known as "Henrietta Peak," about 2 miles from the one known as Santa Ana. The station is easily reached from the town of Hollister by going out the main street to the north, crossing the railroad track, and taking the first road to the right or east. Follow this road for about 2 miles to a road running north and south, turn to the north and proceed until a second road leading to the right is reached; take this and proceed easterly, following the main wagon road and crossing the creek at the mouth of the Dos Picachos Canyon. By following the grade which winds up the ridge on the north side of the Dos Picachos Canyon for about 6 or 8 miles a point is reached near the summit of the grade, about halfway between Herrington's ranch house and the Stayton mine, where the wagon road should be left and the backbone of the ridge followed in a southwesterly direction until the station is reached, about half a mile south of and 1,000 feet above Herrington's house. The station was marked by an irregular-shaped rock with a copper bolt in the top, around which a concrete foundation 3 feet square and about 10 inches deep was laid, and upon this a concrete pier, hexagonal in shape, and 26 inches in diameter, was built. A copper bolt with cross cut upon it was set in top of pier to mark center of station, 5 feet 2½ inches above the subsurface mark. A concrete pier, occupied in 1885 for latitude observations, was 37 feet 6 inches from the △, in azimuth 129° 07′ 01″.

Mount Toro (Monterey County, Cal., George Davidson, 1885).—On a smooth, grassy hill of the smooth, untimbered range of mountains bordering the Salinas Valley on the west; about 500 yards south of Mr. A. B. Parson's house, and upon his land. The station was marked by a copper bolt set in a flat-topped rock, 2 feet beneath surface of ground, and in center of a concrete pier; a cross on a copper bolt in the top of the pier constituted the surface mark, and was 1.498 meters above the subsurface mark. Northwest of the station were the vertical circle pier, distant 10.18 meters; the zenith telescope pier (concrete), distant 19.81 meters, azimuth 135° 55′; and the transit pier (concrete), distant 20.85 meters, azimuth 132° 25′.

Hepsedam (San Benito County, Cal., J. S. Lawson, 1885–86).—On the sharp, rocky top of a very prominent peak of that name in the Mount Diablo range of mountains in the southern part of San Benito County; it is the highest and sharpest peak in the vicinity. The station may be reached by following the road up Lewis Creek from its junction with San Lorenzo Creek, near Lonoak post-office, Monterey County, 1 mile to the house of Fred Taylor. One and a half miles farther, on the south side of the mountain, was the place of Samuel Saffell. The trail from there up the mountain was long and steep. The trail from a point in a canyon, about 3 miles farther up the road, near the house of Trinidad Garcia, is better, but can be followed only on horseback. During the dry season the best way to reach the station would be by the road up the San Benito River to the place of Lorenzo Vasquez, called Sweetwater Springs; thence for about 7 miles on the road to the Laguna ranch to the foot of the mountain, from which place to the top is 1½ or 2 miles. The station was marked by a copper tack leaded into a hole drilled into an outcropping rock. Three similar marks were made, approximately north, south, and west, at the following distances: north, 6.90 feet; south, 7.98 feet; west, 6.70 feet. Over the center mark was built a concrete pier, marked in the top by a copper bolt, with a small drill hole in it. The concrete pier for the meridian instrument was 1.57 meters due east of the station, and the wooden pier for the vertical circle was 9.753 meters a little south of west.

Santa Lucia (Monterey County, Cal., George Davidson, 1885; A. F. Rodgers, 1890).—On the eastern summit of the highest peak of the Santa Lucia range, which consists of two rocky knobs about 200 yards apart, with a saddle or depression of 20 feet between them. The best way to reach the station is by a rough wagon road up the San Antonio Valley from Jolon to a point about 13 miles beyond the old Mission, or about a mile before reaching the place of Eusebio Ensinal; here leaving the road and turning to the right, follow up a flat ridge for about a mile, cross the canyon to the east side and keep up the smooth ridge for about a mile, till just beyond an old log cabin; recross the canyon to the west side and follow a very rough and steep trail winding up the ridges to the summit, rising about 3 500 feet in about 4 miles. The station was marked by a cross cut in the projecting end of a copper bolt set in the solid rock. Over that was laid a concrete foundation 3 feet square and 10 inches deep, and upon it a concrete pier hexagonal in shape and 26 inches in diameter was built, and a copper bolt with a cross cut in it was set in top of pier to mark the center of the station. The distance from the subsurface mark to the copper bolt in top of pier was 4.6 feet.

The reference marks were holes drilled in outcropping rocks, filled with lead, into which copper tacks were driven, and distant as follows: north, 6.88 feet; south, 7.18 feet; east, 5.91 feet, and west, 10.08 feet.

The concrete pier occupied for latitude in 1885 was 44 feet 1 inch from the △ in azimuth 227° 28′.

The azimuth from the center of △ to the frame pier used for the vertical circle in 1885 was 56° 14′, and the distance was 5.486 meters. The stations occupied by the eclipse expedition of 1880 were a little north of west from the △ and distant from it 546 feet and over.

Rocky Butte (San Luis Obispo County, Cal., J. S. Lawson, 1884–85; A. F. Rodgers, 1890).—On the top of the peak of that name in the Santa Lucia range of mountains, about 14 miles from Cambria, about 1½ miles west from the house of Mr. Newton Mathers, at the foot of the mountain, and about 6 miles from the house of J. P. Coffee. It may be reached by the road along the north fork of the San Simeon Creek. The top of the peak is rather flat and is covered with a growth of low brush. It is somewhat dome-shaped, and surrounding it, extending to the top on the north side, is a growth of tall pine trees. The top itself is free from timber, with the exception of a few scattering trees on the north edge. The east, south, and west sides of the peak are very steep and rocky, but by approaching it from the north the top can easily be reached with saddle horses and pack animals. On the east side of the peak and about 400 feet from the summit (about ½ mile by trail), there was a good spring where water could be had the year round. There was also a good spring about ½ mile from the station in the canyon to the northwest. The station was marked by a copper tack leaded into the top of a stone about 1 foot long and 8 inches square on top buried 2 feet below the surface of the ground. Over this was built a concrete pier. Four reference stones of about the same size, with leaden bolts and copper tacks, were placed approximately north, south, east, and west. The distances from the station mark were: north, 47.12 inches; south, 44.38 inches; east, 31.25 inches, and west, 41.81 inches. The meridian instrument used in observing latitude in 1885 was placed on the station pier 5.13 feet due west from the station mark. The vertical circle was mounted upon a wooden pier, north of the station 56.28 feet.

Castle Mount (Monterey-Fresno counties, Cal., J. S. Lawson, 1885–86).—On a small rocky mound on the western end of a long, flat ridge, the highest in the divide between Fresno and Monterey counties, and about 10 miles by trail from the house of John Cahill, on the Rock Corral road. The local name for the peak is the "Black Hole." The Spanish name is "Zapato Chino," meaning Chinese shoe. From the house of John Cahill follow the road leading off from the northwest for about 2½ miles, then turn up the canyon leading toward the foot of the mountain to the right. After about three-fourths of a mile the foot of the mountain will be reached. About three-fourths of a mile up the mountain is a good spring of water. From here the station can be reached only with saddle horses and pack animals, but the trail is not a hard one during dry weather. The station was marked by a hole drilled in an outcropping rock. Over this was built a concrete pier and the center marked by a copper bolt with a small hole drilled in it. Four reference marks, consisting of copper tacks leaded into holes drilled in outcropping rocks, were put approximately north, south, east, and west, at the following distances from the center: north tack, 4.525 feet; south tack, 6.540 feet; east tack, 3.520 feet; west tack, 10.390 feet. The concrete pier for the meridian instrument was 1.6 meters due east of the station, and the wooden pier for the vertical circle 10.642 meters to the southwest.

San Luis (San Luis Obispo County, Cal., J. S. Lawson, 1883).—On what is known as The Pine Ridge in the Santa Lucia or Coast Range, about 6 miles east of San Luis

Obispo. This is the highest peak in the vicinity, and is covered with pine trees. To reach the station from San Luis Obispo take the main road running toward Arroyo Grande. About 2 miles from the town, and just before crossing the first of what are known as the Twin Bridges, the peak comes in sight, and can be distinguished by its being somewhat dome-shaped. After crossing the first of these small bridges, turn to the left and continue on to what is known as the Larsen Dairy on the Rancho Corral de Piedra, owned by the Steele Brothers, of San Luis Obispo. Follow the creek back of the Larsen Dairy, known as the Canal de Piedra Creek, passing through the place of Patrick McHenry, and about 1½ miles up the creek from the Larsen Dairy take the trail around to the southeast until you arrive at the main ridge, and follow this to the top. The station was marked by a concrete pier, with a cross on a copper bolt in the top of the pier marking the center. The reference stones for the station were put approximately north, south, east, and west, each 4 feet from the station.

San Jose (San Luis Obispo County, Cal., J. S. Lawson, 1884).—On the top of a peak about 8 miles from the town of San Jose, which is about 30 miles from San Luis Obispo. About 4 miles from San Jose in a canyon is the house of Vidal Garcia. The station is about 4 miles from there by the American Canyon. The station was marked by a concrete pier, a cross on a copper bolt marking the center. Four reference stones were put down, approximately north, south, east, and west, and each 5 feet from the station.

Lospe (Santa Barbara County, Cal., O. H. Tittmann, 1875; J. S. Lawson, 1883).—On the highest ridge of hills rising from the shore at Point Sal, just back of and about 500 feet above the house of Mr. Henry Dolcini. It can be reached from Guadaloupe by taking the Point Sal road to the Corralitas Canyon; at this point the road forks, the one to the right going over the grade to Point Sal. Thence by the left-hand road up the Corralitas Canyon into the Pilita Ranch and to Dolcini's house. Follow up the right-hand canyon to the top of the ridge and the station is about 250 meters to the right. The station can also be reached from Point Sal by taking the road to Guadaloupe until the crest of the ridge is reached, and then following an ill-defined road to the right, which leads to the house of Mr. Henry Dolcini. The station was marked by a flat stone, buried about 2 feet below the surface, with a drill hole marking the center of the station. The station was marked at the surface with a copper bolt and cross. Over this was built a substantial brick pier in such a way that the surface mark was accessible. The center of the station was marked also on the top of the pier. The brick pier for the meridian telescope, used for latitude in 1883, was distant 5.210 feet from the station, true azimuth 89° 55′, and the concrete pier for the vertical circle was distant 62 feet, true azimuth 300° 17′ 36″. Four stones with cross lines were placed approximately north, south, east, and west at the following distances from the station: south, 5 feet 4⅝ inches; east, farthest hole, 6 feet; north, 4 feet 4¼ inches; west, 5 feet 1⅜ inches.

Tepusquet (Santa Barbara County, Cal., O. H. Tittmann, 1875, J. S. Lawson, 1882).—On the top of Tepusquet Range. The mountain is covered with a thick growth of chaparral to the north, northeast, northwest, and west, while to the south and southwest the side of the mountain extends to fields of wild oats. The station can be reached from Santa Maria, by way of Fuglers Point, at the junction of the Santa Maria and Sis Quoc rivers, at which place take the road leading to the left, crossing the river and following the foothills. From this point the road can not be mistaken, as it leads directly into Tepusquet Canyon. Continue up the canyon 1¼ miles beyond the house of Jose Vidal, to the mouth of another wide canyon, to the right, from which place the peak can be seen and easily distinguished from the contrast of the wild oats and chaparral. The trail leads up this canyon direct to the top of the peak. About two miles up the trail, in a small nook to the left, just before ascending the steep part in the canyon, a good spring of water was found. From Los Alamos the peak can be reached by taking the road leading through Foxens Canyon, past the store of Fred. Wickenden, at Sis Quoc, into the Sis Quoc Valley. On leaving Foxens Canyon and entering the Sis Quoc Valley, take the road leading across the river, directly into Tepusquet Canyon, continuing as already described. The station was marked by a hole drilled in the outcropping ledge of rock on the top of the mountain. Over this was built a concrete pier 21 by 21 inches and 3.95 feet high, with a copper bolt in the top marking the center of the station. A small concrete pier built for the meridian telescope, is 67.78 feet distant, in azimuth 152° 15′. Four reference stones were placed about level with the surface, each marked by a tack leaded into a drill hole. Two were 6 feet each from the station, approximately north and south, and two 5 feet, approximately east and west.

Arguello (Santa Barbara County, Cal., O. H. Tittmann, 1875).—About 10 miles northwest from Point Conception and near Point Arguello, on the highest part of Tranquillon Peak, the highest peak in the vicinity. The station was marked by a piece of rough stone, 2½ feet high, set on a foundation of concrete about 2 inches thick, which rested partially on the solid ledge of the station and partially on earth. Four holes were drilled into the surrounding ledge and rocks, and into each a copper tack, marked with cross lines, was leaded. The distances and azimuths to these tacks were as follows: 3 feet 8.8 inches, 47° 59′; 7 feet 5.2 inches, 168° 29′; 10 feet 11.2 inches, 205° 57′; 6 feet 10.9 inches, 270° 06′. The pier of cement and stone for the latitude station of 1876 was 27.57 meters (or 95.10 feet measured on the inclined surface) from the station, in azimuth 67° 13′. The old Tranquillon △, now lost, was 0.2 meter northwest of Arguello △.

Gaviota (Santa Barbara County, Cal., O. H. Tittmann, 1873; W. S. Edwards, 1875).—On the top of one of the high peaks to the eastward of the Gaviota Pass. The peak is covered with yellow sandstone rock, and is made conspicuous by a field of wild oats 60 meters long, about 500 meters southwest of the summit. The peaks to the eastward are between 150 and 300 feet higher than the one on which the station is located. The station was most accessible through the canyon making up toward the eastward from Gaviota Pass, at a distance of about 1 mile from the wharf. The north face of the ridge was covered with a dense growth of chaparral and was very steep. The south face has a more gentle slope. The station was marked by a cross on a copper tack leaded into a large stone 20 inches below the surface. Over this was placed a large rock, flush with the surface, in which was leaded a copper tack to mark the center, and on it a pier, 2 feet square and 2 feet 7¼ inches in height, was built of large blocks of cut sandstone held together by cement. The reference marks were as follows: To the north, a wooden stub with copper tack, 7 feet 8¾ inches from the center; to the east, a wooden plug with a nail in a drill hole in the rock, 7 feet 2½ inches, and to the west, a hole bored in the rock holding a wooden plug (no nail in this plug), 13 feet 3⅜ inches. At a distance from the center of 29.74 meters, in azimuth 200° 10′, there was buried, flush with the ground, an irregular-shaped stone, about 18 inches square, in which was leaded a copper tack to mark the point occupied in 1875 for latitude. This was surrounded by four wooden stubs with copper tacks in their tops placed as follows: to the north, 7.985 feet distant; to the south, 7.280 feet; to the east, 6.505 feet; and to the west, 8.235 feet.

New San Miguel (San Miguel Island, California, O. H. Tittmann, 1873).—On the highest part of Green Mountain and about 177 meters to the southeast of Green Mountain △. The station was marked by a rectangular brick pier, whose foundation was laid about 2½ feet in the ground. Set into the foundation was a smooth stone about 8 by 8 by 8 inches in size, taken from the beach, having in its center a leaden bolt and copper tack to mark the station point. The latitude station of 1873 was marked by a copper tack leaded into the top of an irregular-shaped sandstone block, which rested on a foundation of and was surrounded by bricks. The top of the stone was 6 inches below the surface of the ground. The latitude station was distant 19 feet 3 inches from the primary triangulation station, in azimuth 324° 56′.

Santa Cruz West (Santa Cruz Island, California, W. E. Greenwell, 1861; O. H. Tittmann, 1874).—On the high bluff forming the western extremity of the island. The station was marked by a copper tack leaded into a hole drilled in the ledge. A brick pier about 2 feet square and 2 feet 11 inches above ground was built over the station. A large stone, with a lead bolt and a copper tack in the top, surrounded by brick and cement, 51 feet 8.5 inches from the station and in azimuth 255° 03′, marked the point occupied for latitude in 1874.

Santa Barbara (Santa Barbara County, Cal., W. E. Greenwell, 1858; G. Davidson, 1869; O. H. Tittmann and William Eimbeck, 1874; A. T. Mosman, 1898; A. F. Rodgers, 1904).—On La Vigia, the southern one of two conspicuous smooth round hills to the west of Santa Barbara and of Honda Valley. The station was marked by a stone lettered

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even with the surface of the ground and embedded in a brick pier 2 feet by 2 feet, surrounded by concrete to 4 feet by 4 feet. Over the stone a pier of concrete 25 inches in diameter and 3 feet 4 inches high was built, and the center marked by an iron nail in the top. Two reference marks, 2-foot sections of 4-inch tile drain pipe, filled with concrete in which a nail was set, were placed at the intersection of a fence line and the lines to Santa Cruz East and to Santa Barbara Light-house. The distances and azimuths to these reference marks are: pipe toward Santa Cruz East, 128.20 feet, azimuth 340° 16′; pipe toward Santa Barbara Light-house, 350.38 feet, azimuth 37° 03′. A triangular concrete pier for the vertical circle was 48.6 feet distant, azimuth 204° 18′.

Santa Cruz East (Santa Barbara County, Cal., W. E. Greenwell, 1857; O. H. Tittmann, 1876; A. T. Mosman, 1898).—Near the east point of Santa Cruz Island, one-half mile from Scorpion ranch, on a high rocky bank facing the north, 20 feet from the edge of the cliff, which goes down sheer for some 300 feet or more to the water. To the south and east of the station the ground slopes down gradually to an old barley field about 150 feet distant. The point on which the station is located is about 40 feet higher than the barley field and is very rocky. The under-ground mark was a copper tack in a lead bolt in a stone of irregular shape, marked U. S. C. S., set in concrete about 13 inches below the surface of the ground. Over the mark was placed a wooden box, which was filled with concrete even with the surface of the ground, and a copper bolt 6 inches long and one-half inch in diameter with a cross on the top was put in to mark the center; the concrete was marked U. S. C. & G. S. 1898. For reference marks holes were drilled in the solid rock 1 inch in diameter and 4 inches deep, as follows: on a large black rock projecting 2 feet above the surface, distant 13.58 feet, azimuth 304° 21′ 46″; on a rock projecting about 1 foot above surface, distant 24.81 feet, azimuth 1° 57′ 52″; in a solid ledge close to the edge on the west side, distant 15.40 feet, azimuth 50° 06′ 38″; in a solid rock close to the edge of the cliff on the north side, level with the surface, distant 14.94 feet, azimuth 174° 43′ 11″. The vertical circle was distant 45 feet, azimuth 282° 22′.

Chaffee (Ventura County, Cal., W. E. Greenwell, 1867; A. T. Mosman, 1898).—On the highest point of the first range of high hills west of Ventura, about 2½ miles from Mr. Lewis's house, on the property of Mrs. Taylor. The station was marked by a bottle buried with its neck about 2½ feet below the surface. Above this bottle was set a sewer pipe filled with concrete, with a copper bolt 5 inches long in its center to mark the station. For a depth of 1 foot around the pipe solid concrete was filled in even with the surface of the ground and the supporting plates for the iron stand were embedded in the concrete. Reference marks, consisting of sewer pipes 4 inches in diameter and 2 feet long, were sunk as follows: No. 1 nearly in line to Santa Cruz East, in true azimuth 37° 7′, distant 9.95 feet; No. 2, azimuth 127° 5′, distant 8.05 feet; No. 3, azimuth 215° 14′, distant 7.58 feet; No. 4, 6° to north of line to Laguna or in azimuth 305° 16′, distant 7.50 feet.

Laguna (Ventura County, Cal., W. E. Greenwell, 1857; O. H. Tittmann, 1877; A. T. Mosman, 1898).—On the top of a mountain about 1 mile from the ocean and 1 mile from the house on the Logan ranch. For underground mark a piece of 4-inch tile drain pipe, 8 inches long, was buried, the top being 2 feet below the surface of the ground. This was filled in with cement and in the center was placed a 5-inch spike to mark the center. Over this was laid a mass of concrete, triangular in shape and 27 inches on a side and 13 inches thick, in the center of which was placed a sandstone post, 5 by 5 by 15 inches, with a small hole in the top marking the center. The top of the post is about 1½ inches below the surface of the concrete, which was cut out to show the block. The surface of the concrete is level with the surface of the ground. The corners of the concrete triangle were built up 4 inches, like posts. For reference marks 4-inch tile drain pipes 2 feet long were put in and were filled with concrete, with a spike in the center, and their tops about level with the surface of the ground, as follows: No. 1, distant 6.93 feet, azimuth 107° 06′, or in line to Point Hueneme Lighthouse; No. 2, distant 6.92 feet, azimuth 197° 06′; No. 3, distant 7.35 feet, azimuth 287° 06′; No. 4, distant 7.23 feet, azimuth 17° 06′. Four other marks, stones, each with a lead bolt in the top, were set at the following distances from the center: To the north, 4.05 feet; to the west, 4 feet; to the south, 4.95 feet, and to the east, 4.02 feet. In 1876 a small tin tube inclosing a paper dated July 12, 1875, by a party of United States Engineers under Lieutenant Whipple, calling his station West End, was found.

Santa Clara (Ventura County, Cal., A. T. Mosman, 1898).—On the highest part of the mountain on the south side of Santa Clara River, about 2 miles distant from the town of Santa Paula, and reached from Mr. Hobson's house by a sled road passing his upper ranch house and well and leading directly to the station. It is steep, but can be traveled on horseback. The underground mark was a bottle sunk 2.3 feet below surface, mouth up. Above this was sunk a sewer pipe 4 inches in diameter and 2 feet long, filled with concrete, with a copper bolt in its top marking the station. The lower part of the sewer pipe was incased in well-rammed earth, but the upper foot of its length was incased in concrete in the form of a triangle, at the apexes of which three marble blocks 6 by 6 by 4 inches were set in cement. Four reference marks, consisting of sewer pipes 2 feet long and 4 inches in diameter, filled with concrete and with an iron nail in the upper surface, were placed as follows: in line to brown church spire, Santa Paula, distant 6.32 feet; on prolongation of this line through station, distant 6.36 feet; at right angles to this line, easterly, distant 6.48 feet; at right angles to first line, westerly, distant 644 feet.

Castro (Los Angeles County, Cal., A. T. Mosman, 1898).—On one of the peaks of the coast mountains, 4 or 5 miles distant in a northerly direction from Point Dume. The mountain can be reached from Montalvo, a station on the Southern Pacific Railroad between Los Angeles and Santa Barbara, by team to Mr. Russell's ranch in the Conejo Valley. From Russell's a road leads to Ballard's place and from there up the ridge on which Castro is located. About three-fourths of the distance up the ridge an old sled road leads in to O'Grady's cabin. For a stranger wishing to find the station it would be better to drive all the way up the grade from Ballard's to the top of the ridge, and either at Chapman's place or Mr. Charles Sailsbury's get a guide. Mr. Sailsbury was the heliotroper at the station in 1898. Another way to reach the station, and the shortest from Los Angeles, is over the Ventura road from Chatsworth Park, past Calabasas and Daice's post-office, and as far as the old Vejar stage station. At this place, which is about 5 miles from Mr. Russell's ranch above mentioned, a road leads off sharp to the left down a canyon. Follow this road about 3 or 3½ miles and then turn to the right around the point of a very prominent hill and follow up another canyon till Ballard's place is reached. Ballard's is the first house you come to except an old deserted cabin. The station was marked underground by a quart bottle with top of neck 25¾ inches below the surface. Over this was a bed of concrete, triangular and 12 inches thick, in the center of which was a copper bolt, 5 inches long and three-fourths inch diameter, on which was a cross marking the station. The corners of the concrete block were truncated and on each was set a cube of cement 6 inches on a side. Four stones, about as large as a man could move alone, each with a hole drilled about 2 or 3 inches deep and 1 inch in diameter, were set at the following true azimuths and distances: 312° 03′, distant 8.35 feet; 30° 27′, distant 6.68 feet; 138° 29′, distant 6.77 feet; 213° 40′, distant 7.13 feet.

San Fernando (Los Angeles County, Cal., A. T. Mosman, 1898).—On the highest point of the western knob of the highest or western crest of San Fernando Mountain, about 5 miles from the long tunnel of the Southern Pacific Railroad, about 10 miles nearly north of Chatswood Park, and about 2 miles from Mr. F. Reiss's house. The station was marked by a bottle sunk 18 inches, and over this was a section of sewer pipe 24 inches long and 4 inches inside diameter. The neck of the bottle extended 2 or 3 inches into the lower end of the sewer pipe, which was filled with concrete rammed tight. The center was marked at the top of the pipe by a copper bolt three-fourths inch in diameter and 4 inches long, with a cross cut on its upper end. The lower foot of the pipe was surrounded by earth, tightly rammed, and the upper part by a bed of concrete 1 foot deep, in the form of a triangle. The three marble blocks which formed the foundation of the iron stand of the theodolite, each 4 by 6 by 6 inches, were set in concrete on this concrete base. Reference marks, consisting of 4-inch sewer pipes 24 inches long, sunk even with the surface of the ground and filled with concrete, with an iron spike set in the top of the concrete, were placed as follows: in line to Castro (west of south), distant 5.99 feet; in prolongation of that line (to northward), distant 5.85 feet; at right angles to first line (westerly), distant 5.99 feet; at right angles to first line (easterly), distant 5.95 feet.

San Pedro (Los Angeles County, Cal., George Davidson, 1853; W. E. Greenwell, 1855; A. W. Chase, 1870, 1872; D. B. Wainwright, 1878; E. F. Dickins, 1896; A. T. Mosman, 1899).—A little northeast of the highest point, on the flat top of the hill of the same name, in the Palos Verdes Range, about 4 miles west of San Pedro Harbor. The station was marked by a copper bolt with a cross, leaded into a hole drilled in the top of a granite post 6 inches square and about 2 feet long, projecting about 1 inch above the surface of the ground. A triangular bed of concrete surrounds the post and a cairn of large rocks covers it, making a pyramid 3½ feet high. The reference marks consisted of sewer pipe 4 inches in diameter and 24 inches long sunk in the ground and filled with concrete, with an iron spike in the center, at the following distances and directions: No. 1, in line to Point Fermin Light-house, distant 6.05 feet; No. 2, in prolongation of this line through station, distant 6.08 feet; No. 3, at right angles (southerly), distant 5.97 feet; No. 4, at right angles (northerly), distant 5.99 feet.

Wilson Peak (Los Angeles County, Cal., G. Davidson, 1890; E. F. Dickins, 1896; A. T. Mosman, 1898).—On Wilson Peak, in the Sierra Madre Range, about 500 or 600 feet above and 1 mile from Martin's camp, and directly in front and 4 feet from the porch of a building known as the Casino. The subsurface mark was a copper bolt with a cross, leaded into a hole drilled in a large rock 20 inches below the surface of the ground. Over it was a hexagonal concrete pier, 26 inches in diameter and extending 3.2 feet above the surface of the ground, in the top of which was set a copper bolt, with a cross to mark the center. The following are the true azimuths and distances to reference marks: big pine, wire nail in blaze, 61° 24′, distant 41.5 feet; southwest corner of porch of Casino, 149° 24′, distant 21.3 feet; nail in center of doorsill of Casino, 213° 44′, distant 11.6 feet; southeast corner of porch of Casino, 286° 44′, distant 19.2 feet; big pine, wire nail in blaze, 299° 19′, distant 109 feet.

San Juan (Orange-San Bernardino counties, Cal., P. A. Welker and Fremont Morse, 1886; E. F. Dickins, 1896; A. T. Mosman, 1899).—On the top of the highest and sharpest peak of the range of hills, northeast of and 5 or 6 miles distant from Yorba station on the Southern California Railroad. The station is marked by a cross on a copper bolt leaded into a hole drilled in the top of the rock, 2½ feet below the surface of the ground, above which is a hexagonal concrete pier, 26 inches in diameter, extending 3.1 feet above surface of ground, in the top of which is set another copper bolt with cross marking the center of station. Three reference stones, with drill holes filled with lead, were placed north, south, east, and west, each 6 feet from center. A cairn of stones marking the boundary between Orange and San Bernardino counties is N. 33½° W., by compass, and distant 16 feet from station.

Los Angeles Northwest Base (Los Angeles County, Cal., G. Davidson, 1889, 1890; E. F. Dickins, 1896).—On the rising ground, about a mile and a half northwest of the little village of Norwalk, and about 200 yards east of the Southern California Railroad. The surface mark was a small hole made by a needle in the silver core of a five-eighths inch copper bolt set in a granite block, 26 inches square, flush with the surface of the ground and built in the brick foundation of the pier. Over this was cemented a granite monument, 24 inches square at the base and sloping to 12 inches, 2 feet above base, with a pyramidal top, a small hole drilled at apex of pyramid marking the center. On the side toward the base it is lettered as follows: U. S. C. & G. S. N. W. BASE 1889. The foundation pier was 72 inches square at the bottom, a distance of 5 feet below the surface of the ground, and was stepped in at the sides to 54 inches square. The earth filled in around the foundation pier was coarse sand with sand and charcoal. The subsurface mark consisted of a small hole made by a needle a little northwest of the center of a piece of silver wire, about one-tenth of an inch in diameter, driven into the head of a copper bolt, five-eighths of an inch in diameter, fixed with melted sulphur into a granite block, squared on top and 3 feet long, directly under the foundation pier. The copper bolt was covered with a hemispherical chemical evaporating glass dish, cemented on the block. The top of the granite block is 1 foot square and bears besides the station mark, the letters $\overset{\text{U}}{\text{C}}$ & $\overset{\text{S}}{\text{G}}$ S. There were four reference marks. Each was a small hole (one-fourth millimeter in diameter) in a silver wire driven into a five-eighths inch copper bolt, leaded into the upper face of a 1-foot granite cube, buried about 18 inches below the surface of the ground, surrounded by brick in cement. A glass inverted and cemented upon the granite covered the mark. Two were in the line of the base and two at an angle of 90° with it to the northwest at distances of 10 and 100 feet from the station. Marked with a steel point on the heads of the copper bolts were: Southeast Witness 100 feet, Southeast Witness 9.995 feet; Southwest Witness 100 feet, and "Southwest Witness 10 feet." When this station was occupied as a triangulation station in 1890, a brick pier 15 feet high was erected as a support for the theodolite and left standing.

Los Angeles Southeast Base.—(Los Angeles County, Cal., G. Davidson, 1889, 1890; E. F. Dickins, 1896). About 100 meters west of the main road from Anaheim to Garden Grove, and 1 mile from the latter place. The surface and subsurface markings are similar in every particular to those at Los Angeles Northwest Base, and the granite monument is lettered on the side toward the base line U. S. C. & G. S. S. E. BASE, 1889. The reference marks are at 10 and 100 feet distant from the station, in line of base and at 90° north from it, and are marked S. W. Witness 100.003 ft., S. W. Witness 10.02 ft., N. W. Witness 100 ft., and N. W. Witness 10 ft. When this station was occupied as a triangulation station in 1890, a brick pier 35 feet high was erected as a support for the theodolite and left standing.

Los Cerritos (Los Angeles County, Cal., G. Davidson, 1853; A. W. Chase, 1872–73; A. F. Rodgers, 1883; F. Westdahl, 1887; G. Davidson, 1890; E. F. Dickins, 1896).—On the top of a prominent round-topped hill, on the Los Cerritos ranch, 4 miles northeast of the town of Long Beach. It was marked by 6-inch granite post, dressed on top, and projecting about 2 inches above the surface of the ground, in which a ½-inch hole was drilled to mark the center.

Las Bolsas (Orange County, Cal., G. Davidson, 1853; W. E. Greenwell, 1855; A. W. Chase, 1873; D. B. Wainwright, 1878; G. Davidson, 1890; E. F. Dickins, 1896).—About a mile from the coast and about 5½ miles south of Westminster, on the Las Bolsas ranch, on the highest part of the mesa, and about 100 yards east of the road. On the west side of the road, nearly opposite the station, was another hill, on which were a number of graves. The station was marked by a cross in the top of a copper bolt leaded into a drill hole in the top of a granite post, 6 inches square, and projecting about 2 inches above the surface of the ground. There were four stubs, each 1.2 feet from the center, approximately north, south, southeast, and southwest, into each of which was driven an empty cartridge shell.

Santiago (Riverside and Orange counties, Cal., A. T. Mosman, 1898).—On the highest and most southeastern peak of Santiago Mountain, about 8 miles by a trail for pack horses from a house at the head of the second canyon to the left above the schoolhouse at Trabuco Canyon, which is about 13 miles from Capistrano, or about 20 miles by a desert road from Santa Ana. From El Toro the schoolhouse is about 15 miles, and this is the best station to which to ship freight, which can then be hauled by wagons to the beginning of the trail. A good spring of water is near the trail about 1½ miles below the top. The station is located on a sharp rocky elevation about 20 feet in diameter and some 25 feet higher than the surrounding ground, and was marked by the center of a stone bottle with a handle placed 3½ feet below the surface. A thin layer of earth was placed over bottle, and over this was built a solid concrete pier, triangular in shape, 4 feet on a side and 3 feet thick. A large stone with a copper bolt in it was placed in the pier, with its top projecting about 3 inches above the surface of the concrete, the bolt marking the station. Built at the corners of the pier were triangular pillars 6 inches high and 12 inches on a side. The azimuths and distances to the reference marks, holes in the rock with lead in them, are as follows: 199° 24′, distant 10.31 feet; 273° 49′, distant 12.65 feet; 25° 42′, distant 26.70 feet; 105° 11′, distant 8.35 feet.

Niguel (Orange County, Cal., A. F. Rodgers, 1884; A. T. Mosman, 1898).—About 9 miles from Capistrano on the highest part of the flat summit of the highest ridge between San Juan Capistrano and Aliso Canyon, which is the highest summit on the coast between Aliso Canyon and the Cañada Salada. The station is on land belonging to the United States, near the northwest corner of a tract of land belonging to Mr. Foster and R. Egan, of Capistrano, and was marked by a cross on a copper bolt in a large stone buried 21½ inches. On top of this was placed a section of 4-inch pipe 2 feet long, filled with concrete, with a 4-inch copper bolt in the top, a cross in the bolt marking the station. The pipe was surrounded to a depth of 1 foot by a bed of concrete, triangular in form, and at the vertices of this triangle were 3 marble blocks. Reference marks, consisting of 4-inch pipes 2 feet long, filled with concrete, with iron nails in their tops, were placed at the following directions and distances: In line to Santiago, distant 5.93 feet; in prolongation of this line, distant 6.19 feet; to eastward at 90° to above, distant 6.20 feet; to westward at 90° to above, distant 6.21 feet.

Soledad (San Diego County, Cal., A. F. Rodgers, 1887; A. T. Mosman, 1898).—On the highest part of the hill, back of La Jolla Beach. The station was marked by a bottle 32 inches below the surface of ground, and a 3-inch pipe 24 inches long placed above the bottle and filled with concrete, in which was embedded a copper bolt three-fourths inch in diameter and 4 inches long, with a cross on the top marking the center of station. This pipe was surrounded to a depth of 1 foot by a triangular bed of concrete, at the vertices of which were embedded 3 marble blocks. Reference marks were put in as follows: In line to Point Loma Light-house (old), distant 5.85 feet; in prolongation of that line, distant 6 feet; at 90° to westward, distant 6.19 feet; and at 90° to eastward, distant 6 feet. A brick pier 18.02 meters to the north was occupied in 1899 for latitude and azimuth.

Cuyamaça (San Diego County, Cal., A. T. Mosman, 1898).—About 10 feet south of the highest point of the backbone of the large ledge that forms the highest part of the southern and highest peak of Cuyamaca Mountain, about 60 miles northeast from the city of San Diego, and about 4 miles from Cuyamaca. There is an old wood road up to within about a mile and a half of the summit, and a wagon could go still nearer the station with light loads. The station was marked by drilling an inch hole 4 inches deep in the ledge, in which a copper bolt was set with cement and on which was a cross marking the center. Three crosses were cut in the rock and a copper bolt set at the intersection of each as follows: north, distant 7.72 feet; northeast, distant 7.04 feet; and south, distant 6.27 feet.

San Jacinto (Riverside County, Cal., A. T. Mosman, 1898).—On the highest and most northern peak of the San Jacinto Mountain, 12 miles from Keen's Hotel in Strawberry Valley, which is 23 miles from the town of San Jacinto. From Strawberry Valley the station is reached only by trail, the worst part of which is from Strawberry Valley up what is known as the Tangritz trail which goes to Tangritz Valley. This part is only about 2½ miles long, but is very bad, in places almost impassable for animals. The rest of the trail is not very bad, being mostly through heavy woods and over rolling land, but not rocky except in places. Tamarack Valley, at the foot of the final peak and about 1 mile from the station, is a very good camping place, having timber, good grass, and generally plenty of good spring water. The trail up to the station from Tamarack Valley is somewhat steep in places, but not at all bad, and can be easily ridden to within 50 yards of the station. The whole top of the mountain consists of a mass of enormous granite bowlders (or stone similar to granite). The highest point is a large rounding bowlder which sticks up about 7 feet above all others. On top of this bowlder was built a cairn of stones about 5 feet in diameter and 8 feet high. The station was located on a large flat rock or bowlder 13 feet, 63° 42′ true azimuth, from the bowlder with the cairn on it. The station was marked by a 1-inch hole drilled 1 inch deep in the rock. The azimuths and distances to the reference marks, holes drilled 1¼ inches diameter and 3 inches deep in four large bowlders, are: 21° 19′ 14″, 56.41 feet; 162° 26′ 04″, 28.70 feet; 252° 55′ 09″, 11.30 feet; 332° 59′ 09″, 34.28 feet.

San Miguel (San Diego County, Cal., A. T. Mosman, 1899).—On the top of the highest peak of San Miguel Mountain, about 2 miles from the Dahlin ranch. It can be conveniently reached from San Diego by following the mail route to Campo, a little farther than "Cockatoo Grove" in Telegraph Canyon, thence by road across San Miguel Mesa, passing a schoolhouse and the ranch house of Mr. Raaka to the Dahlin ranch, which is as far as wheeled vehicles can go. In 1899 the only trail up the mountain was on the south side, passing over one of the minor peaks before reaching the main one. The station was marked by a hole drilled 2 inches deep in bottom of a crevice about 6 inches long and 2 inches deep.

Boundary Monument 258 (International Boundary Commission, United States and Mexico, 1891–96; A. T. Mosman, 1898).—A monument of white marble about 14 feet high, surrounded by an iron fence 7 feet high, enclosing an area of 12 by 12 feet.

Tecate (San Diego County, Cal., A. T. Mosman, 1898).—About 40 feet southeast of the cairn which marks the highest point of Tecate Mountain. The station is reached by trail from the house of Manuel Flores in Mexico, about 2 miles from Brown's store and saloon on the boundary, which is 6 miles south of Potreso. The station was marked by a drill hole in the solid rock. The reference marks were distant 3.77 feet in line to Cuyamaca; distant 4.14 feet in line to Ragged Peak; and distant 9.81 feet in line to San Miguel.

Dominguez Hill (Los Angeles County, Cal., E. C. O. Ord, 1854; W. E. Greenwell, 1855; G. Davidson, 1870, 1881; A. F. Rodgers, 1883).—On the northern edge of a flat-topped ridge running about east and west, with a long, gentle slope of about 100 feet in a mile to the northward. About one-third mile to the southeastward the ridge is a few feet higher. The station was marked by an octagonal brick pier, extending 3 feet below the surface and 3 feet above, with a hollow shaft in the center and two arches about 8 inches high. Into the center of this pier and projecting 3 inches above the ground was built a gravelstone, in the top of which was an irregular depression marking the center of the station. The brick and cement pier, 25 by 13 inches and 2½ feet high, on which the zenith telescope was mounted for latitude observations in 1870, was 15 feet 5.5 inches east and 8.8 inches south of the △. A similar pier, 3¼ feet high, 20 feet 11.6 inches east and 9.8 inches south of the △, was used for time observations and for the latitude observations with the meridian instrument in 1870. Only the station pier and the meridian instrument pier were mentioned in 1883.

West Beach (Los Angeles County, Cal., George Davidson, 1854; W. E. Greenwell, 1856; George Davidson, 1870; A. F. Rodgers, 1883).—On the highest of the grassy hills near the beach. From Los Angeles it is on the first ridge of hills that makes out from the sand dunes and stretches toward San Pedro Hill. To reach the station, follow the road from the Pacific Salt Works to Los Angeles to about 100 yards beyond the corral near the northwest end of Salt Pond, then take a road leading to the left around a point of sand hills for nearly a mile and a quarter to one of the grass-covered hills, which is thickly covered with cacti and which joins the sand hills. On the top of this hill the station is located. The station was marked by a granite block 8 inches square, with the top level with the ground, and with a hole at its center. Four stubs were driven into the ground, 4 feet from the center, to the north, south, east, and west; also three stubs, each 1 foot 3 inches in length, 6 feet from the center.

San Pedro Northwest Base (Los Angeles County, Cal., G. Davidson, 1853; W. E. Greenwell, 1856; G. Davidson, 1881).—On the plains between Los Angeles and San Pedro, about 300 yards north northwest of the road from the salt works to Los Angeles, on the rancho Saural Redondo, claimed by Antonio Ignacio Abila (1853). The station was marked by a hole in the top of a blue limestone slab, 5¾ by 5¾ inches and 35¾ inches long, with its top 15 inches below the surface. One face was rough and was to the northeast. A stub projecting a few inches marked the station at the surface.

San Pedro Southeast Base (Los Angeles County, Cal., George Davidson, 1853, 1870).—On the plains between Los Angeles and San Pedro. The depression about 180 yards northwest of the station is but 15 feet below the station and has no water in it. The first depression, 80 yards toward Dominguez Hill, is dry, but the second and deeper one has water in it. From here the rise to Dominguez Hill is gradual to a height of about 135 feet. The southwest gable of Nassano Dominguez's house, adobe with large piazza, surrounded with pepper trees, is distant 3 613 feet, in azimuth 253° 51′. The northeast gable of a small cabin, at a sheep ranch, is distant 2 373 feet, in azimuth 44° 17′. South end of white house near Northwest Base is in azimuth 128° 16′. The rear gable of house showing above the 9-mile ridge is distant 1½ miles in azimuth 187° 30′. The station was marked by a blue limestone shaft, 6½ by 6½ inches, embedded in the earth, projecting 6¾ inches above the surface, with an irregular shaped hole in the top, the center of which marks the station. Two stubs, each about 2½ inches above the ground, were placed as follows: To the northwest, 3 feet ⅜ inches; to the southeast, 3 feet ⅝ inches; and two other stubs, each with copper nail with cross mark in the top, were placed to the northeast and southwest, distances not given.

San Buenaventura (Ventura County, Cal., W. E. Greenwell, 1858).—About 2 miles southeast of the San Buenaventura Mission, and on a perpendicular bluff about 40 feet high, on the road to the house of Raimundo Olivas. It is close to the bluff at the point where the road approaches nearest it. The center was marked by a red stone monument sunk 1½ feet in the ground marked Ranging north, south, east, and west from this were eight cedar stubs with copper tacks in the tops, the nearest of which were 3 feet 11 inches, and the outside ones 5 feet 10 inches distant. All the marks were covered with earth.

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Anacapa (Anacapa Island, California, O. H. Tittmann, 1876).—On the middle of the three islands forming Anacapa Island, not on the highest point but nearest the east end. The station was marked by an irregular pier of rough stone, built on a bed of concrete 2 feet below the surface. In the top of the pier a hole was drilled, filled with lead, marked with a cross. The reference marks were copper tacks leaded into holes drilled in the outcropping rock, distant from the center as follows: to the north, 5 feet; to the northeast, 6.11 feet; to the south, 13.95 feet; to the west, 6.45 feet.

Conejo (Ventura, Cal., W. E. Greenwell, 1857).—On the highest part of an isolated mountain on the Rancho del Conejo owned by Don Jose Lorenzana, of Santa Barbara, and 1 mile north from the house occupied by the foreman of the ranch. The station was marked by a granite slab 5 inches square sunk in the ground and marked

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Four live oak stubs, 6 inches in diameter, with nails in the center, were driven in the ground, to the north, south, and east, 4 feet 5 inches from the center; and to the west 3 feet 10 inches from the center.

Santa Clara (*old*) (Ventura County, Cal., W. E. Greenwell, 1855–1860.)—About 18 miles northeast of San Buenaventura, and about 5 miles east of Punta de la Loma; on the rancho San Cazotano owned by T. Wallace Moore; on the mountain range south of the Santa Clara Valley, running from San Fernando to Punta de la Loma; on a red egg-shaped peak, the highest in this immediate range. The station was marked by four live oak stubs 2 feet from the center to the north, south, east, and west.

Saddle Mountain (Los Angeles County, Cal., W. E. Greenwell, 1860).—On the top of the northeastern and sharper of two peaks, in an isolated mountain range commencing near the Cowango and ending at the laguna near the ocean. It is 5 or 6 miles from Point Dume and about midway between the ranchos of Malga and Santa Monica. The station was marked by a sandstone monument sunk 2 feet inthe ground and projecting 3 inches above it, with the letters

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on the top. Four sandstone blocks, each sunk 1 foot 6 inches, were placed to the north, south, east, and west of the center.

San Fernando (*old*) (Los Angeles, Cal., W. E. Greenwell, 1855–1860.)—About 5 miles from the old mission of San Fernando, on a peak, not the highest, of a mountain range known as San Fernando Mountains. To reach the station, start about west by north from the old mission of San Fernando and follow the foothills to Los Alisos Canyon; about halfway up this a trail leads to the left over a sharp ridge and up a winding canyon; follow the canyon up to a sulphur spring near its head; a trail leads from there to the mountain top, which is free of underwood and trees. The mountain lies in a northwest direction from the Puebla de Los Angeles and is crossed by the road to Fort Lyon. The station was marked by a red stone monument with

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on the top. To the north, south, east, and west 5 feet from the center were four live oak stubs with composition nails in the tops.

Cowango (Los Angeles County, Cal., W. E. Greenwell, 1856).—On the northwest peak of a conspicuous red hill, which is very abrupt, has little or no vegetation, and is on the east side of and about midway through El Paso de Cowango, a pass or wagon road through a range of the Coast Mountains which separates the Los Angeles plains from the San Fernando Valley. The station was marked by a sandstone slab with the letters U S C S on top. To the north of the center 4 feet 2 inches, a hole was drilled in the rock and lead was poured into it and marked with a cross on top; a similiar mark was made 6 feet 7 inches south of the center. Two wooden stubs, each with a composition tack marked with a cross on the top, were driven in the ground 3 feet 10 inches to the east and west.

Catalina Peak (Santa Catalina Island, Cal., S. Forney, 1876; D. B. Wainwright, 1870).—On the top of the highest peak of the island. (Note 20, p. 617.)

Santa Barbara Island (Santa Barbara Island, Cal., A. W. Chase, 1871; H. C. Taylor, 1876; O. H. Tittmann, 1876; D. B. Wainwright, 1878).—On the southwest one of two rounded knolls, on the highest part of the island. The station was marked by a square granite block, bearing the letters U. S. C. S., and having an iron bolt in its center. Four bottles were placed just under the surface of the ground, one on each side of monument, 33.2 feet from it, in line with the station and the high mountain on Santa Cruz Island, and one on each side of monument, 33.2 feet from it, in line with the station and the northwest end of Santa Catalina Island. Also the bottoms of the holes in which the framework of the signal of 1876 rested were covered with layers of broken stone, 8 inches thick, packed down, and they occupy the corners of a square of which the monument is the center.

Harbor (San Clemente Island, Cal., W. E. Greenwell, 1860; D. B. Wainwright, 1877–78; S. Forney, 1878–79).—On the top of a conspicuous hill on the north face of the island, south of a cove. The center was marked by a stone 3 by 6 inches on the top, with a lead bolt, buried even with the surface of the ground. Four redwood stubs, 2 by 3 inches, were driven in the ground each 2 feet from the center. The three Oregon pine theodolite stubs were left.

West Peak (Santa Catalina Island, Cal., S. Forney, 1875; D. B. Wainwright, 1876–78).—On the highest peak on the west end of the island. (Note 20, p. 617.)

Saddle Peak (San Luis Obispo County, Cal., L. A. Sengteller, 1872; W. E. Greenwell, 1881; J. S. Lawson, 1884).—On one of the peaks of the range of mountains which, commencing with the west side of the San Luis Creek, about 2½ miles from its mouth, extends westward toward Morro Bay. Looking from San Luis Hill or from the coast, two mountains, whose tops bear resemblance to a saddle, will be seen. The station was located on the northern and higher peak of the western mountain. The eastern mountain, about three-fourths mile distant, is the highest in the range. The peak on which the station was located is the sharpest of the high peaks. There are no high peaks between it and the ocean, to the south and west. A stone with a small hole drilled in its upper surface was buried 3 feet below the ground. Another stone was placed with its top even with the ground. Four reference stones were placed as follows: To the north, 4.03 feet from the center; to the south, 4.18 feet; to the east, 3.54 feet; to the west, 2.62 feet.

Cahto (Mendocino County, Cal., A. F. Rodgers, 1880).—On the highest point of a range of mountains just at the eastern edge of the redwood forest belt. To reach the station follow the Humboldt wagon road for about 3 miles from Cahto P. O. (or about one-fourth mile beyond Roderick's ranch), then turn into the field to the left and take the trail to the "Big Opening," where there is a spring; the trail to the station leads up the hillside to the right from this spring. The station was marked by a glass bottle embedded in the center of a concrete pier and by a nail in the wooden core in the top of the pier, 2.73 feet above the bottle. Another bottle was placed as a subsurface mark, 1.38 feet below the first.

King Peak (Humboldt County, Cal., A. F. Rodgers, 1879, 1881–82).—About 10 miles north of Shelter Cove or Point Delgada and about 4 miles east of the nearest point of the coast line, on the highest summit in that vicinity. The underground mark was a brass candlestick set in cement and protected from vertical or lateral pressure by a redwood board. The center of the socket marks the station. The surface mark was a hexagonal concrete pier, with a wooden core 3 inches in diameter, having the station center marked on it by intersecting lines. The observations of 1871 were made on the highest point of the peak, which should correspond closely to the △.

Mount Lassic (Humboldt County, Cal., E. F. Dickins, 1892).—On the most western and least prominent of the three buttes which rise in sharp conical outlines about 200 feet above the general surface of the mountain. The highest of the three buttes is east of and about three-fourths of a mile from the one on which the station is located and which is the easiest of access. The rocks to the westward of the station are about 3 feet higher than the station. The station was marked by a flat-top, irregular-shaped rock, set in concrete, the top even with the surface of the ground, in which was drilled a hole, with a copper bolt to mark the center. Over this was erected a concrete pier, 20 inches square and 4 feet in height, in the top of which was set another copper bolt to mark the center of the station. Two reference marks (holes drilled in the surface rock and filled with lead) were placed, one nearly in line to King Peak, distant 7 feet 8 inches from center, and the other on prolongation of the same line to the northeast, distant 8 feet 11¼ inches from the center.

Chemise Mountain (Humboldt County, Cal., A. F. Rodgers, 1872; B. A. Colonna, 1878; D. B. Wainwright, 1881).—On the high knob of the summit of Chemise Mountain, the highest coast summit immediately east of Shelter Cove. The station was marked by a black bottle, buried neck up, 10 inches below the surface; over this was 3 inches of earth, then a stone even with the surface, in the top of which was a half-inch drill hole about 1 inch deep. Three stones, each with a drill hole in the top, were placed 5 feet distant, as follows: One on the line to Cahto Mountain and the others, roughly, 120° from it. The three form a triangle, with sides 7.7 feet, 8.4 feet, and 9.7 feet.

Bear Ridge (Humboldt County, Cal., A. F. Rodgers, 1869; S. Forney, 1882; A. F. Rodgers, 1883).—Upon the first main ridge north of Cape Mendocino, which, at the ocean, forms False Cape; upon that part of the ridge known locally as the Big Hill. The station was marked by a heavy redwood stub placed 3 feet in the ground, the top level with the surface, over which was a heavy stand of redwood timber, with the feet firmly set in the ground. Four quart bottles were buried in the ground north, south, east, and west of the center and 6 feet from it.

Mad River (Humboldt County, Cal., A. F. Rodgers, 1870–1883; E. F. Dickins, 1892).—Upon the northern of the two summits known as the "Mad River Buttes," on the ranch of Tod and Crawford, 5 miles from and 3 300 feet above their ranch house. The station was marked by a pine stub 1 foot in diameter covered with a cairn of rocks, and by four bottles placed 6 feet from the center to the north, south, east, and west.

La Mesa (Los Angeles County, Cal., W. E. Greenwell, 1856; G. Davidson, 1871; A. W. Chase, 1875; F. Westdahl, 1887).—About 1½ miles from the ocean, on the side of a hill northeast of Santa Monica; about 400 meters southwest of the tracks of the Los Angeles and Independence Railroad and about 300 meters north of a road; about 35 feet above the level of the road and 175 feet above sea level; about 40 yards from the northwest corner of the table-land of the hill and almost in line with Twenty-second street, Santa Monica. The station was marked by a hole in the top of a red sandstone about 3 inches above the surface of the ground and leaning a little to the northeast. There was a similar hole in the side of the stone, plugged with wood.

Point Dume (Los Angeles County, Cal., W. E. Greenwell, 1856; G. Davidson, 1871).—On the headland of Point Dume, about 1 foot lower than the highest point and about 12 feet in a southerly direction from it. The station was marked by a large stone with an inch drill hole in the top, buried 3 inches below the surface. Four redwood stubs, 4 inches square, projecting 3 inches above the ground, each with a copper nail in the top, were placed thus: to the north, 4 feet 9¾ inches from the center; to the east, 4 feet 10½ inches; to the south, 4 feet 11½ inches, and to the west, 4 feet 10½ inches.

Gavilan (Monterey County, Cal., R. D. Cutts, 1852; W. E. Greenwell, 1864).—On the crest of the mountain separating the Pajaro Valley from Valley of Salinas, and about 4 miles to the southward of the Mission of San Juan. The crest is composed of a line of sharp rocky peaks from 2 800 to 3 000 feet high, and the station is on the western extremity, on a small platform of level land, just where the ground commences to fall rapidly. The station was marked by a stone block, with a drill hole in the top, filled with lead, set 2½ feet below surface of ground. Three lead bolts in fixed rocks are as follows: one 13 feet 2 inches south by west (approximately); one 13 feet 9 inches southeast (approximately), and one 5 feet 9 inches north by east (approximately) from the center.

Pajaro Mouth (Monterey County, Cal., R. D. Cutts, 1852).—On the north side of the mouth of Pajaro River, on the summit of a sand knoll about 20 feet high. A line of these sand knolls extends from the mouth of the river along the shore, and the knoll on which the station is located is about 50 meters from the south end of the line. The station was marked by a stone block, with a drill hole filled with lead, set 3 feet below surface; also by three other blocks, similarly marked, even with the surface, two in line and one at right angles, and each 6 feet from the center.

Santa Cruz Azimuth Station (Santa Cruz County, Cal., R. D. Cutts, 1852–54; W. E. Greenwell, 1864).—On a smooth, rounded hill back of the village of Santa Cruz, ½ mile west by south of the Mission and 2 miles west-northwest of the Embarcadero. About 170 meters northeast of station is Gordon's limekiln. The station was marked by a stone block, in which a hole was drilled and filled with lead, set 3 feet below surface, and three other blocks, similarly marked and placed, two in line with the center and one at right angles to this line, and each 6 feet distant from the center.

Point Pinos Latitude Station (Monterey County, Cal., G. Davidson, 1851; W. E. Greenwell, 1864; A. F. Rodgers, 1875; Lieut. F. Swift, 1904).—On northeasterly part of Point Pinos, 680 meters east of the light-house and 200 meters from the shore. The center of a rocky knoll, with a pine tree standing on the western edge, bears N. 15° E. by compass, distant 153 feet from the center of the station, and is in range with and south of another rocky knoll and a large broken rock on the beach, the first large rock east of Luces Point △. From the center of the station another rocky knoll bears N. 73° W. by compass, distant 104 feet. This knoll is in the direction of and in range with the whistling buoy off Point Pinos and White Rock △'s. There are three pine trees northwest of the knoll and one south of it within a short distance. The station was marked by a stone block, the top of which was even with the surface and had in it a drilled hole filled with lead. West of station 6.5 feet, east 6 feet, and south 8 feet are bottles buried with the necks even with the ground. Eighteen feet southwest and 18 feet southeast are stones with holes drilled in top. The center stone and each of these reference marks were covered with a pile of stones; 18.8 feet northeast was a hole drilled in a large rock. A copper nail in a double pine tree was 75.7 feet S. 55° W. of the station.

San Bernardino Meridian (San Bernardino County, Cal., A. T. Mosman, 1899).—A cairn of rocks on the top of the western peak of San Bernardino Mountain, marking the origin of the principal meridian for the United States Land Survey in Southern California.

MEXICAN BOUNDARY TO POINT LA JOLLA.

Old Town (San Diego County, Cal., R. D. Cutts, 1852; G. Davidson, 1871; A. F. Rodgers, 1887; C. H. Sinclair, 1892; F. Westdahl, 1899).—On the top of the hill about ¾ mile southwest of the old town, or North San Diego; just south of a road from North San Diego over the hill. The southwest corner of a new (1898) two-story house was about 108 feet east of the station. The station was marked underground by a pine stub with a nail in the top. Over this and 12 inches below the surface was placed a flat sandstone about 14 by 8 by 6 inches, with a ½-inch drill hole in the top 1½ inches deep. Three redwood stubs, each with a copper nail in the top, were placed 6 feet from the station; two are in line with Point Loma Light-house and the other at right angle, nearly northwest. The three theodolite stubs, each with a fencing staple in the top, were left as reference marks.

Middle Loma (San Diego County, Cal., A. F. Rodgers, 1887; C. H. Sinclair, 1892).—On Point Loma, on the crest of the ridge between San Diego Latitude Station 1851 and the ocean. The road to the light-house passes within 22 paces of the station, between it and San Diego Bay. (Note 2, p. 615.)

Chula (San Diego County, Cal., O. B. French, 1892).—About 1 mile south of National City, on the east side of National City avenue or National City and Otay road, on the south side of the top of a ridge, about 20 feet east of a cut for that road through the ridge—the first and only cut for the road south of National City. The station was marked by a stone jug (neck and handle broken) set about 2 feet below the surface of the ground. The surface mark was a 3-inch drain tile projecting about 4 inches above the ground, the center being marked by a wire nail in the wood plug in the top of the tile.

San Diego Longitude Station 1892 (San Diego County, Cal., C. H. Sinclair, 1892).—In the southwest part of the San Diego city park, nearly where the south line of Fir street produced would intersect the center of Seventh street. The point was marked by a brick and cement pier 17 by 23 inches at the top, 3 feet above ground and about 1 foot below, built on the hardpan. Probably destroyed (1903).

San Diego Latitude Station 1892 (San Diego County, Cal., C. H. Sinclair, 1892).—A brick and cement pier 17 by 17 inches, 3 feet above ground and about 1 foot below, 50 inches due west of the center of the longitude pier of 1892. Probably destroyed (1903).

San Diego Latitude Station 1851 (San Diego County, Cal., G. Davidson, 1851, 1871; A. F. Rodgers, 1887; F. Westdahl, 1899).—About 2 feet below and about 40 feet northeast of the highest part of the first round-topped hill southwest of the north end of La Playa. The station was marked 2 feet below the surface by a porter bottle, bottom up, and below this a second bottle. In 1871 a large piece of sandstone rock was set with its top surface 4 inches below the general surface of the ground, a half-inch hole 1½ inches deep marking the exact center. To the north, 8 feet from the center, was a buried bottle, and a stub, with a copper tack in the top, at the surface. Six feet to the east of the center a bottle was buried and a stub placed at the surface, and similar marks 8 feet south of the center. The middle of the east side of a wooden block, a foot and a half square and 2$\frac{3}{4}$ feet above ground, was distant 17 feet 7$\frac{1}{2}$ inches from the center of the station. The three theodolite stubs, each with a fencing staple in the top, were left standing.

Middle (San Diego County, Cal., F. Westdahl, 1899).—About 800 meters west of the southwest extremity of Spanish Bight, between the roadway outside the wire fence and the edge of the bluff. The station was marked by a bottle buried about 2 feet in the ground, with a 4-inch glazed tile above it, projecting 6 inches above the surface of the ground, the whole surrounded by a cairn of stones.

New South (San Diego County, Cal., F. Westdahl, 1899).—About 1.3 miles southeast of Hotel Coronado, about 15 paces inside the ridge. The station was marked by a 4-inch glazed tile firmly planted in the ground and projecting about 6 inches above the surface, filled with cinders and coal ashes. Under this a bottle was buried, the center of which marks the station.

Mud (San Diego County, Cal., A. F. Rodgers, 1887).—On the south shore of the entrance to San Diego Bay, about $\frac{1}{2}$ mile inside, on a level piece of ground quite near high-water mark, where the ground begins to rise from the marsh which makes into the peninsula just inside the entrance. The mud flat is quite wide opposite the station. (Note 2, p. 615.)

San Diego 2 (San Diego County, Cal., G. Davidson, 1871; A. F. Rodgers, 1887).—In San Diego, on the line of the east side of Seventh street and 11 feet 10 inches south of the north line of Ash street. It was marked underground by a drilled hole in the irregular surface of the hardpan, which is composed of pebbles cemented together. The brick pier marking the San Diego Longitude Station 1871 was 15 feet 9$\frac{1}{16}$ inches true east of the station. The street was graded in 1887, and the marks probably destroyed.

San Diego Longitude Station 1871 (San Diego County, Cal., G. Davidson, 1871).—Near the northeast corner of Ash and Seventh streets, on the west side of the ridge, between Seventh and Eighth streets; about 4.87 meters south of the corner concrete wall, and 11 feet 10$\frac{1}{2}$ inches south and 15 feet 10$\frac{1}{2}$ inches east of the northeast corner of Seventh and Ash streets. Marked by a brick pier. Reported lost (1892).

Indian Point (San Diego County, Cal., R. D. Cutts, 1851; G. Davidson, 1871).—Destroyed. See Indian Point 2 (p. 649).

Blackfish Point 2 (San Diego County, Cal., G. Davidson, 1871).—On the first jutting point of the bluff inside the ocean beach of the peninsula at San Diego Bay, 56 yards from a bluff on the south and 12 yards from the edge of a bluff 18 feet high on the east. The station was marked by a block of sandstone 14 inches by 8 inches by 5 inches, with a half-inch hole drilled 1$\frac{1}{2}$ inches deep. A small pile of stones was placed around the foot of the signal; no other stones are near the station and very few anywhere near on the surface. Four redwood stubs, each with a copper nail in the top, were placed each 6 feet from the station mark.

Peninsula Point (San Diego County, Cal., A. F. Rodgers, 1887).—On a point which projects into San Diego Bay from the low land between Point Loma and the main land, and connected with the flat inshore by a narrow neck; on a narrow sand ridge covered with marsh grass, very near high-water mark. (Note 2, p. 615.) A small stake was driven into the center of the pipe level with the top.

San Diego Sherman School (San Diego County, Cal., F. Westdahl, 1899).—The tower on Sherman Heights Schoolhouse, situated on the heights in the southern part of the city of San Diego.

Old Adobe (San Diego County, Cal., A. F. Rodgers, 1887).—On Point Loma, on the top of the hill which overlooks both San Diego Bay and False Bay, in the center of the remains of an old adobe house, the only house of this kind on the hill. (Note 2, p. 615.) In 1898 the remains of the adobe house were fast disappearing; all of the earthenware pipe had been broken off except the bottom 4 inches. A small stake was driven in the center of the pipe remaining, and a bottle placed alongside; the broken pieces of pipe were replaced and covered over.

New False Bay (San Diego County, Cal., A. F. Rodgers, 1887).—On Point Loma, on top of the ridge, about the middle and 10 feet from the top of an eroded bluff 8 feet high, on the ocean face of the ridge, overlooking the ocean shore line for a considerable distance and the greater portion of False Bay. (Note 2, p. 615.)

Bay Point (San Diego County, Cal., A. F. Rodgers, 1887).—About the middle (east and west) of the prominent point which makes into False Bay from north side, about 6 feet from the edge of the bluff, which is between 30 feet and 40 feet high opposite the station. (Note 1, p. 615.)

Back Bay (San Diego County, Cal., A. F. Rodgers, 1887).—About 3½ miles north of North San Diego, on top of a hill just back of the northernmost bight of False Bay, on the prolongation of the shore line of the bight (marsh line) which runs nearly straight for one-fourth of a mile toward the ocean from the nearest point of the bay. The ground is almost level near the station, rises gradually back of it and falls away toward the bay. The California Southern Railroad runs between the station and the bay. (Note 1, p. 615.)

Hill (San Diego County, Cal., A. F. Rodgers, 1887).—On the slope of the line of hills which lie back of the mesa bounding False Bay on the northwest. The hill falls rapidly to the mesa and the road from San Diego to La Jolla Park runs near its foot. The soil is quite hard and there are many loose rocks and bowlders. The slope of the hill is almost covered with a growth of cactus. (Note 1, p. 615.)

Beach (San Diego County, Cal., A. F. Rodgers, 1887).—On the shore about a half mile up the coast from the extreme northwest part of False Bay, on top of a small mound about 9 paces from the top of the bluff bank to the beach, which is about 5 feet high at this point. (Note 1, p. 615.)

Knoll (San Diego County, Cal., A. F. Rodgers, 1887).—On a bench in the hills overlooking the mesa northwest of False Bay. The knoll is quite level on top near the station, and the ground falls behind the station before rising to the higher portion of the ridge inland. A deep gulch is cut through the mesa from the hills south of the station to the beach on the north. The range of hills along the coast is not visible from the hill beyond this station. (Note 1, p. 615.) The soil is soft on top, but the underlying sandstone is soon reached.

False Point (San Diego County, Cal., A. F. Rodgers, 1887).—On the extremity of the point from which it takes its name, 5 paces from the edge of the bluff, which is about 50 feet high. At the foot of the bluff there is no sand beach, but a quantity of bowlders, which are exposed at low tide. The ground is level inshore from the station for some distance. (Note 1, p. 615.)

Wash (San Diego County, Cal., A. F. Rodgers, 1887).—On the hills back of the mesa which lies north of False Bay, on a hill whose sides are very much eroded; about 6 feet from the edge of one of these gulches, which is about 20 feet deep opposite the station. The eroded sides of this ridge are quite prominent. (Note 1, p. 615.)

Island Point (San Diego County, Cal., A. F. Rodgers, 1887).—About 2½ miles south of La Jolla Park, on the edge of the mesa, overlooking the coast, and about 300 meters from the shore. The ground falls seaward from the station to a level bench 40 feet below and about 250 meters wide. The bluff here is not high, and there is a detached rock forming an island a short distance offshore. (Note 1, p 615, except the top of the bottle was 6 inches below the surface and the bottom rested on solid rock.)

Moss (San Diego County, Cal., A. F. Rodgers, 1887).—On a bench in the hills south of the La Jolla Park, where these hills approach nearest to the ocean. It is, apparently, in the prolongation of one of the streets as laid out. The ground is almost level near the station and is covered by a growth of moss, and the end of the ridge is very steep and bare and covered with bowlders. The station is on a small mound of red clay, the color contrasting distinctly with the surrounding gray moss. (Note 1, p. 615.)

Sandstone Point (San Diego County, Cal., A. F. Rodgers, 1887).—Near the coast, about 1¾ miles south of La Jolla Park, on the mesa, near a clump of green bushes, and where the mesa begins to fall off rapidly toward the shore (about 150 meters distant). Inshore the ground is almost covered with a growth of cactus, and offshore a large sandstone reef extends, which is uncovered at low water. (Note 1, p. 615).

Boulder (San Diego County, Cal., A. F. Rodgers, 1887).—On the end of a small ridge back of La Jolla Park, on the prolongation of the line of Lincoln street. The end of the ridge is composed entirely of small bowlders which show very plainly from the mesa below. (Note 1, p. 615, except the top of the bottle is 2 inches below the surface of the rocks.)

Sand Ridge (San Diego County Cal., A. F. Rodgers, 1887).—Near the coast, about 1 mile south of La Jolla Park, at the highest point of a ridge of white sand, with green bushes growing along the sides and top. The bushes were cleaned away immediately around the station. (Note 1, p. 615.)

Pentagon (San Diego County, Cal., A. F. Rodgers, 1887.)—In La Jolla Park, on the edge of the slope overlooking the shore. (Note 1, p. 615.)

Bench (San Diego County, Cal., A. F. Rodgers, 1887.)—On a prominent bench of the high ridge running inshore from La Jolla Park. The soil is very hard and rocky, and numerous small rocks and bowlders are scattered over the ground near the station. (Note 1, p. 615.)

La Jolla Park (San Diego County, Cal., A. F. Rodgers, 1887).—In the town of La Jolla Park, on the top of the slope overlooking the coast, on lot 14, Prospect street, opposite the end of Lincoln street. (Note 1, p. 615.)

Barranca (San Diego County, Cal., A. F. Rodgers, 1887).—On the coast about 1½ miles above La Jolla Park, on the bluff overlooking the beach, and 10 paces south of the mouth of a barranca. (Note 1, p. 615.)

Bush (San Diego County, Cal., A. F. Rodgers, 1887).—About 1½ miles up the coast from La Jolla Park, on the top of the first ridge across the valley back of the cove above La Jolla Park. There are some bushes growing on the hill at the station peculiar from the fact of their leaning away from the coast and shading a good deal of open ground beneath them. (Note 1, p. 615.)

Center (San Diego County, Cal., A. F. Rodgers, 1887).—About 2 miles up the coast from La Jolla Park, on the side of the ridge overlooking the coast. The ground near the station is flat. There are no marked features near the coast, but it is the only point to be found that will see the four stations, Barranca, Ball, Round Top, and Bush. (Note 1, p. 615.)

Ball (San Diego County, Cal., A. F. Rodgers, 1887).—On the coast about half way between La Jolla Park and Soledad Canyon, on top of a narrow ridge overlooking the shore and running parallel to it. On the end of the ridge is a knoll, back of which is a narrow neck connecting it with another knoll, and again back of this the ridge narrows before joining the main body. The station is on the side nearest the canyon, inshore and a little down the hill. (Note 1, p. 615.)

Round Top (San Diego County, Cal., A. F. Rodgers, 1887).—On the hills between La Jolla Park and Soledad Canyon, on top of a long flat ridge on the eastern side of these hills and overlooking a good deal of the back country and a portion of the road from San Diego to Del Mar. Between the station and the ocean is a large basin, which is probably covered with water in wet seasons. It has none of the brush growing on the surrounding hills, and forms a marked feature in this locality. (Note 1, p. 615.)

Point Meganos (San Diego County, Cal., A. F. Rodgers, 1887).—On the sand spit just north of the entrance to False Bay, on the top of the first and most prominent sand hill north of the broad flat beach on this side of the entrance. North of this sand hill is a large depression, the bottom of which is almost entirely covered with round bowlders. A number of these were collected and placed around the bottom of the signal. (Note 1, p. 615.)

Standpipe (San Diego County Cal., F. Westdahl, 1898-99).—A tall iron standpipe belonging to the San Diego Water Company, on the north slope of the hill above Old Town, about 600 meters north of Old Town △.

Channel Point (San Diego County, Cal., A. F. Rodgers, 1887; F. Westdahl, 1898).—On the point forming the north side of the entrance of Spanish Bight, San Diego Bay, on the peninsula between San Diego Bay and the ocean (note 2, p. 615), the pipe projected 3 inches from the ground.

Meridian Mark (San Diego County, Cal., G. Davidson, 1871; A. F. Rodgers, 1887; F. Westdahl, 1899).—On the narrow peninsula forming the western boundary of the Bay of San Diego, on the west side of a clear place of white sand about 60 feet from the bay shore and within the margin of the bushes. The station was marked by a stub and by three theodolite stubs, each with a fencing staple in the top. A brick pier 25 inches by 17 inches, 3 feet below the surface and 3 feet above, was built north of the station, and the center of the brick pier was marked by a copper tube 1½ inches in diameter and 2 feet long. In 1887 the pier was even with the ground and fast crumbling to pieces.

Glorieta Bight (San Diego County, Cal., A. F. Rodgers, 1887).—On the north shore of Glorieta Bay, on the Boulevard of Coronado Beach, near the corner of Ynes

Place. (Note 2, p. 615.) It was stated in 1887 that the station would probably be destroyed in the course of a year.

Indian Point 2 (San Diego County, Cal., A. F. Rodgers, 1887).—On the beach of San Diego Bay between the La Choyas Valley and the valley of La Carbonera, on the top of a bank of earth thrown up by the California Southern Railroad Company, which was leveled in the immediate vicinity of the station. (Note 2, p. 615.)

Made Point (San Diego County, Cal., A. F. Rodgers, 1887).—On a point of made ground on the Peninsula opposite San Diego, on the west shore of San Diego Bay. Reported destroyed in 1899.

National City (San Diego County Cal., A. F. Rodgers, 1887.—On the embankment built into the bay for the California Southern Railroad wharf at National City, Cal., on the south side of the railroad. (Note 2, p. 615.)

Sand Hill (San Diego County, Cal., A. F. Rodgers, 1887).—On the narrow part of the peninsula between San Diego Bay and the ocean, about 2½ miles down the coast from the Hotel del Coronado on top of a sand hill, which is a little higher than any other within ¼ mile. The slope of the hill is very steep toward the bay and there is a wide strip of marsh at its foot extending to the bay shore. There is another, but lower, sand ridge between the station and the ocean. (Note 2, p. 615.)

Sweetwater (San Diego County, Cal., A. F. Rodgers, 1887).—On a narrow sand ridge on a low marshy point, which forms the south side of the entrance of Sweetwater Valley. A quantity of beach sand was placed around the station over the marsh grass growing there. (Note 2, p. 615.)

Shell Hill (San Diego County, Cal., A. F. Rodgers, 1887).—On a sand hill on the peninsula between San Diego Bay and the ocean, about 5 miles down the coast from the Hotel del Coronado, and just back of a prominent point which makes out into the bay opposite the south side of the Sweetwater Valley. A brickyard is situated on this point and there is a windmill a short distance southeast of the station. A quantity of white shells are scattered over the ocean face of the sand ridge near the station. (Note 2, p. 615.)

Brush Hill (San Diego County, Cal., A. F. Rodgers, 1887).—At the beginning of the peninsula between San Diego Bay and the ocean, on top of a prominent sand hill covered with a growth of small bushes, some of which were cut down around the station, clearing the top of the hill. (Note 2, p. 615.)

Marsh Point (San Diego County, Cal., A. F. Rodgers, 1887).—On the east side, near the head of San Diego Bay, on the low marshy shore; near the mouth of a small slough, on its north side, in a patch of marsh grass growing in the sand. (Note 2, p. 615.)

Fisherman Point (San Diego County, Cal., A. F. Rodgers, 1887; F. Westdahl, 1899).—On a point which projects into San Diego Bay from Point Loma at a place called Roseville. Several fishermen's huts are situated on the point, and directly inshore from the station is a two-story frame house belonging to J. K. Milky. (Note 2, p. 615.)

Cemetery Bluff (San Diego County, Cal., A. F. Rodgers, 1887).—On Point Loma a short distance from Point Loma Light-house, on top of the ridge between the United States Cemetery back of Ballast Point and the ocean, on a small knob almost surrounded by an eroded bluff 12 to 15 feet high and connected by a very narrow ridge with the hillside toward San Diego Bay. The station was marked by the center one of five copper tacks driven into the top of a pine stub 4 inches square, projecting 14 inches above the surface of the ground, which is hardpan. The three theodolite stubs, each with a fencing staple driven in the top, were left as reference marks.

Entrance (San Diego County, Cal., A. F. Rodgers, 1887; F. Westdahl, 1899).—The offshore post of a large sign placed by the San Diego authorities on the south shore of the entrance to San Diego Bay, to warn ships not to anchor near the pipe line from San Diego to Coronado Beach. It was used as a hydrographic signal by the Corps of Engineers, United States Army. A 4-inch earthenware pipe was placed in the ground beside this post. It was reported in 1899 that the sign had been rebuilt, but probably in the same position.

Ballast Point 2 (San Diego County, Cal., A. F. Rodgers, 1887).—On the point of this name which projects from Point Loma into the entrance of San Diego Bay, just outside of the grass or bush line. (Note 2, p. 615, except no reference marks are mentioned.)

South (San Diego County, Cal., A. F. Rodgers, 1887).—A hydrographic signal, erected by the Corps of Engineers, United States Army, near the ocean shore line on the peninsula between San Diego Bay and the ocean, about a mile down the coast from the Hotel del Coronado. (Note 2, p. 615, except no reference marks were mentioned.)

Black Flag (San Diego County, Cal., A. F. Rodgers, 1887; F. Westdahl, 1898).—On the south shore of the entrance to San Diego Bay, Cal., about a mile inside. The station was marked by a 4-inch pipe filled with coal cinders and ashes, into which a small stake was driven. A post used as a hydrographic signal was formerly beside the pipe, but was gone in 1898.

Blackfish Point (San Diego County, Cal., R. D. Cutts, 1851).—Destroyed. (See Blackfish Point 2, p. 645.)

Ballast Point (San Diego County, Cal., R. D. Cutts, 1851).—Destroyed. (See Ballast Point 2, p. 650.)

San Diego Azimuth Station (San Diego County, Cal., G. Davidson, 1851, 1871).—Nine feet nine and three-fourths inches west of San Diego Latitude Station 1851 (p. 644). Marked by a bottle buried 3 feet underground, and by a stub 6 feet to the west of the center.

Middle Hydrographic Signal (San Diego County, Cal., A. F. Rodgers, 1887).—A hydrographic signal, erected by the Corps of Engineers, United States Army, on the ocean shore line of the peninsula between San Diego Bay and the ocean, about ¾ mile north of Spanish Bight. Reported lost in 1899.

Tank (San Diego County, Cal., F. Westdahl, 1899).—A large water tank on Coronado Island, about 500 meters southeast of Ferry Tower △.

San Diego Court-House (San Diego County, Cal., F. Westdahl, 1899).—The figure of "Justice" on the cupola.

Loma Southeast Tangent (San Diego County, Cal., F. Westdahl, 1899).—At high-water mark on the southeast extremity of Point Loma. Not permanently marked.

Loma East Tangent (San Diego County, Cal., F. Westdahl, 1899).—The edge of the bluff over the perpendicular cliff constituting the eastern tangent of Point Loma. Not permanently marked.

Bluff (San Diego County, Cal., F. Westdahl, 1899).—About 1 650 meters south of Ballast Point, at a point where the cliff line extends the farthest to the eastward, on top of and near the edge of the cliff. The station was marked by a bottle buried about

2 feet and a surface mark consisting of a 4-inch glazed tile pipe placed above it, the top of which projects 6 inches above the surface of the ground.

Pole (San Diego County, Cal., F. Westdahl, 1899).—On a rocky point about midway between Ballast Point and La Playa, locally known as China Point, and prominent for the reason that the land falls immediately behind it before rising to Loma Ridge. Not permanently marked.

Jetty (San Diego County, Cal., F. Westdahl, 1899).—On the outer end of the piling of the jetty, San Diego Bay. Not permanently marked.

Chimney (San Diego County, Cal., F. Westdahl, 1899).—A brick chimney erected on the north end of the structure used as a weighing house by the United States Engineers during the construction of the jetty in 1895–1897. Near and to the westward of the inshore end of the jetty, San Diego Bay.

Phone (San Diego County, Cal., F. Westdahl, 1899).—A telephone pole standing about 750 meters east of the inshore end or base of the jetty, San Diego Bay.

Quarantine (San Diego County, Cal., F. Westdahl, 1899).—The tall flagstaff in the center of the plaza of the United States Quarantine Station at La Playa Point.

Cupola (San Diego County, Cal., F. Westdahl, 1899).—The cupola on the residence of Mr. F. M. Howell on top of Loma Ridge, about 950 meters northwest of the United States Quarantine Station at La Playa Point.

Bight (San Diego County, Cal., F. Westdahl, 1899).—About 375 meters southeast from the southeast extremity of Spanish Bight and about 3 meters north of the Boulevard. It was marked by a redwood stake driven 3 feet into the ground and surrounded by a cairn of rocks.

Red Roof House (San Diego County, Cal., F. Westdahl, 1899).—A cupola on a building surrounded by orchards, on Loma Ridge.

Ferry Tower (San Diego County, Cal., F. Westdahl, 1899).—The tower on the south end of the Coronado Ferry Company's building on the Coronado Island side of San Diego Bay.

Stone (San Diego County, Cal., F. Westdahl, 1899).—The southeast gable of a small pink house said to belong to a Mr. Stone, near the county road; about 100 meters above high-water mark, and from it Coronado Hotel is seen just to the right of Beacon 5.

Ways Smokestack (San Diego County, Cal., F. Westdahl, 1899).—The iron smokestack on the engine-house of the marine railway located at Channel Point.

Nail (San Diego County, Cal., F. Westdahl, 1899).—The iron smokestack on the building of the nail works at Roseville.

Electric (San Diego County, Cal., F. Westdahl, 1899). The tall brick stack of the San Diego Electric Railroad Company's power house near the Santa Fe Railroad depot.

Soledad Latitude and Azimuth Station (San Diego County, Cal., Fremont Morse, 1879; A. T. Mosman, 1899).—A pier of brick laid in cement, 18.02 meters from Soledad △ (p. 636), in azimuth 178° 32′ 48″.

POINT LA JOLLA TO SAN MATEO POINT.

Shell Mound (San Diego County, Cal., A. F. Rodgers, 1887).—On the coast, about 1½ miles below the mouth of Soledad Canyon; on the first hill down the coast from a prominent eroded bluff with a gap in it. The top of the hill is round and flat and numerous pieces of small white shells are scattered over its surface, a feature not observed at any other station in this locality. (Note 1, p. 615.)

Deer (San Diego County, Cal., A. F. Rodgers, 1887).—On the high, rolling mesa, south of Soledad Canyon, inshore from a prominent eroded hill (with a gap in it) near the coast. (Note 1, p. 615.)

Red Bluff (San Diego County, Cal., A. F. Rodgers, 1887).—On the edge of the bluff overlooking Soledad Canyon and inshore from an eroded hill (with a gap in it) near the coast. The bluff is almost perpendicular for a short distance on both sides of the station and the red of the eroded clay suggested the name. (Note 1, p. 615.)

Pine (San Diego County, Cal., A. F. Rodgers, 1887).—On top of a very prominent sand hill at the south side of the entrance of Soledad Canyon. Two pine trees growing on top of this hill (the only ones) are conspicuous objects for some distance along the coast in both directions. The hill is the highest in the vicinity and a gap between the pine trees is a distinguishing feature. (Note 1, p. 615.)

White Bluff (San Diego County, Cal., A. F. Rodgers, 1887).—On a bluff overlooking a branch of the Soledad Canyon and its entrance near Delmar, Cal. The point of this bluff extends some distance south of the station and is very prominent from the canyon below. It is much eroded and the narrow neck connecting the knoll at the end with the bluff near the station is washed through at one place. A quantity of white eroded sandstone is exposed on the side toward Soledad Canyon. (Note 1, p. 615.)

Railroad (San Diego County, Cal., A. F. Rodgers, 1887).—On the slope of the ridge forming the north side of the entrance of Soledad Canyon, about 250 meters from the bluff overlooking the beach and on the prolongation of the line of the seaward rail of the California Southern Railroad along the straight portion of the track through the town of Delmar. The ridge inshore is much eroded near the station. (Note 1, p. 615.)

Delmar (San Diego County, Cal., A. F. Rodgers, 1887).—On the top of the ridge back of the schoolhouse, in the town of Delmar, Cal. The seaward face of the ridge is much eroded near the station and quite near it the top of the ridge is bare and covered with small brown pebbles. The small pavilion at the head of the steps leading to the bathing pool is visible through a gap in the eroded banks in front of the station. (Note 1, p. 615.)

Wave Crest Point (San Diego County, Cal., A. F. Rodgers, 1887).—On the low bluff overlooking the San Dieguito Valley, on the south side of its entrance, and on the prolongation of the line of the seaward rail of the California Southern Railroad, along the straight portion of the track through the town of Del Mar, about 10 feet from the edge of the bluff. (Note 1, p. 615, except the bottle was a white glass beer bottle.)

Red Cliff (San Diego County, Cal., A. F. Rodgers, 1887).—About 2 miles up the coast from Del Mar, on a sand hill in the southwest corner of land owned by Judge

Lane, on the bluff overlooking the beach, quite near the northwest corner of Red Cliff ranch. (Note 1, p. 615.)

San Dieguito (San Diego County, Cal., A. F. Rodgers, 1887).—In Del Mar, Cal., on the edge of the bluff overlooking the San Dieguito Valley, at the end of the second ridge back from the coast on the hills between the Soledad and San Dieguito canyons. The bluff is very much eroded near the station and is almost perpendicular. A little to the east it is 40 to 50 feet high. (Note 1, p. 615.)

Town (San Diego County, Cal., A. F. Rodgers, 1887).—In Del Mar, Cal., on the second ridge back from the coast, about halfway between Soledad and San Dieguito canyons. The ground is unbroken near the station and has no peculiarities. (Note 1, p. 615.)

Pebble (San Diego County, Cal., A. F. Rodgers, 1887).—On the ridge back of the mesa between San Dieguito and San Elijo creeks, at a point on the ridge when it falls abruptly to a lower level, making the station quite prominent. The ground near the station is level and is covered with bushes. A great many round pebbles are scattered about. A black glass beer bottle, buried neck up, with its top 4 inches beneath the surface of the ground, the bottom resting on solid rock, was used as the station mark.

Ledge (San Diego County, Cal., A. F. Rodgers, 1887).—On the point forming the south side of the entrance of the San Elijo Valley, on the edge of the bluff overlooking the beach, about 10 feet distant on two sides. A large ledge of rock uncovers at low water, near the point. (Note 1, p. 615.)

Search (San Diego County, Cal., A. F. Rodgers, 1887).—On the second ridge back from the coast and about ½ mile north of the San Elijo Valley, on top of a long, flat ridge with nothing distinctive near it. The sandstone crops out in several places, and there is very little soil anywhere. (Note 1, p. 615.)

San Elijo (San Diego County, Cal., A. F. Rodgers, 1887).—Near Encinitas, about 125 meters up the coast from the point which forms the north side of the entrance of the San Elijo Valley, on the bluff overlooking the beach at the mouth of San Elijo Creek. A small house stands by the road a short distance inshore from the station. (Note 1, p. 615.)

Rancheria (San Diego County, Cal., A. F. Rodgers, 1887).—About 1½ miles down the coast from Encinitas, on top of the first ridge back from the coast, near the point where there is a sudden fall of about 30 feet and the bluff is eroded. There are numerous rock, shells, etc., indicating its occupancy by the Indians. (Note 1, p. 615.)

Flint (San Diego County, Cal. A. F. Rodgers, 1887).—On the end of a ridge about 1 mile in shore from Encinitas; on top of the ridge north of an eroded place. Standing off the end of the ridge is a very peculiar mound shaped like the frustrum of a cone, its base being of white sandstone, then a thick layer of red sandstone with a little earth on top in which two or three bushes are growing. (Note 1, p. 615.)

Encinitas (San Diego County, Cal. A. F. Rodgers, 1887).—On the bluff overlooking the ocean opposite the town of Encinitas, on the highest of the sand hills opposite the south end of the town, but there is only one house down the coast from the station and none opposite to it. (Note 1, p. 615.)

Kincaid (San Diego County, Cal., A. F. Rodgers, 1887).—On top of the ridge ¼ mile back of Mr. L. C. Kincaid's house, near Encinitas. Inshore and south of the station, the hill is eroded, forming a steep bluff, the top of which is six paces distant. (Note 1, p. 615.)

Leucadia (San Diego County, Cal., A. F. Rodgers, 1887).—On the bluff overlooking the ocean opposite the town of Leucadia, on top of a small sand hill. (Note 1, p 615.)

White Rock (San Diego County, Cal.,A. F. Rodgers, 1887).—On top of a long and prominent ridge back of the entrance of San Marcos Creek and about ½ mile south of this creek. A quantity of white pebbles are scattered over the ridge. (Note 1, p. 615.)

Scott (San Diego County, Cal., A. F. Rodgers, 1887).—On the bluff overlooking the beach about ½ mile south of the entrance of San Marcos Creek across the California Southern Railroad from the house of Mr. Scott, on the top of a sand hill covered with a growth of weeds except on its seaward face, which is bare. About 30 paces south of the station is a sand ridge which is bare on the side facing the station. (Note 1, p. 615.)

Rock (San Diego County, Cal., A. F. Rodgers, 1887).—On the hills about 1½ miles north of San Marcos Creek and the same distance from the ocean, on top of a ridge crowned by a ledge of rock, about 2 feet of which is exposed on its seaward face about 15 feet back of the edge of the ledge. A small patch of disintegrated sandstone is down the ledge just north of the station. Two small houses are near the station and a shed is quite near, but they will probably be changed. (Note 1, p. 615.)

Post (San Diego County, Cal., A. F. Rodgers, 1887).—About 5 miles north of Encinitas, on land owned by Dr. A. H. Vail, on the top of the bluff overlooking the beach, 4 paces from a line of fence posts running from the bluff to the California Southern Railroad. (Note 1, p. 615.)

Escondido (San Diego County, Cal., A. F. Rodgers, 1887.)—About 1 mile from the coast, and back of Stewarts railroad station, on the top of a hill, commanding a considerable portion of the Agua Dodienda Valley. Numerous broken shells are scattered over the surface of the hill. The road from Stewarts railroad station to Escondido passes near the station. (Note 1, p. 615.)

Mull (San Diego County, Cal., A. F. Rodgers, 1887).—On the coast about ½ mile south of Carlsbad; on the bluff overlooking the beach in front of the residence of James Mull. A fence runs along 6 paces inshore from the station, and a road passes between it and the fence. The ground falls gently from the station both up and down the coast. (Note 1, p. 615.)

Kelly (San Diego County, Cal., A. F. Rodgers, 1887).—On the ridge back of Carlsbad, about 2 miles from the coast; on top of a knoll slightly higher than the rest of the ridge. (Note 1, p. 615.)

Fire (San Diego County, Cal., A. F. Rodgers, 1887).—On the top of the ridge back of South Oceanside, about 2 miles from the coast. The hill on which it is situated is quite prominent and the south end, about 300 meters south of the station, is eroded, forming a bluff of red sandstone. (Note 1, p. 615.)

Trestle (San Diego County, Cal., A. F. Rodgers, 1887).—On the coast, about 1 mile south of Oceanside; on the bluff overlooking the beach on the point forming the north bank of the first creek south of Oceanside. The California Southern Railroad crosses this creek on a trestle bridge which is in sight a short distance from the station. (Note 1, p. 615.)

San Luis (San Diego County, Cal., A. F. Rodgers, 1887).—On the northwest end of a long ridge in the town of Oceanside. (Note 1, p. 615.)

Wire (San Diego. County, Cal., A. F. Rogers, 1887).—On the Santa Margarita ranch, on top of the ridge back of the point between the mouths of the Santa Margarita and San Luis Rey rivers, about 2 miles from the coast and 300 meters north of the wire fence on the ranch line which crosses this ridge. (Note 1, p. 615.)

Oceanside (San Diego County, County, Cal., A. F. Rodgers, 1887).—On the coast in the town of Oceanside, on the bluff overlooking the beach at the point where it begins to fall toward San Luis Rey River. (Note 1, p. 615.)

Spade (San Diego County, Cal., A. F. Rodgers, 1887).—On the coast about 2½ miles below the mouth of Las Flores Creek on the Santa Margarita ranch. There is a level mesa inshore from the station for a mile or more toward the foot of the hills. (Note 1, p. 615.)

Rabbit (San Diego County, Cal., A. F. Rodgers, 1887).—On Santa Margarita ranch, on the slope of the ridge back of the mesa just on top of the first steep slope and about 3 miles from Las Flores. The old coast stage road passes over the ridge a short distance north of the station. (Note 1, p. 615.)

Quartz (San Diego County, Cal., A. F. Rodgers, 1886).—On the Las Flores ranch, about 1 mile down the coast from Las Flores Creek, on top of a long flat ridge, the crest and offshore slope of which is nearly all visible from the mesa below. Two large pieces of white quartz crop out of the ground, and a small, rough hole, drilled in the upper surface of the inshore and larger one, marks the station. This stone is 2 feet 10 inches by 1 foot 10 inches and projects 8 inches above the surface of the ground. The smaller stone is 2 feet 10 inches by 1 foot 10 inches, the west end being as high as the larger stone and the east end even with the ground. The two stones are quite close together, being separated by 6 inches of earth at the surface of the ground. A small piece of red quartz, 8 by 8 inches and projecting 2 inches above the ground, is distant 4 feet 8 inches from the station.

Mound (San Diego County, Cal., A. F. Rodgers, 1886–87).—On the Las Flores ranch, about a quarter of a mile down the coast from the mouth of Las Flores Creek, on the edge of the bluff overlooking the beach, on top of a small mound, which is near a barranca (down the coast from the station), distinguished from others by having an earthen pyramid left standing in its mouth. (Note 1, p. 615.)

Flores Hill (San Diego County, Cal., A. F. Rodgers, 1886).—On the Santa Margarita ranch, about 1 mile up the coast from Las Flores Creek, near the brow of a wide, round-pointed ridge, which falls off abruptly to the mesa. There is a higher knob between this ridge and the Las Flores Valley, but it is farther back from the coast and does not see Horno Hill. (Note 1, p. 615.)

Barranca Bluff (San Diego County, Cal., A. F. Rodgers, 1886).—On the Las Flores ranch, about 1¼ miles up the coast from the mouth of Las Flores Creek, on the bluff overlooking the beach. There are several barrancas near it, on both sides, extending a short distance into the mesa. (Note 1, p. 615.)

Horno Bluff (San Diego County, Cal., A. F. Rodgers, 1886).—On the Santa Margarita ranch, on the bluff overlooking the beach, about half a mile up the coast from the mouth of Horno Canyon. (Note 1, p. 615.)

Horno Hill (San Diego County, Cal., A. F. Rodgers, 1886).—On the Santa Margarita ranch, about 4 miles up the coast from Las Flores Creek, on the slope of the ridge which runs back from the coast opposite the corner of the wire fence running up the coast from Las Flores ranch house, and which forms the lower side of a canyon, within 300 meters of the top of the ridge, which is the crest of the San Onofre Mountains nearest the eastern side slope. A prominent peak is near the station and a large quartz rock on the side of the ridge can be seen from the road below. (Note 1, p. 615.)

Cuate Hill (San Diego County, Cal., A. F. Rodgers, 1886).—On the Santa Margarita ranch, about 3½ miles down the coast from the mouth of San Onofre Creek, on the highest point of a long ridge leading back from the coast, which commands an almost unobstructed view of the coast. The ridge forms the east or lower side of the lower fork of the Cuate Canyon. The station is not on the summit, but is high enough to see the still higher hills inshore. (Note 1, p. 615.)

Cuate Bluff (San Diego County, Cal., A. F. Rodgers, 1886). On the Santa Margarita ranch, about 3½ miles down the coast from the mouth of San Onofre Creek, on a small point of the bluff overlooking the beach, immediately below the month of the Cañola de los Cuates. (Note 1, p. 615.)

Onofre Hill (San Diego County, Cal., A. F. Rodgers, 1886).—On the Santa Margarita ranch, on the highest point of the first ridge down the coast from San Onofre Creek, commanding a view of the coast from the point above the entrance to San Juan Creek to a point near San Diego. This ridge is the beginning of the San Onofre Mountains. (Note 1, p. 615.)

Onofre Bluff (San Diego County, Cal., A. F. Rodgers, 1886).—On the Santa Margarita ranch, about 1½ miles down the coast from the mouth of San Onofre Creek, on the edge of the bluff overlooking the beach. The top of the bluff up the coast is much eroded and bare near the station. (Note 1, p. 615.)

Cuchillo (San Diego County, Cal., A. F. Rodgers, 1886). On the Santa Margarita ranch, about 11 miles down the coast from Capistrano, on the highest point of the ridge known as the "Cuchillo Medio" or "Middle Knife," between the San Mateo and San Onofre creeks, overlooking the coast and inshore from Medio. There are several small knobs along this ridge. (Note 1, p. 615.)

Medio (San Diego County, Cal., A. F. Rodgers, 1886).—On the Santa Margarita ranch, about 11 miles down the coast from Capistrano, on the point of the bluff forming the east side of the mouth of San Mateo Creek, quite near the edge of the bluff, which is perpendicular offshore from the station. (Note 1, p. 615.)

Mesa Point (San Diego County, Cal., A. F. Rodgers, 1886).—On the Santa Margarita ranch, about 12 miles down the coast from Capistrano, on the point of the bluff where it rises from the mesa of the San Onofre Creek to the level of the coast mesa, at the lower end of the wide beach formed below the mouth of San Onofre Creek. (Note 1, p. 615, except a layer of cobblestones was placed in the hole immediately over the earth layer which holds the bottle in place.)

Ridge (San Diego County, Cal., A. F. Rodgers, 1886).—On the Santa Margarita ranch, on the crest of the San Onofre Mountains, overlooking the east San Onofre Valley, on the ridge back of Cuate Hill. A small, rough hole was made with a pick in the round point of the top of a stone which projects 8 inches above the surface of the ground, and the center of this hole marks the station. The top of the hill at the station is covered with laurel bushes, and the ocean slope is covered with grass.

Road Knoll (San Diego County, Cal., A. F. Rodgers, 1886–87).—On the Santa Margarita ranch, about 3 miles from the Las Flores ranch house, on the road to the

Santa Margarita ranch house, about 1 mile from the point where it leaves the coast road to San Diego, on a knoll 15 feet above and 100 yards from the road. The surface of the knoll is covered with sage brush and with loose, irregularly shaped stones of the ordinary size of cobblestones, but not waterworn. Looking directly seaward, the white sediment patch near the beach at Shingle Bluff in the Cañada de las Salinas is a prominent feature. (Note 1, p. 615.)

Shingle Bluff (San Diego County, Cal., A. F. Rodgers, 1886–87)—On the Santa Margarita ranch, about 3 miles below the mouth of Las Flores Creek, on the bluff overlooking the beach immediately below the mouth of the Cañada de las Salinas. In the Cañada de las Salinas there is a large bed of white sediment a short distance inshore from its mouth. The beach in this vicinity is backed by a broad ridge of round stones, and is called the Shingle Beach. (Note 1, p. 615.)

Vailetta Point (San Diego County, Cal., A. F. Rodgers, 1887).—On the bluff overlooking the beach known as Vailetta Point, about one-quarter of a mile north of entrance of San Marcos Valley, on land owned by Dr. A. H. Vail. (Note 1, p. 615.)

San Marcos (San Diego County, Cal., A. F. Rodgers, 1887).—On the top of a prominent hill on the north bank of San Marcos Creek, about 1½ miles back of the entrance, commanding an extensive view of the San Marcos Valley and all the surrounding country. There is only 6 inches of soil on the underlying sandstone, and consequently no surface mark could be used. A black glass beer bottle buried neck up, with its top 4 inches beneath the surface of the ground, was used as the station mark.

Stewarts Point (San Diego County, Cal., A. F. Rodgers, 1887).—On the coast opposite Stewarts station, on the California Southern Railroad, on the bluff overlooking the beach on the first prominent point up the coast from San Marcos Creek. The coast road to Oceanside passes close to the station. (Note 1, p. 615.)

Santa Margarita River (San Diego County, Cal., A. F. Rodgers, 1887).—On the Santa Margarita ranch, on the bluff overlooking the beach at the point forming the north side of the entrance of the Santa Margarita River, 5 paces back from the bluff on both sides. (Note 1, p. 615.)

SAN MATEO POINT TO NEWPORT BAY.

Westminster (Orange County, Cal., A. W. Chase, 1873).—In Westminster, on the great plain stretching back from the Anaheim Landing, about 5 miles northeast of the landing and 4 miles from the sea, on the farm and 80 feet northwest of the northwest corner of the house owned and occupied (1873) by a Mr. Strong, about 20 feet east of north and south line dividing sections 2 and 3, township 5 south, range 11 west, and in section 2. The ground is perfectly flat and level, and there are no prominent marks to identify the point. The ground west of Strong's line, east of the station, is laid out as a road, and if so used the station will be in the road. The station is in line east and west with Strong's fence and artesian well. The station was marked by two glass bottles, the lower buried 4 feet below the surface, the upper touching the lower. On the surface was a stone block 6 by 6 inches, 8 inches long, projecting 1 inch above surface, marked U. S. C. S., with a cross to mark the center of the station. Four redwood stubs, each distant 3 feet from the center and with a copper tack in the top, were placed to the north, south, east, and west (magnetic).

Santa Ana (Orange County, Cal., A. W. Chase, 1873–4–5).—About 1½ miles east of Santa Ana River, 1 mile west of the town of Santa Ana and 12 miles from Anaheim Landing, and 67 paces from the road between them. Near the station and near the apex of the sharp angle of this road with a road leading from the house of Sepulveda, one of the old rancheros of the county, 40 paces east of a willow fence, there is a small but very remarkable elevation in the road. A glass bottle was buried 3 feet for the underground mark, and on the surface was placed a square stone block, marked U. S. C. S., with a hole drilled in the center. Four redwood stubs, each with a copper tack in the top, were also placed, each 3 feet from the station, to the north, south, east, and west.

La Mesa (Orange County, Cal., A. W. Chase, 1873–4–5).—On the table-land beyond the Santa Ana River forming the Rancho La Mesa, about three-quarters of a mile from the sea and about 2 miles west from the house on the Rancho La Mesa, about 185 yards eastward from the end of a branch canyon or barranca which is found about 750 paces from the fork in the Santa Ana River. The station was marked by a glass bottle buried 3 feet underground, and on the surface by a square stone block with a drilled hole and the letters U. S. C. S. on the top. Four stubs, each with a copper tack in the top, were placed 3 feet from the station, to the north, south, east, and west.

French Hill (Orange County, Cal., A. W. Chase, 1875).—On the San Joaquin ranch, on the highest hill about 2 miles E. 20° S. (magnetic) from the ranch house and S. 10° E. (magnetic) from Mount San Antonio, about three-quarters of a mile southwest of a very distinct loma covered with ragged rocks, much lower than the hill on which the station is located, at the foot (southern) of which winds a ditch running northeast and southwest, through which water runs and finally loses itself in the sand. The station was marked by a half-inch hole drilled 2 inches deep at the center of a cross in flat stone lying on surface of ground. Three stubs, each with a copper nail in the top, were placed 6 feet from the center, one in line to the town of Santa Ana, one in prolongation of this line, and the third at right angles, to the northeast.

San Joaquin (Orange County, Cal., A. W. Chase, 1874; A. F. Rodgers, 1884).—On one of the peaks of the range of hills back of the San Joaquin ranch house, and east of Newport Bay. To reach the station, go south from the San Joaquin ranch house by the faint trail used to send supplies to the sheep camps. Before starting, notice the highest peak of the hills; it is crowned with a heap of stones that show black from the house. When halfway through the canyon, take a long ridge to the right and follow it up. You can drive up this ridge for a long distance, but not directly to the station. When you get to a sudden breakdown in the hills, walk up to the highest point that you see; you will find it crowned with large rocks. Then go over this knoll, and directly west, about 500 meters distant and on the next commanding point, you will find the station. From this point you see through a gap the bluff on the seacoast to the west and the kelp bed lying offshore. You also see Newport bar, and to the south, the point and reef of rocks above San Juan Capistrano River. The station is about the middle of the knoll, and was marked by a cross on a stone 6 inches square. Three bottles were buried, each 2 feet from center point and bearing north, south, and east (magnetic), 1 foot beneath surface of the ground. Three redwood stubs, 3 by 4 by 18 inches, each with a fencing staple in the top, were driven around the center with their tops even with the surface of the ground, to support the theodolite stand, 2.9 feet from the station.

Newport (Orange County, Cal., A. W. Chase, 1875).—Near the head of Newport Bay, where it expands into a wide and shallow basin, on the south side, about opposite the old fence of the San Joaquin ranch, near which are the sulphur springs, on the second bench or rise. (Note 11, p. 616.)

Spur (Orange County, Cal., A. W. Chase, 1875).—On the southern part of the top of the spur of the foothills, the only prominent hill in the neighborhood upon which any brush grows; W. French's house bears N. 15° E. The station was marked by a buried bottle and a 2-foot redwood stub at the surface with a copper tack in the top.

Brush (Orange County, Cal., A. W. Chase, 1875; A. F. Rodgers, 1884).—Northeast of the mouth of a slough and north of the point of rocks next east of the slough, on the first brush-covered hill east from La Mesa △, conspicuous for the density of the brush. The station was marked by a 2-foot redwood stub, with a copper tack in the top, projecting 4 inches above ground, under which was a glass bottle. Three reference stubs, 1.05 feet in length, projecting 1 inch above the ground and with a copper tack in the top, were set 6 feet from the center, two in line with the east end of Santa Catalina Island and the third at right angles, to the westward. Three redwood stubs, 3 by 4 by 18 inches, buried even with the surface of the ground, with a fencing staple in the top of each, were placed distant from the center as follows: The one toward the ocean, 3.2 feet; the others, 3.2 and 3.1 feet.

Pond (Orange County, Cal., A. W. Chase, 1875; A. F. Rodgers, 1884).—On the same ridge as Brush △, and about three-fourths mile east of it. There is a small fresh-water pond 100 meters northeast of the station, over the middle of which San Joaquin △ shows. The station was marked by a 2-foot redwood stub, with a copper tack in the top, even with the surface of the ground, under which a bottle was buried. Three reference stubs, each with a copper tack in the top, were placed 6 feet from the center. Three other stubs, with a fencing staple in the top, were placed 3.3, 3.4, and 2.8 feet from the station.

Abalone Knoll (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin ranch, in the vicinity of Laguna Canyon, on a very prominent isolated mound, the only mound of this description near the coast between Laguna Canyon and Newport Bay. The soil is very rocky. (Note 10, p. 616.)

Reef Hill (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin ranch, on the top of the ridge inland from Reef Point, where the ground is hard and there are numerous rocks. The station is surrounded by patches of mustard (note 10, p. 616); the distances to the stubs are 2.3, 3, and 3.6 feet. Four small stubs were also driven in the ground, each 20 inches from the station.

Aliso Peak (Orange County, Cal., A. F. Rodgers, 1884).—On the top of a very prominent sharp peak immediately east of Aliso Canyon, overlooking the canyon and the ranch of Mr. G. W. Thurston, whose house is nearly north of the station. (Note 10, p. 616.)

South Niguel (Orange County, Cal., A. F. Rodgers, 1884).—In the vicinity of Aliso Canyon, on land belonging to Forster and Egan, of Capistrano, on the point of the main Niguel ridge, which near the station is quite narrow, and south of it falls away rapidly to the coast. (Note 10, p. 616.)

Dana (Orange County, Cal., A. F. Rodgers, 1884).—In the vicinity of Capistrano, on land owned by Henry Charles, on the summit of a prominent conical-shaped hill which forms the west headland of the bight of San Juan Capistrano. (Note 10, p. 616.) Some "clinkers" from a blacksmith shop were placed around the bottle and scattered over the surface of the ground around the station.

Egan (Orange County, Cal., A. F. Rodgers, 1884).—About 1 mile west of Capistrano, on land owned by J. E. Bacon, on the top of a prominent flat-topped hill, one of the range forming the west boundary of the San Juan Capistrano Valley. (Note 10, p. 616.) The bottle was surrounded with clinkers from a blacksmith shop, and some were scattered on the surface of the ground around the station.

Widows Hill (Orange County, Cal., A. F. Rodgers, 1884).—On a very prominent hill on the Boca de la Playa Rancho, about one-third of a mile east of Mrs. Pryor's house; the ground on all sides falls away rapidly from the station. (Note 10, p. 616)

Ring Cliff (Orange County, Cal., A. F. Rodgers, 1884).—On the Boca de la Playa Rancho, 1 mile east of the mouth of the San Juan Capistrano River and quite close to the road from Capistrano to San Diego, on the coast bluff. (Note 10, p. 616.)

Forster (Orange County, Cal., A. F. Rodgers, 1884).—On the Boca de la Playa Rancho, about 2 miles from the San Juan Capistrano River, on the top of the highest hill northeast of its mouth. (Note 10, p. 616.)

Martin (Orange County, Cal., A. F. Rodgers, 1884).—On the Boca de la Playa Rancho, on the edge of the bluff overlooking the coast, at a point 300 yards north of the first bridge on the coast road south of the mouth of the San Juan Capistrano River, 60 yards from the road and 120 feet above it. The station can be approached from the north by a wagon (over the mesa), but from the bridge mentioned only on horseback or on foot. (Note 10, p. 616.)

Flat Top (Orange County, Cal., A. F. Rodgers, 1884).—On the Boca de la Playa Rancho, on the highest summit overlooking the coast of the ridge which is reached after crossing the first bridge on the coast road south of the mouth of the San Juan Capistrano River; the greater part of this ridge is densely covered with mustard, which is a characteristic of this particular summit. (Note 10, p. 616.)

No Brace (Orange County, Cal., A. F. Rodgers, 1884).—On land owned by M. A. Forster of Capistrano, about three-quarters of a mile south of the first bridge on the coast road at the first prominent ravine south of the mouth of the San Juan Capistrano River; on the south headland which rises about 120 feet above the beach and is about 15 feet wide on top at its end. (Note 10, p. 616).

Green Ridge (Orange County, Cal., A. F. Rodgers, 1884).—On land owned by M. A. Forster, of Capistrano, about a quarter mile from the coast road and about a mile and a half below the point where, about 4 miles below the mouth of the San Juan Capistrano River, the coast road leaves the beach and goes upon the mesa; on the summit of a sharply-defined ridge which is covered with verdure except during the drought of summer. (Note 10, p. 616.)

San Mateo Point (Orange County, Cal., A. F. Rodgers, 1884).—On land owned by M. A. Forster, of Capistrano, on the bluff above the beach about 200 yards north of the mouth of San Mateo River, 100 yards west of the wire fence which is on the boundary line between Orange and San Diego counties, and 400 yards from the intersection of this wire fence and the coast road. (Note 10, p. 616.)

Mendelson (Orange County, Cal., A. F. Rodgers, 1884).—On land owned by M. A. Forster, about 1½ miles southeast of Capistrano, near the north boundary of the Boca de la Playa Rancho, on the western brow of a prominent conical hill. (Note 10, p. 616.)

Sheehan (Orange County, Cal., A. F. Rodgers, 1884).—About 1 mile north of Capistrano, on the main ridge between the San Juan and Trabuco valleys, on land owned by Henry Charles. The ground falls gradually away from the station to a mesa on which the Catholic Cemetery is situated. (Note 10, p. 616.)

Argens (Orange County, Cal., A. F. Rodgers, 1884).—About 1 mile northwest of the headland of the bight of San Juan Capistrano, on land owned by J. E. Bacon; near the northwestern edge of the top of a smooth flat-top hill. (Note 10, p. 616.)

Black Flag (Orange County, Cal., A. F. Rodgers, 1884).—About a quarter of a mile west of Canada Salada, on a prominent bench at the southeast extremity of the Niguel ridge; on land owned by Forster and Egan, of Capistrano. (Note 10, p. 616.)

Mussel Cove (Orange County, Cal., A. F. Rodgers, 1884).—About 2 miles east of the mouth of Aliso Canyon, on land owned by the United States; on top of a small island (at high water). (Note 34, p. 618, the theodolite stubs being 2.7 feet, 2.4 feet, and 2.7 feet, respectively, from the center.)

Abalone Hill (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin Rancho, on the ridge inshore from Abalone Knoll. The station is surrounded by rocky ground for a distance of 50 feet and a large patch of chaparral is 15 feet back of it. (Note 10, p. 616.) The bottle was surrounded by small stones.

Two Rock Hill (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin Rancho, on the ridge inland from Two Rock Point, which is the second ridge north of Laguna Canyon. The soil is hard and rocky. (Note 10, p. 616.)

East Bluff (Orange County, Cal., A. F. Rodgers, 1884).—On the Boca de la Playa Rancho, on a nearly level mesa about a quarter of a mile east of the mouth of the San Juan River and about 100 yards north of the bluff overhanging the coast (Note 10, p. 616.)

West Knoll (Orange County, Cal., A. F. Rodgers, 1884).—On the Boca de la Playa Rancho, on a mesa about 250 yards west of the San Juan River and about a third of a mile north of its mouth. (Note 10, p. 616.)

East Knoll (Orange County, Cal., A. F. Rodgers, 1884).—On the Boca de la Playa Rancho, half a mile east of the San Juan River, on a projection of the mesa and between two ravines. (Note 10, p. 616.)

Capistrano North Base (Orange County, Cal., A. F. Rodgers, 1884).—On the Boca de la Playa Rancho, in Mrs. Pryor's walnut orchard, and about 250 yards from her house. (Note 10, p. 616, a copper rivet with a cross on its top being driven into the center stub.)

Capistrano South Base (Orange County, Cal., A. F. Rodgers, 1884).—On the Boca de la Playa Rancho, near a small gully and not far from the boathouse on the beach. (Note 10, p. 616, a copper rivet with a cross on its top being driven into the center stub.)

Capistrano Middle Base (Orange County, Cal., A. F. Rodgers, 1884).—On the Boca de la Playa Rancho, halfway between Capistrano South Base and Capistrano North Base. (Note 10, p. 616, a copper rivet with a cross on its top being driven into the center stub.)

Aliso Point (Orange County, Cal., A. F. Rodgers, 1884).—On land belonging to L. F. Goff, on the first rocky point east of the mouth of Aliso Canyon, distant about 300 yards, and near the southeast extremity of a piece of cultivated land. (Note 34, p. 618.)

Goff Ridge (Orange County, Cal., A. F. Rodgers, 1884).—On land belonging to F. M. Goff, northwest of his house, on the third point of the ridge north of Aliso Canyon, considerably below the summit of the ridge, on the top of a small mound of earth and stones; the soil is extremely rocky. (Note 10, p. 616.)

Goff Island (Orange County, Cal., A. F. Rodgers, 1884).—On land belonging to F. S. Goff, on the top of an island (at high water) offshore from his house. (Note 10, p. 616.)

West Bluff (Orange County, Cal., A. F. Rodgers, 1884).—On land owned by M. A. Forster, on a bluff overhanging the west side of the San Juan River at its mouth. (Note 10, p. 616.)

South Sierra (Orange County, Cal., A. F. Rodgers, 1884).—On land belonging to Forster and Egan, of Capistrano, on the southern extension of the Niguel ridge, about 300 yards north of South Niguel, but not visible from it. (Note 10, p. 616.)

North Sierra (Orange County, Cal., A. F. Rodgers, 1884).—On land belonging to Forster and Egan, of Capistrano, on the western edge of the top of a flat extension of the Niguel ridge. (Note 10, p. 616.)

Rags (Orange County, Cal., A. F. Rodgers, 1884).—On public land, on the first prominent rocky point west of the main headland and about 2 miles from the bight of San Juan Capistrano. (Note 10, p. 616.)

Abalone Point (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin Rancho, on a prominent point near Abalone Knoll; a number of ledges off the point uncover at low water; the ground is very soft and is covered with small pieces of shells. (Note 34, p. 618.)

Extra (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin Rancho. On the end of a bold, precipitous point south of Abalone Knoll, which is the fourth prominent point north of Laguna Canyon. The soil is soft to the depth of 2 feet; then the sandstone is reached. (Note 10, p. 616.)

Two Rock Point (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin Rancho, on the third prominent point north of Laguna Canyon, there are two large white-topped rocks offshore near the station; the soil is hard sand. (Note 34, p. 618.)

Recreation Point (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin Rancho, on the second prominent point north of Laguna Canyon, near ground used as a camping ground by many of the people who come to the Laguna Beach during the summer; a large reef is off the point. (Note 10, p. 616.)

Recreation Hill (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin Rancho, on the top of the first ridge north of Laguna Canyon and inshore from Recreation Point. (Note 34, p. 618.)

Laguna Hill (Orange County, Cal., A. F. Rodgers, 1884).—Near the top of the high ridge immediately inshore from the mouth of Laguna Canyon, near the edge of some cultivated ground, on land owned by G. W. Rodgers, who lived at the foot of the ridge to the west. The Laguna Canyon is immediately north of the ridge, and to the northwest of the station there is a prominent knoll distant 1 200 feet. (Note 10, p. 616.)

Corn Patch (Orange County, Cal., A. F. Rodgers, 1884).—Near Laguna Canyon, on land belonging to G. W. Rodgers, on a small point quite near the beach. (Note 34, p. 618.)

Winston (Orange County, Cal., A. F. Rodgers, 1884).—On land belonging to H. S. Goff, a short distance down the coast from a blacksmith's shop; west of the summit of the ridge. (Note 10, p. 616.)

Cactus Point (Orange County, Cal., A. F. Rodgers, 1884).—On land belonging to L. N. Brooks, on a prominent point covered with a growth of cactus and connected by a natural bridge of sandstone with a large rock of same material which is surrounded by water at high tide. Quite a large reef is off the point; the ground is soft and is covered with broken shells. (Note 10, p. 616.)

Mustard (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin Rancho, on the ridge opposite Rocky Bight and southeast of Newport Bay. The ground around the station is bare and rocky, but there is a mustard patch south and southeast of the station. (Note 10, p. 616, except the bottle was glass.) The theodolite stubs are 2.3, 3.4, and 3.35 feet from the center.

Pelican Hill (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin Rancho, on the second prominent ridge south of Arch Rock △, in line between Pelican Point △ and San Joaquin △. The hill is covered with brush and is difficult of ascent; the station is southwest of its summit. (Note 10, p. 616, except the bottle was glass.) The theodolite stubs were 3.5, 2.9, and 2.8 feet from the center.

Reef Point (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin Rancho, on a prominent point north of Abalone Knoll and south of a large reef with a group of four prominent rocks. The soil is soft, and numerous broken shells are scattered about. (Note 34, p. 618.)

Rocky Bight (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin Rancho, in a bight, upon a point covered with numerous white stones but otherwise bare, between two ledges of rocks to the north and south. (Note 10, p. 616.) The theodolite stub toward the ocean is 2.8 feet from the center, while the other two are 3.0 and 3.1 feet distant, respectively.

Pelican Point (Orange County, Cal., A. Rodgers, 1884).—On the San Joaquin Rancho, on the middle one of three prominent points near together. A ledge of rocks extends out to sea about a half mile opposite the station. The second point north of the station has three large rocks projecting from it into the ocean. (Note 10, p. 616.) The theodolite stub toward the ocean was 1.8 feet from the center, and the other two each 3.1 feet distant therefrom.

Arch Rock (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin Rancho, on the third prominent point south of Newport Bay. About 300 feet beyond the end of the point is a large rock, 80 feet in length, in the center of which is an arch. (Note 10, p. 616.) The theodolite stub toward the ocean is 2.9 feet from the center; the others are 3.5 and 3.3 feet distant.

Pond Point (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin Rancho, on the shore a little north of the second point south of Newport Bay; there are three rocks offshore from the station which can be seen at high water. (Note 10, p. 616.) The theodolite stubs are 3.3, 3.4, and 2.8 feet from the center.

Table Ridge (Orange County, Cal., A. F. Rodgers, 1884).—On the San Joaquin Rancho, on the ridge inshore from Arch Rock △; the main ridge above this station leads to the point. (Note 10, p. 616.) The theodolite stub toward the ocean is 2.7 feet from the center, and the others are 3.0 and 3.4 feet.

Clam Point (Orange County, Cal., A. W. Chase, 1874).—On the top of the bluff overlooking the Santa Ana bottom, about a mile and a half south of G. Allen's house. (Note 11, p. 616.)

Black Knob (Orange County, Cal., A. W. Chase, 1874).—On the most easterly of the prominent beach sand-knolls south of the west point of the highland of La Mesa ranch; it was covered with low black bushes. (Note 11, p. 616.)

Turning Point (Orange County Cal., A. W. Chase, 1875).—About a half mile southwest of the landing place in Newport Bay, on the edge of the mesa, the most commanding point above the great turn of the bay from west to northeast, about 4 meters directly southwest of the edge of a deep gulch or rain wash in the bank. (Note 11, p. 616.)

Prickly Point (Orange County, Cal., A. W. Chase, 1875).—About a quarter mile east and down the line of the bluff toward the mouth of the Santa Ana, from Middle Bend △, about 3 meters from the bluff edge and southeast of a large barranca of semicircular shape. (Note 11, p. 616.)

Bitter Point (Orange County, Cal., A. W. Chase, 1875).—On a point of land at the turning point of the slough called Bitter Lake, commanding a view of Bitter Lake, its juncture with the Santa Ana River to the northwest, and the continuation of the same toward the east and south. (Note 11, p. 616.)

Promontory (Orange County, Cal., A. W. Chase, 1875).—About three-quarters of a mile from the landing place at Newport and directly opposite it, on a prominent point surrounded by marsh on three sides; on the southwest side of the point, about 15 meters from it and about 100 meters from the northwest end. (Note 11, p. 616.)

Sand Point (Orange County, Cal., A. W. Chase, 1875).—On the sand dunes about 50 meters from the turning point from southeast to east, 20 meters from high-water mark on the south, and 75 meters from Bitter Lake on the north. (Note 11, p. 616, except the bottle was 5 feet deep.)

Chalk Rock (Orange County, Cal., A. W. Chase, 1875).—About a mile and a half from Newport Landing on a chalk-rock bluff at the point where Newport Bay changes its course from north to southwest. (Note 11, p 616.)

Dune (Orange County, Cal., A. W. Chase, 1875).—About 2 miles from Newport Landing, on the beach about 53 paces from high-water mark and about 100 meters from the edge of the lagoon inside. It is on the highest sand dune opposite the fishermen's huts on the lagoon. (Note 11, p. 616.)

First Bend (Orange County, Cal., A. W. Chase, 1875).—About three-quarters of a mile southwest from Chalk Rock △, on the first prominent bluff north of and about a quarter mile from Newport Landing, overlooking the point where the bay makes its first turn to the northward. (Note 11, p. 616.)

Camp (Orange County, Cal., A. W. Chase, 1875).—On the east side of Newport Bay directly opposite the end of the fence which forms the dividing line between the San Joaquin and La Mesa ranchos on the last prominent bluff in Newport Bay; about a quarter mile west of a sand hill covered with a growth of cactus, about 80 meters from a barranca putting into the bay, and about 5 meters from the edge of the bluff. (Note 18, p. 617.)

Sand Cone (Orange County, Cal., A. W. Chase, 1874).—About halfway between the highlands of La Mesa and Las Bolsas ranches, on one of the prominent sand hills of the beach, the first one from La Mesa not covered with dark brush, and about halfway between the high bluffs east and west. (Note 11, p. 616, except that there were iron nails in the stubs instead of copper tacks.)

Scallop Point (Orange County, Cal., A. W. Chase, 1874).—On the edge of the bluff, around a bend of the bluff and northeast from Bitter Lake △. There were scallop ("Pecten") shells on the surface of the ground. (Note 18, p. 617.)

Cactus Knoll (Orange County, Cal., A. W. Chase, 1874).—On the edge of the bluff overlooking the swamps of the Santa Ana River, about a half mile north of Schafer's house, on a mound which had been used as an old sheep corral; the ground was bare of grass, and several cactus plants were near the station. (Note 11, p. 616.)

Anaheim (Orange County, Cal., A. W. Chase, 1874).—The southeast corner of the tin roof of the Planters's Hotel, on the northwest corner of Los Angeles and Centre streets, Anaheim, California.

Las Bolsas Chica (Orange County, Cal., A. W. Chase, 1873).—On the highest part of the mound known as Bolsas Chica Cerrito. The station was marked by a glass bottle buried 3 feet and, on the surface, by a square stone block, 5 by 5 inches, projecting 2 inches above ground, with the letters U. S. C. S. marked on top and a cross for the center of the station. Three redwood stubs, each with a copper tack in the top, were placed 3 feet from the center to the north, south, and east.

Landing Hill (Orange County, Cal., A. W. Chase, 1873).—On the highest point of the mesa or table-like hill north of Anaheim Landing, between the road to Anaheim and the one to the Alamitos; below it on the west is a gully through which the road passes. The station was marked by a glass bottle buried 3 feet, and on the surface by a square stone block projecting 2 inches above ground and having a cross for center and the letters U. S. C. S. cut thereon. Four redwood stubs, each with a copper nail in its top, were placed 4 feet from the center to the north, south, east, and west.

Bolsas Bluff (Orange County, Cal., A. W. Chase, 1873).—On the same high land as Las Bolsas △ (see p. 636); on the southeast corner of the mesa, 8 feet from the bluff. (Note 18, p. 617.)

Sand Knoll (Orange County, Cal., A. W. Chase, 1873).—On the last large sand knoll east of Bolsas Creek. There are no prominent marks to identify the station. (Note 18, p. 617, with a similar stub also to the west.)

Ice Plant (Orange County, Cal., A. W. Chase, 1874).—On the top of the bluff, directly overlooking the sand beach south of Las Bolsas △ (p. 636); on a small rise above the general level east of a depression in the bluff line; 6 feet from bluff edge. (Note 18, p. 617.)

Bitter Lake (Orange County, Cal., A. W. Chase, 1874).—On the bluff edge overlooking the willow swamps of the Santa Ana River, at a point where the bluff narrows down, and about a quarter of a mile west of the knoll where it runs into the sand knolls at the head of Bitter Lake. (Note 18, p. 617.)

NEWPORT BAY TO POINT DUME.

Centinela (Los Angeles County, Cal., A. W. Chase, 1875).—On the highest point of the long ridge in front and north of the Centinela ranch house.

Sand Hill 3 (Los Angeles County, Cal., A. W. Chase, 1875).—On the sand hill east of a lagoon. (Note 18, p. 617.) The dune is shifting, and it is not probable that the marks of the station are permanent.

Ridge (Los Angeles County, Cal., A. W. Chase, 1875).—On a long grass-covered ridge north of the coast road and east of the gulch beyond the railroad; on the end of the ridge overlooking the marsh. (Note 18, p. 617.)

High Table (Los Angeles County, Cal., A. W. Chase, 1875).—On the highest part of a hill to the left of the old Los Angeles road, to the east of a race track. (Note 18, p. 617.)

Reef (Los Angeles County, Cal., W. E. Greenwell, 1862).—About 200 meters from the beach, on a hill a little to the east of the third conspicuous point from a black bluff point down the coast from Point Dume, about three-fourths of a mile west of a lagoon, near which there is a ranch. The station mark was a drill hole in a fixed rock. The reference marks were two drill holes in fixed rocks, one bearing about southwest, distant 10 feet 3 inches, and the other bearing southeast, distant 12 feet.

Linn (Los Angeles County, Cal., W. E. Greenwell, 1862).—On the edge of a high red sandstone bluff about a mile to the eastward of a lagoon. (Note 35, p. 618.)

Malaga (Los Angeles County, Cal., W. E. Greenwell, 1862).—About 400 meters from the shore, and about 900 meters east of the house on the Rancho del Malaga; on the top of a peak covered with rotten slate which outcrops toward the eastward; a deep gulch runs up to the west and a smaller one to the east; to the north is a deep basin covered with underbrush of every kind. The station was marked by a drill hole in a fixed rock.

Buck (Los Angeles County, Cal., W. E. Greenwell, 1862).—On a hill to the westward of a large gulch, deep and wooded, which seems to divide the mountains to the northward. (Note 35, p. 618.)

Corral (Los Angeles County, Cal., W. E. Greenwell, 1862).—On the highland, about a quarter mile from the beach, about 100 meters east of a large gulch, very steep and wooded, which appears to divide the mountains to the northward, about 50 meters east of a clump of live oak trees; immediately on the edge of the gulch. (Note 35, p. 618.)

Point (Los Angeles County, Cal., W. E. Greenwell, 1862).—Immediately on the point of the second bluff point from Point Dume, about 2 miles from it. (Note 35, p. 618.)

Deadmans Island (Los Angeles County, Cal., W. M. Johnson, 1859; A. W. Chase, 1870–72; F. Westdahl, 1899).—Marked by a small drill hole in a round stone buried 3 inches below the surface.

Drum (Los Angeles County, Cal., A. W. Chase, 1872).—About 15 feet south of the fence inclosing Drum Barracks, and 30 feet east of the road from Wilmington. (Note 24, p. 617.)

Point Fermin (Los Angeles County, Cal., W. E. Greenwell, 1855; A. W. Chase, 1870–72; F. Westdahl, 1899).—About 30 yards north of the site selected for the light-house. The station was marked by a monument of red granite, about 4 inches square, projecting about 2 inches above the ground, and by four redwood stakes driven in the ground about 2 feet from the center.

Cactus (Los Angeles County, Cal., A. W. Chase, 1870).—On the third marked bench, following the trail leading up to the summit, on the right hand of the trail and in front of a large patch of cactus or prickly pear. (Note 18, p. 617).

Solitary (Los Angeles County, Cal., A. W. Chase, 1870; F. Westdahl, 1899).—On the first hill rising from the flat plain, directly behind the ruined houses on the edge of the bluff (old San Pedro). The center was marked by a bottle buried 3 feet in the ground. In 1899 the three theodolite stubs were left.

R. R. Flagstaff (Los Angeles County, Cal., F. Westdahl, 1899).—About 835 meters N. 2° 27′ E. from Point Fermin Light-house, on a flat hill, around the base of which the road from San Pedro turns toward the sea. The center was marked by a small hole in a flat stone 1½ feet below the surface. Three stubs were placed 4 feet 3 inches from the center, bearing north, west-southwest, and east-southeast. The three theodolite stubs were also left in place.

Timm (Los Angeles County, Cal., F. Westdahl, 1899).—On the top of the bluff at Timms Point, about 25 feet from the extreme end. A bottle was placed 12 inches below the surface and a piece of scantling over it, the top of which is level with the ground.

Old (Los Angeles County, Cal., F. Westdahl, 1899).—On the next prominent point south from Timms Point, about 30 feet from either edge of the bluff. A bottle was buried 15 inches below the surface of the ground, and the theodolite stubs were left.

San Pedro Latitude Station (Los Angeles County, Cal., G. Davidson, 1852; W. E. Greenwell, 1855).—On the bluff just on the left of the south road up from the landing, about 20 yards from the north side of Alexander and Banning's office. The station was marked by two stakes, each 5 feet from the center, to the north and south.

Black Beacon (Los Angeles County, Cal., F. Westdahl, 1899).—The beacon marking the eastern edge of the shoal extending from the mainland to the channel inside the harbor.

Red Beacon (Los Angeles County, Cal., F. Westdahl, 1899).—The beacon marking the western end of the spur projecting southwestward from the east jetty.

Curve (Los Angeles County, Cal., F. Westdahl, 1899).—A small signal on the eastern jetty, 620 meters north from Deadmans Island, probably used by the U. S. Engineers.

Jetty (Los Angeles County, Cal., F. Westdahl, 1899).—A small signal on the eastern jetty, about 325 meters north from Deadmans Island, probably used by the U. S. Engineers.

Post (Los Angeles County, Cal., F. Westdahl, 1899).—An old telegraph pole on the edge of the bluff; probably lost.

Hotel (Los Angeles County, Cal., F. Westdahl, 1899).—The northwest corner of a deserted hotel building standing just above Post △, at the turn of the road leading from San Pedro to White Point.

Rattlesnake Island 2 (Los Angeles County, Cal., A. W. Chase, 1872).—Marked according to Note 24, p. 617. Bottle buried 2 feet in the ground; stubs 3 feet from the center.

San Gabriel River 2 (Los Angeles County, Cal., A. W. Chase, 1872).—On the western end of Rattlesnake Island, on the most prominent sand hill, midway between a slough on the right and high-water mark; about 250 feet from the river. (Note 24, p. 617, reference stubs 3 feet from center.)

Station I (Los Angeles County, Cal., A. W. Chase, 1872).—About 10 feet from the western edge of a low bluff near the sea, southeast and across the bottom from San Gabriel River. (Note 24, p. 617.)

Station II (Los Angeles County, Cal., A. W. Chase, 1872).—About 10 feet from the edge of the highest part of the same bluff as Station I, about midway between the flats of the San Gabriel and New rivers. (Note 24, p. 617.)

Station III (Los Angeles County, Cal., A. W. Chase, 1872).—About 10 feet from the edge, at the end of the same bluff as Station I and Station II. (Note 24, p. 617.)

Los Alamitos (Los Angeles County, Cal., A. W. Chase, 1872).—On the ranch called Los Alamitos, on one of the little points making out into the marsh land, about a half mile from Alamitos house. (Note 24, p. 617, stubs 4 feet from center.)

New River (Los Angeles County, Cal., A. W. Chase, 1872).—On the sand spit forming the west side of the mouth of New River, about 600 feet west of the mouth. (Note. 24, p. 617, stubs 4 feet from center.)

Landing (Orange County, Cal., A. W. Chase, 1872).—On the second prominent sand hill west of the tower used as a beacon by the Lighter Company, about 12 feet above high-water mark. (Note 24, p. 617; stubs 3 feet from center.)

Slough (Orange County, Cal., A. W. Chase, 1872–73).—At the head of one of the principal sloughs of Anaheim Creek, in an easterly direction from Anaheim Landing, near and northwest of a fisherman's cabin. (Note 24, p. 617; three stubs left when recovered in 1873.)

Sand Beach (Orange County, Cal., A. W. Chase, 1872–73).—On one of the inside, but most prominent, sand knolls, about 1¼ miles southeast from Anaheim Landing. (Note 24, p. 617; stubs 3 feet from center; the west one gone in 1873.)

Little Hill (Orange County, Cal., A. W. Chase. 1872).—On the highest point of a little isolated hill close to the main slough, three-fourths of a mile from the shore line and 2½ miles from the landing in an easterly direction. (Note 18, p. 617.)

Bolsas Creek (Orange County, Cal., A. W. Chase, 1872).—On the first prominent sand hill west of the mouth of Bolsas Creek, just above high-water mark. (Note 24, p. 617; stubs 3 feet from center and no stub to the west.)

Grass Edge (Orange County, Cal., A. W. Chase, 1872).—On the lowland between Bolsas Chica △ and Las Bolsas △, on the line where the firm land commences. (Note 18, p. 617; a stub also placed to the west.)

Mustard Point (Orange County, Cal., A. W. Chase, 1873).—On the extreme westerly point of the highland of Las Bolas ranch, about 2 000 meters north of the shore, and 200 meters east of a small fresh-water pond. The station was marked by a glass bottle, buried 2 feet underground; and 4 redwood stubs, each with a copper tack in the top, were placed 3 feet from the center to the north, south, east, and west.

Los Angeles Normal School (Los Angeles County, Cal., A. F. Rodgers, 1883).—The flagstaff on the tower above the main entrance of the Los Angeles Normal School.

Los Angeles Magnetic Observatory (Los Angeles County, Cal., A. F. Rodgers, 1883).—The center of the roof of the magnet room in the Normal School grounds, Los Angeles.

Los Angeles Presbyterian Church (Los Angeles County, Cal., A. F. Rodgers, 1883).—The figure of the Angel Gabriel on the spire.

Los Angeles Signal Service (Los Angeles County, Cal., A. F. Rodgers, 1883).—Baker block; tower.

Los Angeles Longitude Station 1889 (Los Angeles County, Cal., C. H. Sinclair, 1889).—A pier of brick laid in Portland cement 3 feet in the ground and 3 above, 47.04 meters north of and 56.77 meters west of the flag pole over the cupola at the entrance of the Normal School on Fifth street, Los Angeles.

Los Angeles Longitude Station 1892 (Los Angeles County, Cal., C. H. Sinclair, 1892).—In the grounds of the Normal School on Fifth street, Los Angeles; marked by a pier, 46.18 meters west and 1.55 meters south of the flag pole on the Normal School.

Los Angeles Latitude Station (Los Angeles County, Cal., C. H. Sinclair, 1892).—A pier of brick laid in cement, 50 inches due west of Los Angeles Longitude Station 1892, in the grounds of the Normal School.

Los Angeles Northwest Base Latitude Station (Los Angeles County, Cal., J. J. Gilbert, 1890).—A pier 45.1 feet from Los Angeles NW. Base △ (p. 635) in azimuth 264°49′32″.

Dominguez Hill Zenith Telescope Station (Los Angeles County, Cal., G. Davidson, 1870).—A pier of brick laid in cement, 2½ feet below the surface and 30 inches above, 15 feet 5.5 inches east and 8.8 inches south of Dominguez Hill △. (p. 638).

Dominguez Hill Meridian Instrument Station (Los Angeles County, Cal., G. Davidson, 1870).—A pier of brick, laid in cement, 2½ feet below the surface and 30 inches above, 20 feet 11.6 inches east and 9.8 inches south of Dominguez Hill △. (p. 638).

Cove (Los Angeles County, Cal., W. E. Greenwell, 1855; A. W. Chase, 1871).—About 500 meters from the shore, in the bight between the salt works and Point Vincent; on the first series of hills; not on the highest point of the hill, but on a lower bench. (Note 24, p. 617.)

Salt Pond (Los Angeles County, Cal., W. E. Greenwell, 1856; A. W. Chase, 1871).—On a smooth hill on the left of the road going to San Pedro, about a half mile east of the forks of the road and about east by south of the salt works. (Note 24, p. 617.)

Rocky Point (Los Angeles County, Cal., W. E. Greenwell, 1856; A. W. Chase, 1871).—On a smooth, round hill which terminates in a ragged bluff. There are some rocks at right angles to the point, the only ones in the vicinity. The station was on the second bench above the point where the rocks are. (Note 24, p. 617.)

Point Vincent N. W. (Los Angeles County, Cal., W. E. Greenwell, 1856; A. W. Chase, 1871).—On a point of Point Vincent, about 120 feet from the bluff. A point farther to the westward projects farther than the point on which the station is located. (Note 24, p. 617.)

Finale (Los Angeles County, Cal., A. W. Chase, 1870).—On a long ridge about three-fourths of a mile northwest of Scorpion △; the ground about is very stony. (Note 18, p. 617.)

East Slope (Los Angeles County, Cal., A. W. Chase, 1870).—On the northeast side of San Pedro Hill. About 410 feet above mean tide. (Note 18, p. 617.)

Mustard (Los Angeles County, Cal., A. W. Chase, 1870).—On the second bench from the flat plain along the trail to the summit of San Pedro Hill; well down on the point of the ridge and directly on the trail. (Note 18, p. 617.)

Timms Windmill (Los Angeles County, Cal., A. W. Chase, 1870).—The shaft of the windmill used for drawing water from a well owned by Albert Timms, in a low valley about a mile from San Pedro and directly on the road.

Spring (Los Angeles County, Cal., A. W. Chase, 1870).—On the knoll east of a water hole on the right hand of the trail ascending San Pedro Hill from the east, about 1 000 feet above the sea; one of the two places where running water can be found on the mountain in summer. (Note 18, p. 617.)

Bench (Los Angeles County, Cal., A. W. Chase, 1870).—On the second bench from the sea north of Sea Bench △. (Note 18, p. 617.)

Coyote (Los Angeles County, Cal., A. W. Chase, 1870).—On the second hill beyond San Pedro △; not on the highest part but down on the sea face of the ridge. (Note 18, p. 617.)

Unknown (Los Angeles County, Cal., A. W. Chase, 1870; F. Westdahl, 1887).—On the first point beyond the bold spur of the mountain on which Sea Bench △ is located, and at a point where the ground is broken by slides; a little back of the edge of the first one. In 1870 the station was marked according to note 18, page 617, but in 1887 none of these marks were found, and a stub projecting 6 inches above the ground, with a copper tack in the top, was left to mark the center of the station.

Knob (Los Angeles County, Cal., A. W. Chase, 1870).—On the first projecting point of yellow rock and earth along the edge of the bluff from Point Fermin; on a little knob that has a depression between it and the edge of the bank. (Note 18, p. 617.)

Portuguese Point (Los Angeles County, Cal., A. W. Chase, 1870).—On the western one of two rock points to the west of Portuguese Bend; on the eastern edge, not far from the bluff. (Note 18, p. 617.)

Ranchita (Los Angeles County, Cal., A. W. Chase, 1870).—About a mile along the trail back from Scorpion △; on the sea face of the hill; on the sea side of a singular depression like a crater with a dry bed of mud in the bottom. (Note 18, p. 617.)

Sea Bench (Los Angeles County, Cal., A. W. Chase, 1870).—On the point of a bold spur of the mountain about a mile west from Knob △, and on the first flat bench from the sea. (Note 18, p. 617.)

Long Point (Los Angeles County, Cal., A. W. Chase, 1870).—At the end of a long rocky point west from Portuguese Point. (Note 18, p. 617.)

Gus (Los Angeles County, Cal., A. W. Chase, 1870).—On the edge of the next bench up the trail from Yonder △. (Note 18, p. 617.)

Wash Rock (Los Angeles County, Cal., A. W. Chase, 1870).—On the extreme point of Point Vincent, near the bluff. There is a large wash rock off the point. (Note 18, p. 617.)

Portuguese Bend (Los Angeles County, Cal., A. W. Chase, 1870).—At a little bay known as Portuguese Bend, on the top of the first bench from the sea, and on the east edge of a great gully that comes down into the bend. (Note 18, p. 617.)

Last (Lost Angeles County Cal., A. W. Chase, 1870).—On the left of the trail and on the edge of the next bench up from Gus △, between two ledges of sandstone rock which run across the hill and crop out here. (Note 18, p. 617.)

Scorpion (Los Angeles County, Cal., A. W. Chase, 1870).—On the southwestern point of an isolated hill above the trail along the top of the mountain. (Note 18, p. 617.)

Yonder (Los Angeles County, Cal., A. W. Chase, 1870).—On the edge of the third bench up the face of the long ridge making down to Point Vincent, on the right of the trail. (Note 18, p.617.)

Buenavista (Los Angeles County, Cal., G. Davison, 1870).—In Los Angeles, upon the top of a round-topped hillock just behind the Episcopal Church. Upon a rock foundation was built a rectangular brick pier laid in cement and capped with a stone block 25 by 18 inches, and 19 inches thick. In the center of the capping a copper bolt was let in and leaded, with a small hole punched in the bolt to mark the center of the station, and on the block were lightly cut the letters U. S. C. S. The station was occupied for longitude in 1870. In 1884 the station had been covered by the Union School building.

POINT DUME TO SANTA BARBARA.

Pelican (Santa Barbara County, Cal., W. E. Greenwell, 1862; D. Delehanty, 1890; A. P. Osborn, 1896; F. W. Edmonds, 1900).—On the end of a long, low point, near a large lagoon, partly dry, that is south of the road leading from the Santa Barbara and Gaviota Pass road to the asphalt mine. The station was marked by a 6 by 9 inch sandstone pier sunk about 2 feet 6 inches in the ground and showing about 6 inches above the surface, marked U. S. RANGE 30 MILES.

Hill (Santa Barbara County, Cal., W. E. Greenwell, 1862–70; A. P. Osborn, 1896).—On the top of a large, conspicuous hill, the highest within about 2 miles to the west of Santa Barbara △. The southern end of a large bend in the Arroyo del Burro (San Roque Creek) is 800 meters east-northeast of the △. This bend is about 1 500 meters long, and forms a quarter circle, described from a point northeast of it as center. The center of the station was marked by a 6 by 9 inch sandstone, with a hole in the center, sunk about 1 inch below the surface. Four pine stubs, with three nails in each, were placed north-northwest, east-northeast, south-southeast, and west-southwest, distant 4 feet from the center. Reported destroyed by plowing in 1900.

Cluster (Santa Barbara County, Cal., W. E. Greenwell, 1862; A. F. Osborn, 1896; F. W. Edwards, 1900).—On the top of the northern one of a cluster of hills rising above the surrounding level to the east of a large wooded valley, the second hill to the left along the wooded arroyo after passing the ranch house to the east of the road to the cemetery. The station was marked by a drill hole in a fixed rock level with the surface. The reference marks are drill holes in the tops of two fixed rocks projecting 1 foot above the ground, one about west, 7 feet 11 inches from the center, and one about northwest, 4 feet 9 inches.

Thompson (Santa Barbara County, Cal., W. E. Greenwell, 1862; D. Delehanty, 1890; A. P. Osborn, 1896).—On a rocky knoll about 200 meters west of the Arroyo del Burro, on Dixie Thompson's ranch, about 1 mile northwest of his house, which is in full view, in a field to the right of the wood road leading to ranchero Ontare, at a point where it curves off to the westward. The field is covered with rocks, and is not the highest in the vicinity. The station was marked by a drill hole in a fixed rock covered 3 feet deep with loose stone, and secured by three holes drilled in fixed rocks, 7 feet 8 inches from the center to the southwest, 7 feet 9 inches to the northeast, and 11 feet 8½ inches to the south. The center and the south holes were found in 1890.

Mission (Santa Barbara County, Cal., W. E. Greenwell, 1862).—On the top of the first range of hills above and to the eastward of the Mission of Santa Barbara, about a quarter mile distant; about 100 meters west of the wood road to Santa Barbara. The station was marked by a drill hole in a fixed rock nearly level with the surface.

Bens (Santa Barbara County, Cal., W. E. Greenwell, 1862).—On the top of a hill to the left of the road from Santa Barbara to the Sulphur Springs. The station was marked by a stone firmly placed in the ground about 4 inches below the surface, in which was drilled a hole to mark the center. A nail in a bench mark on a three-pronged oak tree in a southeast direction was 26 feet 8 inches from the center, and a nail in a single oak tree in a northeast direction, 31 feet 6 inches. In 1890 the station was reported probably lost.

White (Santa Barbara County, Cal., W. E. Greenwell, 1862).—On a low, black-looking point on the road from Santa Barbara to San Buenaventura, near the beach about 100 meters from White's house, at the southwest corner of a corral of about an acre. The station was marked by a drill hole in a stone placed even with the surface of the ground.

Ridge (Santa Barbara County, Cal., W. E. Greenwell, 1863; D. Delehanty, 1890; W. I. Moore, 1893).—About the middle of the top of a high point in a range of hills running about northeast and southwest and terminating at the coast in a bluff, about 1½ miles from the coast, about 1½ miles from a house on the road from Santa Barbara to San Buenaventura. The station was marked by a drill hole in a rock firmly placed in the ground with the top about 3 inches below the surface. Three other holes were drilled in fixed rocks to the east, west, and south, 12 feet 8 inches, 12 feet 5½ inches, and 7 feet 2½ inches distant, respectively.

Mound (Santa Barbara County, Cal., W. E. Greenwell, 1863).—Near the eastern end of the top of a small hill forming a precipitous bluff toward the ocean, on the right of the road from Santa Barbara to San Buenaventura. The station was marked by a drill hole in the top of a stone about 4 inches below the ground. Three redwood stubs, each with a copper nail in the top, were driven to the north, south, and east, 3 feet from the center.

Boyle (Santa Barbara County, Cal., W. E. Greenwell, 1863).—On the top of a high hill. To reach the station take a road leading off from the stage road east of Mound △, about halfway between Arroyo del Toro and Arroyo del Muerto; follow it across and along the latter arroyo, and a kilometer beyond the place where it leaves the arroyo the hill will be reached. The station was marked by a copper nail in the top of a redwood stub sunk in the ground about 18 inches and secured by copper tacks in the tops of three redwood stubs 3 feet from the center, to the southeast, southwest, and northwest.

Sheep (Santa Barbara County, Cal., W. E. Greenwell, 1863).—On a low, sandy point, about 50 meters west of a small creek and about the same distance from low-water mark.

Oregon (Santa Barbara County, Cal., A. P. Osborn, 1896; F. W. Edmonds, 1900).—On a hill near Mr. Cattel's ranch, about 20 meters northwest of the brow of the hill. To reach the station, take the first branch road to the right west of Goleta on the Santa Barbara-Gaviota Pass road; about 1½ miles from here, at a fork, take the left-hand road along a small creek and turn into a branch road to the right just before reaching a bridge. The road passes through the barnyard of the ranch, and the hill in question is on the right. The station was marked by a sandstone projecting about 3 inches above ground and lettered U. S. RANGE 31 MILES.

More (Santa Barbara County, Cal., F. W. Edmonds, 1900).—In a level cultivated field belonging to John More, about midway between the east and west fences, 11.4 meters south of center of the road and about 150 meters back from the edge of an 80-foot bluff. To reach the station, turn south at a point about one-eighth mile beyond Goleta on the Santa Barbara–Gaviota Pass road, into the road leading to Mores Landing and when within about 200 meters of bluff take the road leading eastward into the field. The subsurface mark was a ¾-inch drill hole in a stone (natural rock) about 10 by 12 by 9 inches set in sandy soil about 2½ feet below the surface. Over this was a sandstone 24 inches long, dressed on upper end to 6 by 10 inches, set in cement so as to show 2 inches above the surface of the ground, lettered U. S. RANGE 32 MILES and having a ¾-inch drill hole to mark the center of the station.

Wisconsin (Santa Barbara County, Cal., F. W. Edmonds, 1900).—On a cultivated hill on the ranch of Mr. F. M. Moore on the Santa Barbara–Santa Inez road; on the southeast slope of the second knoll from the corral, where a windmill stands on the western edge of the cattle trail. The subsurface mark was a ¾-inch drill hole in a three-cornered stone (natural rock) about 10 inches in diameter, and 10 inches deep, set about 2 feet below surface of ground. Over this was set in the hard rock and clay soil, flush with surface of ground, a sandstone 24 inches long, dressed on the upper end to 6 by 10 inches, and lettered U. S. RANGE 32 MILES, and having a ¾-inch drill hole in top to mark the center of the station.

Conover (Santa Barbara County, Cal., F. W. Edmonds, 1900).—On a low hill back of and north of the house on K. E. Conover's ranch on the Cathedral Oaks road, a branch road northward from the Santa Barbara–Santa Inez road; near the top of hill, at the head of a small gulch and within the inclosure used as a small pasture, the ground being full of rocks and bowlders and rising very gradually to the northwest of the station. The subsurface mark was a ¾-inch drill hole in a stone (natural rock) 12 by 12 by 6 inches, set two feet below the surface of the ground, with a ¾-inch drill hole in the top marking the center and lettered U. S. RANGE 32 MILES.

Gedney (Santa Barbara County, Cal., A. P. Osborn, 1896; F. W. Edmonds, 1900).—On the top of a small hill in a cultivated field running back from the beach to the westward of landing on Mr. More's ranch, and to the right of the road to the landing. The eastern and nearer one of two isolated liveoak trees is about 100 meters about N. by W. from the station, and the other is to the westward and stands in front or to the southward of a small grove of liveoaks. The station was marked by a sandstone pier about six inches above ground and marked U. S. RANGE 31 MILES.

Crane (Santa Barbara County, Cal., A. P. Osborn, 1896).—In a cultivated field about 1 040 meters N. ½ W. from Pelican △, about 200 meters from the fence. The station was marked by a pier, sunk about 2 feet 6 inches in ground and marked U. S. RANGE 30 MILES.

Vista (Santa Barbara County, Cal., D. Delehanty, 1890; A. P. Osborn, 1893).—About 3 miles north of Santa Barbara, on the ridge between Sycamore and Mission Canyons, on a knoll, about 75 feet from the top. The center was marked by a drill hole in a large flat stone buried 4 inches under the ground. Four 2 by 3 inch stubs were driven two feet from the center, to the north, south, east, and west. Drill holes were also sunk in fixed rocks as follows: 12.9 feet from the center hole in the face of a large split bowlder, over which was cut a circle and cross; 12 feet northwest from the center in the face of a rock; 3.7 feet from the center in the top of a rock nearly level with the surface.

Bens 2 (Santa Barbara County, Cal., D. Delehanty, 1890).—On the top of the first of a low range of hills running parallel with the coast to the westward of Montecito. The station was marked by a drill hole in a stone buried 30 inches beneath the surface of the ground and by a drill hole in the top of another stone on which the letters U S are cut, buried 8 inches below the surface. Additional marks were as follows: a bench mark on an oak tree, in which nails, in the form of a cross, were driven, is 47 feet 6 inches south 30° west from the station; a line to the eastern edge of another oak tree, south 31° west and 82 feet distant, passes 2 feet from the center of the bench mark; another bench mark was placed on a 2-pronged oak tree 79 feet 9 inches from the center and 85° west from it.

Spring (Santa Barbara County, Cal., D. Delehanty, 1890; W. I. Moore, 1893).—On the ridge to the eastward of Hot Spring Canyon back of Montecito, near the southern edge of a small plateau on the sea face of the ridge. Above this plateau the ridge rises about 50 feet and turns sharply to the eastward. The lower edge of the plateau is a ledge of bowlders, below which the ridge falls off abruptly. The plateau is free of brush, but the ridge is thickly wooded above and below. The center of station was marked by a drill hole in a flat stone buried a little below the surface of the ground. Around the center were driven four 2 by 3 inch stubs, north, south, east, and west, each 2 feet from the center. Additional marks were placed as follows: a drill hole in the top of a fixed rock, 10.9 feet from the center hole and south of it; a blaze was cut in an oak tree and a cross marked in it with nails, distant 15 meters west by north from the station. There is another oak tree, about 30 meters north of the station, where the ridge begins to rise.

Hassler (Santa Barbara County, Cal., D. Delehanty, 1890; W. I. Moore, 1893).—Almost directly behind the old Catholic Church at Montecito and about 6 feet inside the old chaparral fence which forms the northern boundary of the property. The station was marked by a drill hole in a large flat stone buried 30 inches underground. Over this was a stake 3½ by 5 inches, with a nail in the top, and around the stake was built a brick monument 2 feet square and 2 feet high.

Front (Santa Barbara County, Cal., D. Delehanty, 1890; W. I. Moore, 1893).—On the eastern end of a low bluff opposite where the wagon road crosses the railroad track at the station at Montecito. The station was marked by a drill hole in a large flat stone, buried 3 feet underground. Over this was a stake 3½ by 5 inches, with a nail in the top, around which a brick monument was built.

Sand (Santa Barbara County, Cal., W. E. Greenwell, 1862).—Immediately on the edge of a sandy bluff about 80 feet high and about 50 meters to the eastward of a sandy place. (Note 26, p. 617.) Reported destroyed by plowing in 1900.

Bluff (Santa Barbara County, Cal., W. E. Greenwell, 1862).—Immediately on the high bluff about a fourth of a mile west of the mouth of the Arroyo del Burro. The bluff has no distinguishing features except that the soil is filled with small pieces of limestone, giving it the appearance of being mixed with broken shells.

Camp (Santa Barbara County, Cal., W. E. Greenwell, 1862).—On the bluff about 1 mile to the westward of the light-house and in plain view of it, about 300 meters east of the mouth of the Arroyo del Burro. (Note 26, p. 617.)

Clay (Santa Barbara County, Cal., W. E. Greenwell, 1862).—On a yellow bluff about three-fourths of a mile to the eastward of John Niderer's (?) house, about 150 meters east of a picket fence and within a quarter of a mile of the coast road. (Note 26, p. 617.) Reported probably lost in 1890.

River (Ventura County, Cal., W. E. Greenwell, 1870).—On the west side of the San Buenaventura River, about 400 meters from its mouth; on low sandy land, 100 meters southeast of a low marshy piece of ground. The station was marked by a 3 by 3 inch redwood stub, 3 feet in the ground and projecting 3 inches. Reference marks as in note 26, page 617.

Monument (Ventura County Cal., W. E. Greenwell, 1870).—On the bluff north of Main street, San Buenaventura, about 300 meters west of the Mission at the end of the bluff where the direction changes from west to north. (Note 26, p. 617.)

Meigs Windmill (Santa Barbara County, Cal., A. F. Rodgers, 1904).—A tall windmill above a four-story tank house, the property of Peveril Meigs, 547 meters from Santa Barbara Light-house. To the eastward of the windmill and slightly more in the foreground from seaward is a prominent clump of eucalyptus trees.

San Buenaventura Latitude Station (Ventura County, Cal., G. Davidson, 1870).—A made block, firmly embedded in the ground, 102 yards from the edge of the bluff and 444.6 feet, N. 0° 00′ 22″ W. (true), from San Buenaventura △ (p. 639).

San Buenaventura Azimuth Mark (Ventura County, Cal., G. Davidson, 1870).—On the bluff or plateau on the west side of the San Buenaventura River on the first plateau, about 80 feet above the river and nearest the sea. The station was marked by post of 4 by 4 scantling. The reference marks were nails in the tops of stubs, 6 feet from the center.

Santa Barbara Latitude Station 1869 (Santa Barbara County, Cal., G. Davidson, 1869).—North 6.69 feet and east 16.93 feet of Santa Barbara △ (p. 631). Not permanently marked.

Santa Barbara Latitude Station 1852 (Santa Barbara County, Cal., G. Davidson, 1852; W. E. Greenwell, 1870).—This station was marked by a stone, bearing the letters U. S. C. S., with its top 3 inches below the surface of the ground.

SANTA BARBARA TO POINT ARGUELLO.

Fogg (Santa Barbara County, Cal., W. E. Greenwell, 1863).—On a high hill south of the road from Santa Barbara through the Gaviota Pass, about 3 miles northwest from Hill's house, where the road descends into a large wooded arroyo. Keep up this for about 1 mile and then ascend the hill on the east side for about three-fourths of a mile to the highest part of the hill. The hill may be distinguished from others in that vicinity by having a few oak trees on the top and being free from a growth of mustard. (Note 14, p. 616.)

Bruce (Santa Barbara County, Cal., W. E. Greenwell, 1863).—On the table-land about 150 meters from the bluff. To reach the station, at a point about 2 miles beyond

Hill's house, on the road from Santa Barbara, turn to the left and follow down a slope toward the ocean for about half a mile. (Note 14, p. 616. Center stone 8 inches underground. No reference stones. Stubs to north, south, and west.)

Don (Santa Barbara County, Cal., W. E. Greenwell, 1863).—On the top of a smooth rounded hill, entirely free from any growth of timber or brushwood, about 1½ miles to the northeast of Mrs. Don's house. (Note 15, p. 616.)

Nicholas (Santa Barbara County, Cal., W. E. Greenwell, 1863).—On the bluff at a bend of the shore line about half a mile east of the mouth of the first arroyo east of Mrs. Don's house and about three-fourths of a mile from the house. (Note 15, p. 616.)

Alcatraz (Santa Barbara County, Cal., W. E. Greenwell, 1863).—On the bluff immediately west of the mouth of the second wooded arroyo west of Mrs. Don's house. (Note 15, p. 616.)

Buck (Santa Barbara County, Cal., W. E. Greenwell, 1863).—On a high hill about 1½ miles from the first wooded arroyo west of Mrs. Don's house along the stage road. (Note 15, p. 616.)

Capitan (Santa Barbara County, Cal., W. E. Greenwell, 1863).—On the edge of the first bluff beyond the Cañada El Capitan going from Don's ranch toward Point Conception, not more than 300 meters from the mouth of the cañada, within 40 meters of the main stage road and to the southward of the remains of an old corral. The surface of the ground near the station is covered with bowlders firmly fixed in the earth. (Note 15, p. 616.)

Ortega (Santa Barbara County, Cal., W. E. Greenwell, 1863).—On a high hill about half a mile from a point about a mile from Ortega's house, near where the cañada forks. From Capitan △ the hill appears between two higher hills which are covered with sagebrush, except at the tops. (Note 15, p. 616.)

Goat (Santa Barbara County, Cal., W. E. Greenwell, 1863).—On the top of the first high hill to the eastward of the Arroyo del Refugio and about a quarter of a mile from it, and about the same distance from the beach. The hill is covered with low greasewood bushes and presents a black appearance. (Note 15, p. 616.)

Tahuivas (Santa Barbara County, Cal., W. E. Greenwell, 1863).—On the top of a high hill about half a mile from the Tahuivas Vineyard, on the right side of the cañada running up from the vineyard. (Note 15, p. 616).

Refugio (Santa Barbara County, Cal., W. E. Greenwell, 1863).—On the first ridge west of the Arroyo del Refugio, about 20 feet below the top, on the slope to the ocean, about 70 meters south of a conspicuous ledge of limestone. (Note 12, p. 616, the reference stubs being 2 feet 10 inches from the center, to the east, west, and south.)

Young (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On a round, smooth-top hill to the west of the Sajiguas Canyon, the highest hill between the beach and the Sajiguas ranch house, about 150 yards toward the mouth of the canyon from the highest point on the hill. (Note 13, p. 616.)

Ledge (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the top of a bushy peak to the west of Sajiguas ranch house, on the north side, on the edge of a precipitous ledge or wall of rock descending into a bushy canyon. (Note 13, p. 616.)

Black (Santa Barbara County, Cal., W. E. Greenwell, 1872).—South of a precipitous wall of rock on the top of a hill at the west side of the Cañada Quemada, the first hilltop covered with brush from the beach along the divide between the Cañada Quemada and the first canyon to the west of it. (Note 12, p. 616.)

Quemada (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the bluff near the beach and near the mouth of the first canyon west of the Cañada Quemada, about 200 feet north of where the cañada comes out of the hills. (Note 13, p. 616.)

Rock (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On top of a hill covered with thick brushwood, about midway between the cañadas Los huevas del Cordeva (?) and Piedra de Molar, 100 meters north of a conspicuous ledge of rock. (Note 13, p. 616.)

Stow (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the top of the bluff, on the point at the west side of the mouth of the Cañada Piedra de Molar, about 150 meters south of the main road, near a deep crack in the earth. (Note 13, p. 616.)

Camp (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On a rocky point at the east side of the Cañada de San Onofre, the first high point after leaving the road at the east side of the cañada. (Note 26, page 617.)

Onofre (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On a point at the west side of the mouth of the Cañada de San Onofre, directly on the top of the bluff bank of the seashore and about 150 yards south of the road, near some live-oak trees. (Note 26, p. 617, with a similar stub also to the east.)

Brush (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the top of the second brush-covered peak east of the mouth of Gaviota Canyon. The hill is covered with a gray sagebrush about halfway up, and from thence up with a dark-green bush interspersed with white sandstone. There are three small gulches on the south face of the hill. (Note 3, p. 615.)

Ram (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the top of the bluff back of the coast, about half a mile east of Gaviota Canyon and about 250 meters south of the main road. The country is a bench with a gradual descent from the foot of the mountains, nearly half a mile. (Note 13, p. 616.)

Burke (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the highest point of the first bushy ridge on the left hand going up the Gaviota Pass, in sight from the house of Miguel Burke, near the mouth of Gaviota Canyon. The ridge runs nearly east and west and terminates in the Gaviota Canyon. The whole south side of it is covered with a dense growth of brush. (Note 13, p. 616.)

Bald (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the south slope of the top of the first and highest hill to the west of the mouth of the Cañada del Agua Caliente, the first large canada west of Gaviota Canyon. (Note 12, p. 616.)

Knob (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the west end of the highest point of the ridge at the west side of the Cañada Alegria, a continuation of the ridge on which Alta △ is located and the first bushy point of the ridge going north from Alta △. The south side is covered with loose white stones, giving it a white appearance, and the north side of the hill is covered with thick brush. (Note 13, p. 616.)

Alta (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the highest point of a high, smooth hill, the first one west of the Cañada Alegria, the second large cañada west of Gaviota Canyon, covered with wild oats, brush, and grass; in the center of a rocky ledge of white stones, very much broken, and covering the highest peak of the hill. (Note 12, p. 616.)

Turn (Santa Barbara County, Cal., W. E. Greenwell, 1872).—East of the first small canyon east of Santa Anita, on top of the second high sagebrush-covered knoll east of Cañada de Santa Anita. (Note 12, p. 616, the reference stubs being to the northwest, southeast, and southwest.)

Anita (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the first high point east of the mouth of the Cañada de Santa Anita, about 25 feet from the bluff bank of the sea. (Note 13, p. 616.)

Low (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On a sagebrush knoll at the foot of the hills west of the west branch of the Cañada del Macho, the first ridge running south from the face of the hill. The ridge above the station is covered with scattering live-oak timber and open spaces of a white color. (Note 13, p. 616.)

Gull (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the bluff bank of the ocean between the Cañada del Macho, the first one west of Santa Anita, and the Cañada del Estero, a little to the west of the highest part of the bluff and about 40 feet from the top of the bank. (Note 13, p. 616.)

Seal (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the bluff bank of the sea at the west side of the mouth of the Cañada del Builito (?), the first canada west of the Cañada del Estero, about 10 feet from the top of the bluff. (Note 13, p. 616.)

Ridge (Santa Barbara County, Cal., W. E. Greenwell, 1872).—At the east side of the Cañada del Builito (?), on a sagebrush hill or ridge, not on the highest point of the ridge, but on the southwest slope of the first high point from the cañada. (Note 13, p. 616.)

Duck (Santa Barbara County, Cal., W. E. Greenwell, 1872).—About a quarter of a mile west of the west side of the mouth of the Cañada de San Augustine on the farther small point of the bluff from the mouth of the cañada, about 20 feet from the top of the bluff bank of the seacoast. (Note 13, p. 616.)

Mound (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the first high hill west of the main branch of the Cañada de San Augustine, on a small flat place about 100 feet south of the top. On the highest point of the hill there is a square mound of flat white rocks, about 3 feet square, evidently having been built for some purpose. The hill is divided on its south face by a small canyon or gulch. The next hill west of it is covered with a growth of live oak, and the first hill east is covered on its west face in the same manner. (Note 12, p. 616, the reference stubs being to northwest, southeast, and southwest.)

Undo (Santa Barbara County, Cal., W. E. Greenwell, 1872).—At the east side of the west branch of the Cañada del Barranca Undo (?), on a knoll or spur of the foothills which terminate in the barranca where it leaves the hills, on a grassy spot on the south slope, about 150 feet above the barranca. (Note 13, p. 616).

Bank (Santa Barbara County, Cal., W. E. Greenwell, 1872).—About 300 yards west of the mouth of the Cañada del Barranca Undo (?), about 30 feet from the top of the bluff bank of the sea. (Note 13, p. 616.)

Lime (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the ridge of a conspicuous hill at the east side of the east branch of the Cañada del Cojo Viejo, and at the west side of the first canada west of the Cañada del Barranca Undo (?), on the south slope, which is covered with loose white rock; about halfway up the ridge and nearly midway between two large white rocks, about 100 feet apart. (Note 12, p. 616, the reference stubs being to the northwest, southeast, and southwest.)

Coxo (Santa Barbara County, Cal., C. Rockwell, 1869; W. E. Greenwell, 1872–74; D. Delehanty, 1890).—On the top of extreme bluff between Coxo and Cojo Viejo about 1 mile east of Point Conception East Base △; on the highest part of the point and 42 feet above high-water mark, 30 feet 6 inches from edge of bluff to the south. (Note 6, p. 616, with a reference stub to the south only.)

Wildcat (Santa Barbara County, Cal., C. Rockwell, 1869; W. E. Greenwell, 1872–74; D. Delehanty, 1890).—On the top of a spur above the small valley formed by the forks of the Coxo Canyon, northwest of a pass about 50 feet lower than the station, on the main slope rising gradually to the lomas in the rear. On the east side of the pass is a landslide falling abruptly to the canyon below, presenting a bare, sandy appearance. (Note 6, p. 616, with north reference stub only.)

Point Conception East Base (Santa Barbara County, Cal., C. Rockwell, 1869; W. E. Greenwell, 1874).—Near the eastern extremity of the plateau lying between El Coxo and the bight west from Point Conception, about 200 meters west from the edge of the bluff. (Note 6, p. 616, except there was no reference stub to the east.)

Coyote (Santa Barbara County, Cal., C. Rockwell, 1869; W. E. Greenwell, 1874; D. Delehanty, 1890).—On the main ridge west from the western branch of the Coxo Canyon, the continuing slope rising to the Coxo ranch house, nearly on the highest ground of the slope. About 40 meters north from the station the slope falls down about 50 feet and then gradually rises to the mountains. (Note 6, p. 616, except there was no reference stub to the east.)

Point Conception West Base (Santa Barbara County, Cal., C. Rockwell, 1869; W. E. Greenwell, 1874).—Near the western extremity of the plateau lying between El Coxo and the bight west from Point Conception; about 200 meters east from where the ground commences to fall rapidly. The west end of a pond between the station and the light-house is in range with the easternmost cliff of Point Conception. (Note 6, p. 616, except there was no reference mark to the east.)

Mesa (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On the mesa about 1½ miles north-northeast from Point Conception Light-house and 400 meters from the bluff bank of the sea, 75 meters southeast of the head of a small barranca, which is in a direct line with Point Arguello, about 200 meters southeast of the first important canyon going from the light-house to the north, 17 meters east of the trail leading up the coast. The station was marked by a redwood stub 2 feet in length, projecting 5 inches above the ground.

La Costa (Santa Barbara County, Cal., C. Rockwell, 1869; W. E. Greenwell, 1874).—Near the top of a mountain, about 1 000 feet high, to the westward of the one which the wagon trail passes. The station was marked by two stubs, each 6 feet from the center, to the north and south.

Black Point (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On a small spur of the foothills which comes down quite close to the bluff bank of the sea and on the east side of which is a large canyon, which can be distinguished by a luxuriant growth of willows growing along the bed. The hill is densely covered with black sage-brush, giving it a darkish appearance at a distance. (Note 16, p. 616.) Reference stubs were in line with the light-house and the east and west of the station.

Feldspar (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On a high hill directly back of Black Point △ and northwest of La Costa △. The top of the hill, as well as the sides, is covered with loose rock similar to feldspar. (Note 16, p. 616, the reference stubs in line with the light-house.)

Bluff (Santa Barbara County, Cal., W. E. Greenwell, 1874).—In the innermost part of the bight or bay between Point Conception and Point Arguello, on the high bluff bank, the only rise of any importance on the coast mesa in this vicinity and visible for a long distance in either direction; about 12 feet from the edge of the bluff. (Note 27, p. 617.)

Espada (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On the high grass-covered hill next south of Prospect △, the soil being rocky and dry. The station was marked by a rock 2 feet 9 inches in length and 4 inches thick, placed on end and hole drilled in top to mark the center of station.

Prospect (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On a high grass-covered hill between Tranquillon Mountain and Espada △, southwest of a rocky peak 100 feet higher than the station and distant 300 or 400 meters. The ground at this place is exceedingly rocky.

Flint (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On a low bluff bank of the sea, the next point west of Bluff △, 300 meters west of a small wash or barranca, which runs about north-northwest from the coast for a distance of 400 meters, 15 meters from the edge of the bluff, which is almost perpendicular. The ground falls gently either way along the shore and rises gradually inshore. (Note 27, p. 617.)

Point (Santa Barbara County, Cal.; W. E. Greenwell, 1863).—On the edge of the first conspicuous point to the west of Capitan △, an eighth of a mile west of the Arroyo del Refujio. (Note 15, p. 616.)

Curlew (Santa Barbara County, Cal., W. E. Greenwell, 1863).—On the bluff about 1¼ miles west of Bruce △, and about 200 meters to the west of the mouth of the second wooded arroyo from that station. (Note 12, p. 616, the reference stubs being to the east, west, and south, and no center stub described.)

Sage (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On the west side of the Sajiguas Canyon on the slope of the hill toward the south, 600 or 700 meters from the county road. In the vicinity of the station the ground is covered with sagebrush. (Note 13, p. 616.)

Oats (Santa Barbara County, Cal., W. E. Greenwell, 1872).—On a ridge covered with wild oats at the west side of the first cañada of the Cañada de San Onofre, nearly up to the foot of the highest rocky peak visible. About halfway up the ridge is a conspicuous ledge of sandstone, which extends across the face of the ridge. To reach the station ascend the first ridge west of the cañada to the first high knoll, then skirt the right slope of the ridge to an opening in the rocks, about 140 meters to the right and below the summit of the hill; follow the trail through this point (an oak tree seems to mark the place) and skirt the north slope of the rock to the summit of the ridge. (Note 13, p. 616.)

Ward (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On the mesa near the point toward the Cojo landing, about 400 meters from the bluff bank of the sea (measured in line with the middle of Santa Rosa Island) and 60 meters south of the road leading from the Cojo landing toward Point Conception Light-house, nearly on a line from Wildcat △ through Point Conception Astronomic Station prolonged, distant about 120 meters from the latter. The station was marked by a 3-foot redwood stake, projecting 4 inches above the ground. Two reference stakes were placed each distant 6 feet from the center, in line with the light-house.

Point Conception Astronomic Station (Santa Barbara County, Cal., G. Davidson, 1850; F. W. Edmonds, 1900; A. F. Rodgers, 1904).—About 1 710 meters east and 259 meters north of the Point Conception △, on the edge of a deep railroad cut. The station was marked by a brick monument, 2 feet 1 inch by 2 feet 1½ inches, extending 10 inches below the surface and 1 foot 2 inches above, and by two oak stakes, one 8 feet north and the other 8 feet south; and also by two bottles, one 5 feet and the other 10 feet west and pointing toward the station.

Point Conception (Santa Barbara County, Cal., C. Rockwell, 1869).—Near the highest part of Point Conception, 32.3 feet from the east corner of the light-house and 63.2 feet from the south corner. (Note 6, p. 616, except there was no reference stub to the east.)

Espada Ranch House (Santa Barbara County, Cal., W. E. Greenwell, 1874).—The only chimney on the Espada ranch house, on the north end of the building. The Jalaua Canyon, which is the boundary between the El Cojo and the Espada ranches, has its outlet in a large pond about 100 meters east of the house.

Oak (Santa Barbara County, Cal., W. E. Greenwell, 1863).—Near the edge of the bluff, on a long, low point about 1.5 miles distant from Pelican △. The station was marked by drill holes in the tops of three stones placed to the north, south, and east, each distant 3 feet from the center.

Gaviota Latitude Station (Santa Barbara County, Cal., O. H. Tittmann, 1875).—Near Gaviota △ (p. 630).

Arguello Latitude Station (Santa Barbara County, Cal., O. H. Tittmann, 1876).—Near Arguello △ (p. 630).

Range (Santa Barbara County, Cal., D. Delehanty, 1890; F. W. Edmonds, 1900; A. F. Rodgers, 1904).—On the ridge between the two main branches of El Coxo Canyon, running back for about half a mile in rear of Garcia's house; not on top, but on the last spur of the ridge overlooking the eastern branch of the canyon, within a few hundred yards of where the ridge begins to rise more rapidly. The station was marked by a cross formed of tacks, the center one of which is copper, in the top of a stake 3½ by 5 inches. A bottle buried neck up, 30 inches underground, over which was built a brick monument 2 by 2 by 2 feet.

SAN CLEMENTE ISLAND.

Malva (San Clemente Island, California, W. E. Greenwell, 1860; S. Forney, 1878).—About 700 meters from the beach, on the northwestern slope and near the top of the highest and most westerly long, white sand dune. (Note 3, p. 615, except a leaden bolt alone marked the center in the underground stone, and the stakes surrounding the center stone were pine.) The old reference stubs to the north and south were found in 1878 and left undisturbed.

San Clemente Island North Base (San Clemente Island, California, W. E. Greenwell, 1860; S. Forney, 1878).—The general locality of the base line is given under San Clemente Island South Base. The original markings were the same. In 1878 the center monument and three of the old reference stubs were found and left undisturbed. New reference stones and stakes were placed as described in note 3, page 615.

San Clemente Island South Base (San Clemente Island, California, W. E. Greenwell, 1860; S. Forney, 1878).—The San Clemente Island base line lies along a level stretch of land at the northwest end of the island, about 3¾ miles from the extreme northwest point, and south by west from Wilsons Cove, on the southern face of the island and midway from shore to shore. In 1860 each end of the base was marked by a red sandstone monument, with the letters $\overset{\text{U. S.}}{\text{C. S.}}$ in the top, surrounded by four redwood stubs with copper tacks in the tops, ranging north, south, east, and west, and equidistant from the center. In 1878 the sandstone monument was found and left undisturbed, and reference stakes and stones were placed as described in note 3, page 615, except the stakes around the center stone were pine.

Ridge (San Clemente Island, California, W. E. Greenwell, 1860; S. Forney, 1878).—On the northern end of a conspicuous black ridge, near the head of the little valley running south from the anchorage at Wilsons Cove, and to the left coming up the valley. (Note 3, p. 615, except a leaden bolt alone marked the center in the underground stone.) In 1878 the old reference stubs to the south, east, and west were found and left undisturbed.

Clay (San Clemente Island, California, W. E. Greenwell, 1860; S. Forney, 1878).—Near the head of the little valley starting from the anchorage at Wilsons Cove; about 1½ miles from the cove, on the smooth surface of the land sloping toward the west, the same slope on which Wall △ is located, and one-third of a mile west of road leading south from Wilsons Cove to Half Way House. (Note 3, p. 615.) In 1878 the old reference stubs to the north and south were found and left undisturbed.

Wall (San Clemente Island, California, W. E. Greenwell, 1860; S. Forney, 1878).—At the head and on the west side of the little valley starting from the anchorage at Wilsons Cove; on the first high ridge about 200 meters to the southwest of the road leading from Wilsons Cove to the Half Way House. It is on the right hand or southern one of two ridges between which the road passes at a point about 2 miles from Wilsons Cove. (Note 3, p. 615, except a leaden bolt alone marked the center in the underground stone.) In 1878 the old reference stubs to the north and south were found and left undisturbed.

Ram (San Clemente Island, California, W. E. Greenwell, 1860; S. Forney, 1878).—About three-fourths of a mile from and east-northeast of Shell Cove. A gulch near the station runs up from it in the direction of Wall △. In the immediate vicinity of the station were some bowlders and sage brush. (Note 3, p. 615, except a leaden bolt alone marked the center in the underground stone.) In 1878 the old reference stubs to the east and west were found and left undisturbed.

Vulpus (San Clemente Island, California, W. E. Greenwell, 1860; S. Forney, 1878).—On the top of the western summit of a smooth hill sloping to the northward, the second low hill to the right and about 200 meters southwest of the road leading from Wilsons Cove to the Half Way House. (Note 3, p. 615, except the underground center stone is larger.) In 1878 the old reference stubs to the north, east, and south were found and left undisturbed.

Gull (San Clemente Island, California, W. E. Greenwell, 1860–62; S. Forney, 1878).—On the top of a ridge just north of Vulpus △ and one-half mile from the northeast shore of the island. (Note 3, p. 615, except that the underground center stone is larger.) In 1878 the old reference stubs were found and left undisturbed.

Black Point (San Clemente Island, California, W. E. Greenwell, 1860; S. Forney, 1878).—Near the brow of the west end of a black ridge of land running apparently across the island 2½ miles north of Seal Harbor and two-thirds of a mile southwest of road from Wilsons Cove south △. (Note 3, p. 615, except the underground center stone is larger.)

Malva 2 (San Clemente Island, California, W. E. Greenwell, 1860; S. Forney, 1878).—On the top of a hill 3 miles north of Seal Harbor, about midway the island, and about 300 meters southwest of road from Wilsons Cove to Half Way House, in the largest clump of malva bushes on the island. (Note 3, p. 615.)

Snipe (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—On the top of a large flat ridge on the north face of the island one-half mile from the sea, 2½ miles north by east from Seal Harbor, and 200 meters northeast of road from Wilsons Cove to Half Way House. (Note 3, p. 615.)

Rock (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—On the highest part of the ridge starting west of Seal Harbor and running across the island to the northeast shore 2 miles northeast of Seal Harbor and 100 meters west of road. (Note 3, p. 615, except a leaden bolt alone marks the center of station on the underground stone.)

Martin (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—Six hundred meters from the sea, on the north end of the same general ridge as Rock △, and Bluff △, near the brow of the hill, and 600 meters northeast of road. (Note 3, p. 615.)

Bluff (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—On the extreme end of a bold point jutting out to the westward from the ridge running up to the northeast from Seal Harbor. The center was marked by an underground stone with lead bolt only, and a surface stone similar to that described in note 3, page 615. To the north of the station 6.8 feet was a drill hole in the fixed rock, and a similar one to the south 6.2 feet. To the east 9.4 feet was a rock with a hole in the top set even with the surface of the ground.

Ledge (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—On a round, flat knoll about midway between the northeast and southwest sides of the island, the third hill east of Rock △, and 1¾ miles northeast of Seal Harbor. In 1862 the station was marked by a hole drilled in the fixed rock. In 1878 it was re-marked with a leaden bolt and copper nail marking the center. Holes were drilled in the fixed rock northward from the station, 5.4 feet; southeast, 5 feet, and southwest, 4 feet.

Peak (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1879.)—On the highest point of the most northwesterly of the ridges crossing the main ridge of the island, 2½ miles east of Seal Harbor and 600 meters northeast of road. The top of the ridge is covered with large stones, the outcroppings of a stratum of sandstone. In 1862 the station was marked by a drill hole in a rock, covered by a pile of stones. In 1879 a leaden bolt with a copper tack was driven into this hole, the tack marking the center of the station. Crosses were cut on rocks, each distant 15 feet from the center of the station, as follows: To the east or southeast, on the top of a large bowlder; to the southwest, on a flat rock cropping out from the ledge, and to the north, on a flat rock 1 foot square.

Green (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1879).—On a slight elevation 2⅓ miles northwest of the highest point of the island, three-fourths of a mile northwest of Halfway House, and about midway between the northeast and southwest shores of the island, and about 300 meters to the westward of a large gulch. In 1862 the station was marked by a drill hole in the solid rock, covered by a pile of stones. In 1879 a leaden bolt with copper tack was driven into this hole, the copper tack marking the center of the station. At a distance of 15 feet each, to the north, southeast, and southwest, were buried even with the surface three stones, 1 foot long and 2 inches square on the top, with a drill hole in the top.

Boulder (San Clemente Island, California, W. E. Greenwell, 1862; D. B. Wainwright, 1878; S. Forney, 1879).—On the end of the high ridge one-half mile northeast of Halfway House. The hill is conspicuous by reason of the number of large bowlders near the station. The center of the station was marked as in note 3, page 615. The reference marks were three drill holes in the fixed rock, located as follows: to the north, 4.15 feet; to the southwest, 3.80 feet, and to the northeast, 3.90 feet.

Sedge (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—On the ridge 1⅓ miles southeast of Halfway House between two large gulches, near the edge of the northern one, 300 meters below where it branches, and about midway between the northeast and southwest shores of the island. In 1862 the station was marked by a drill hole in the fixed rock. In 1878 the station was re-marked as described in note 3, page 615, except the center stone is of an irregular shape and there were no reference stubs placed around it.

Thirst (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1879).—On the highest point on the northeast side of the island, at the head of a large gulch running in a southerly direction to the ocean. About 400 meters to the southeast and across a small valley is a conspicuous knoll, covered with large bowlders. The center of the station was not marked in 1862, but three holes were drilled in rocks to the east, west, and north, one in a fixed rock and the other two in rocks placed in the ground, each distant 5.8 feet from the center. They were found in 1879, and the center of station was then marked by a stone, 0.2 foot square and 0.6 foot long, with a leaden bolt and copper tack, buried 2 feet below the surface of the ground. The surface mark and the reference stubs and stones were as described in note 3, page 615, except that the stones were placed northwest, northeast, and south.

Vine (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—On the top of the next hill to the eastward from Sedge △, about 1 mile distant and 1¼ miles southeast of the highest point of the island. About 500 meters west of the station is a very large, deep gulch, and the head of a smaller gulch is about 50 meters southeast. In 1862 the station was marked by two drill holes in the fixed rock, each 37½ inches distant from and in a line with the center point. In 1878 the station was marked in a manner similar to that described in note 3, page 615, except there were no stubs around the center stone nor the reference stones.

Alta (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1879).—On the southeast side of the highest ridge of the island, on the summit of a round, smooth-top hill. Three hundred meters southeast across a small ravine is a prominent ledge of rocks. In 1862 three holes were drilled in the fixed rock: to the east, 7 feet 2 inches; to the west, 8 feet 5 inches, and to the north, 5 feet 9 inches. In 1879 the station was marked as described in note 3, page 615, except the reference stones were set northeast, northwest, and south of the center stone.

Dome Hill (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1879).—On the top of a prominent rocky dome-shaped peak about 1½ miles from the beach and 3½ miles from the south end of the island. The station was not marked.

Fork (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—On a knob about 400 meters from the beginning of a ridge which starts in the forks of a large gulch running in a southwest direction to the ocean and which comes out one-third of a mile east of Cove Point; 1⅓ miles southeast of the highest point of the island. In 1862 the station was marked by three stubs 22 inches from the center and 120° apart. In 1878 the center of station was marked as in note 3, page 615. No reference stubs or stones were placed, but three holes were drilled in the fixed rock: to the east, 12.8 feet; to the west, 13.4 feet, and to the south 11.1 feet.

Gray (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878.)—On the eastern slope near the top of the first large hill to the southeast of Alta △. In 1862 the station was marked by a drill hole in the fixed rock. In 1878 a leaden bolt and copper nail were driven into the hole, the nail marking the center of station. Three holes were drilled in the rock: to the east, 9.8 feet; to the west, 9.6 feet, and to the south, 8.1 feet.

Gulch (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—On the outer end of a high, flat ridge, and on the east side of and near the edge of a large gulch which runs in a southwesterly direction to the ocean, about one-half mile from where it divides near Fork △. To the south and west of the station are two egg-shaped hills, about 1 mile distant and ¼ mile apart. In 1862 a hole was drilled in the fixed rock to mark the station. In 1878 a leaden bolt and copper nail were driven into this hole, the nail marking the center of the station. Three holes were drilled in the fixed rock, to the north, 10.6 feet; to the east, 9.7 feet, and to the south, 8.2 feet.

Rest (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—About 2 miles north by east from Smugglers Cove, on the southern end of a ridge at a point near where the two ridges forming the east and southeast extremities of the island join and about 1 mile southeast of Mosquito Harbor. In 1862 a hole was drilled in the fixed rock to mark the station. In 1878 the station was re-marked, as described in note 3, page 615.

Kelp (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—On the extreme edge of a long black-looking point, sloping in the direction of the southwest part of the island. North of the point, and about 800 meters distant, are two conspicuous hillocks. About 200 meters east of the station runs a deep gulch. In 1862 the station was marked by a drill hole in the rock, and by three similar holes for reference marks 24 inches from the center, the lines connecting these with the center, making an angle of 120° with each other. In 1878 the center of station was re-marked, as in note 3, page 615, but without reference stubs or stones.

Slope (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—On the highest point on a long ridge sloping to the ocean, the first to the west from Smugglers Cove. About 150 meters to the north of the station runs a large gulch. In 1862 a hole was drilled in the fixed rock to mark the station. In 1878 a leaden bolt and copper nail were driven into this hole, the nail marking the center of the station. Three reference drill holes were made; to the east, 6.6 feet; to the south, 8.4 feet, and to the west, 9.9 feet.

Seal (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—About 400 meters from the extreme south point of the island, known as China Point, on the top of the inland and highest of four small hillocks directly north of a small rocky island off south end of the point. In 1862 the station was marked by a drill hole in a large, fixed rock. In 1878 a leaden bolt and copper nail were driven into this hole, the nail marking the center of the station. Three drill holes in the fixed rock were made as reference marks; to the south, 3.3 feet; to the east, 3.6 feet, and to the west, 4.1 feet.

Guds (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—Near the southeast end of a high ridge running northwest and southeast and at a point where it commences to descend to form the point of the island and 1⅛ miles from the point. It is the last high, rocky point on the southeast end of the island. The center of the station was a copper nail in a leaden bolt driven into a drill hole in the solid rock, with four drill holes as reference points, to the north, south, east, and west, each distant 2 feet.

Knob (San Clemente Island, California, W. E. Greenwell, 1862; S. Forney, 1878).—On the same ridge as Guds △, and to the northwest of it, on a small knob on the top of the ridge. The center of the station was marked by a copper nail in a leaden bolt driven into a drill hole in the solid rock. There were two drill holes in the rock, 24 inches each from the station, and in a line with it, and 15 feet distant to the north, southeast, and southwest, were three large stones, level with the surface of the ground, with drill holes in the top.

Cactus (San Clemente Island, California, W. E. Greenwell, 1860–62; S. Forney, 1878).—On the western side, near the top, of a flat hill, northwest of San Clemente North Base and three-fourths of a mile west of Wilsons Cove. The center of the station was marked by a stone, 0.6 foot long and 0.4 by 0.3 of a foot on the top, buried even with the surface of the ground, with a copper nail and a leaden bolt in the top to mark the center. Four redwood stubs, each with copper nail in top, were placed 2 feet from the center, to the north, south, east, and west. The old reference stubs to the north and west were left undisturbed. The theodolite stubs of pine were also left. They have no reference to the center of the station.

Mound (San Clemente Island, California, S. Forney, 1878).—About 1 mile east of the landing at the San Clemente anchorage, on a rocky mound, having on each side of it to the north and south a mound of similar character. The station was marked by a stone 8 inches long and 2 by 4 inches at the top with a leaden bolt and a copper nail in the top, the nail marking the center of the station. Redwood stubs were placed 2 feet from the center of the station, to the north and south; and one to the west, 2.15 feet from the center of the station. A copper nail was driven into a crevice in the rock 1.8 feet east of the center.

Mesa (San Clemente Island, California, S. Forney, 1878).—On the mesa to the east of the isthmus at the western end of the island about midway between Driggs Cove and the San Clemente anchorage. The station was marked by a stone 0.7 foot long and 0.3 foot across the top, with a leaden bolt and a copper nail in its top, the copper nail marking the center of station. Four redwood stubs, each with a copper tack in the top were placed even with the surface of the ground, ranging approximately, north, south, east, and west, and distant 2 feet from the center of station.

San Clemente Longitude Station (San Clemente Island, California, George Davidson, 1852; S. Forney, 1878).—At the San Clemente anchorage, on the sand beach about 50 yards from high water mark. To the eastward are small sand dunes covered with old shells and Indian mounds. The station was marked by a flat, irregular-shaped stone with a leaden bolt and a copper tack in the top, buried 2 feet underground. Above this was a redwood post 4 feet long and 3 by 4 inches, projecting 2 feet above the surface, with a copper nail in the top, marking the center of the station. Four smaller redwood stubs, each with copper nail in the top, were buried beneath the surface of the ground, 2 feet distant to the north, south, east, and west.

North Head (San Clemente Island, California, W. E. Greenwell, 1860; S. Forney, 1878).—Near the northern end of the flat-top ridge at the northwestern extremity of the island, near the shore and 400 or 500 meters from a smooth sand beach. About north-northwest is a small island. (Note 3, p. 615.) In 1878 the four reference stubs were found and left undisturbed.

SANTA CATALINA ISLAND.

Cliff (Santa Catalina Island, California, S. Forney, 1875).—On a high bluff near the sea, about 50 yards northeast of the nearest point of the trail, about 1½ miles east of the east point of Isthmus Cove. To reach the station, follow up the trail to the eastward from the isthmus, until you reach the highest ridge, which runs about northeast and southwest; then follow the ridge to the northeast. (Note 20, p. 617.)

Goat (Santa Catalina Island, California, S. Forney, 1875).—On a high prominent bluff point about 2 miles east of the east point of Catalina Harbor. To reach the station, take the sheep trail that leads over the hill to the eastward of the isthmus to the top of the highest ridge, which runs about northeast and southwest; follow the ridge to the southwest. (Note 20, p. 617.)

Red Peak (Santa Catalina Island, California, S. Forney, 1875).—On the extreme northwest point of the island, on one of several peaks forming this point which has a red appearance. (Note 20, p. 617.)

Granite (Santa Catalina Island, California, S. Forney, 1875).—On the highest point of a stony peak, the second highest on the west end of the island, composed of rock of a light color, in texture resembling granite. (Note 20, p. 617.) On the peak, but a few feet from its highest point, a bottle was found in 1875, buried with its mouth down and covered with loose rock; the distance to the bottle was 19.34 feet; in azimuth, 117° 32′ 00″.

Ridge (Santa Catalina Island, California, S. Forney, 1875).—about midway between Granite △ and West Peak △ the ridge divides, one portion continuing on to West Peak △ while the other runs to the south shore, almost at right angles to the main ridge; before reaching the shore, the southerly ridge becomes broken and divided into several rough, steep spurs. The station is situated on the only one of these spurs that sees stations Granite, Slide, and West Peak; and the space where the station is located is the only point on the spur where the three are visible. (Note 20, p. 617.)

Stony Point (Santa Catalina Island, California, S. Forney, 1875).—On a bold stony ridge making up from the coast to the west of a comparatively level space, or plain, cut in two by a deep canyon, in which there is water in two or three places, and which is west of a large space of ground, very much cut up by the action of the rain, forming a very prominent landmark. (Note 20, p. 617.)

Prospect (Santa Catalina Island, California, S. Forney, 1875).—On the ridge on the west side of the isthmus, on the highest point of the ridge visible from the isthmus. There are three spurs leading from the isthmus to the station; one from the center of the isthmus; another from about the southwest point of the isthmus (these two spurs run together, and go to the station as one spur); the third spur runs from the bluff point, forming the western side of Isthmus Cove, and comes to the station from the northward. (Note 20, p. 617.)

Well (Santa Catalina Island, California, S. Forney, 1875).—On a peak to the westward of the entrance of Catalina Harbor and about southwest of a canyon opening into the harbor, in which is a well of water. The southern face of the peak is very rugged and runs almost perpendicularly down to the sea. The station was marked by a stone bottle with a small hole drilled into its bottom, buried with its neck down and bottom even with the surface of the ground. The reference stubs were placed as in note 20, page 617.

Bird Rock (Santa Catalina Island, California, S. Forney, 1875).—On a bold rock off the northwest entrance to Isthmus Cove and about 1½ miles from the beach in the cove, at the south end of the long narrow top. The position of the station is both difficult and dangerous, owing to the cramped space and the loose and treacherous rocks which were continually giving way underfoot. By watching the swells in the harbor a good landing can be effected on the southwest corner of the rock, whence the top can be reached by climbing from ledge to ledge. The station was marked by a piece of iron, circular in form, 3 inches in diameter, 5 inches long, with leaden bolt and iron spike in its top, placed in a crevice in a rock, and wedged and held in its place by small pieces of rock. Four holes were drilled in large bowlders to the north, east, south, and west, and filled with lead, with copper tack in the center of each bolt, at the following distances from the center: north, 47.00 inches; south, 45.25 inches; east, 47.60 inches; west, 38.70 inches.

Santa Catalina Island Latitude Station (Santa Catalina Island, California, G. Davidson, 1852; S. Forney, 1875).—On the rise back of the beach, at the northern anchorage, about 23 meters from low water. The western side of the harbor is about 2° or 3° to the west of north. A piece of iron, circular in form, 3 inches in diameter and an inch and a half thick, with leaden bolt and copper tack with a cross on top, was sunk about 18 inches below surface of the ground. Above this was placed a piece of iron kentledge, about 16 inches long and 4 inches square, with a leaden bolt and iron spike with a cross on it, surrounded by the letters U. S. C. S. A. S. cut with a cold chisel on its top. The reference marks are similar to those at Santa Catalina Island North Base.

White Rock (Santa Catalina Island, California, S. Forney, 1875).—On the highest part of a long rock, or island, about 1 mile from the beach at Isthmus Cove. The station was marked by a redwood stub, 1 inch by 1½ inches, driven in a crevice of the rock, with a copper tack in the top to mark the center. Four leaden bolts, with copper tacks in the top, were set in the rocks of which this island is composed; one to the south, 0.41 feet from the center (in the side of a round rock which stands about 18 inches above the surface, and alongside of which the center stub is placed); one to the north, 2.36 feet; one to the east, 2.10 feet, and one to the west, 2.27 feet.

Santa Catalina Island North Base (Santa Catalina Island, California, S. Forney, 1875).—On the isthmus between Catalina Harbor and Isthmus Cove, on a slight elevation back of a large house known as the old Government Barracks, and between it and an old brick oven belonging thereto. A piece of iron, circular in form, 4 inches in diameter and 3 inches thick, with leaden bolt and copper tack with cross on it, was sunk 16 inches below the surface of the ground. Over this was placed a piece of iron kentledge 4 inches square and about 14 inches long, the top even with the surface of the ground, having a leaden bolt and tack with a cross on the top of tack to mark the center of the station, and the letters U. S. C. S. N. B. cut with a cold chisel. Four brickbats, with a copper tack leaded into the top of each, were placed to the north, south, east, and west, each 2 feet from the center of station; three redwood theodolite stubs were left standing, but have no reference to the center of the station.

Santa Catalina Island South Base (Santa Catalina Island, California, S. Forney, 1875).—On a little grassy flat on the east shore of Catalina Harbor a piece of iron, about 3 inches thick and 5 inches in diameter, but irregular in form, with a leaden bolt and copper tack with a cross cut on its head to mark the center of the station, was sunk 18 inches below the surface; on this was placed a piece of iron kentledge, 4 inches square and 18 inches long, the top even with the surface of the ground, having also a leaden bolt and copper tack with a cross on its head to mark the center of the station, and the letters U. S. C. S. S. B. cut thereon with a cold chisel. The reference marks are the same as at Santa Catalina Island North Base.

Cactus Peak (Santa Catalina Island, California, S. Forney, 1876).—On the highest peak, on a high rocky ridge about three-quarters of a mile from the shore; on the top, which is covered with cactus bushes. The center was marked according to note 20, page 617; the reference marks were as follows: 2.66 feet southwest from the center, in a bowlder of soft rock, a hole was drilled and filled with lead, and a copper bolt was driven into the top of the lead and a cross cut on its top; 2.46 feet northwest from center; a redwood stub was driven into the ground even with the surface, into the top of which was driven a copper rivet with a cross cut thereon; 4.26 feet east from the center of the station, in a large bowlder of soft rock, a hole was drilled and filled with lead, and a copper rivet with a cross cut on its top driven into the top of the lead; 2.73 feet southeast from the center a redwood stub was sunk even with the surface of the ground, and a copper rivet with a cross cut on it driven into its top.

Slide (Santa Catalina Island, California, S. Forney, 1875).—On the northeast side of the southern one of two steep, reddish knolls of a spur running to the sea, on the top of the knoll above the place where there had been a landslide. (Note 20, p. 617.)

West Point (Santa Catalina Island, California, S. Forney, 1875).—On one of the small peaks, immediately back of the beach and forming the dividing ridge between the two shores of the island. The north side of the hill is steep but regular, while to the southward it is very much broken by washes and landslides. (Note 20, p. 617.)

Black Point (Santa Catalina Island, California, S. Forney, 1875).—Near the water's edge, on a low bluff covered with brush giving it a black appearance. (Note 20, p. 617.)

Fish (Santa Catalina Island, California, S. Forney, 1875).—On the extreme right-hand spur running from the ridge on which Ridge △ is located, and well out toward the shore. (Note 20, p. 617.)

Bluff (Santa Catalina Island, California, S. Forney, 1875).—On the edge of the outer knob of a spur which runs from Granite △ toward the coast in a southeasterly direction. (Note 20, p. 617.)

Spur (Santa Catalina Island, California, S. Forney, 1875).—On the edge of the high bluff in which the spur running from Oak △ toward the south shore of the island terminates. (Note 20, p. 617.)

Cone (Santa Catalina Island, California, S. Forney, 1875).—On the second conical peak of the ridge forming the west side of the entrance to Catalina Harbor, very steep and rugged on its north and south faces. The center of the station was marked as in note 16, page 616; reference stubs as in note 20, page 617.

Oak (Santa Catalina Island, California, S. Forney, 1875).—On a smooth, round-topped hill, commanding a view of the north and south sides of the island, on the south of the divide, at the head of the canyon which separates Well △ and Prospect △ and joins the two ridges which lead from them in a westerly direction. (Note 20, p. 617.)

Pablo (Santa Catalina Island, California, S. Forney, 1875).—On a high, round-topped, green point, forming the eastern entrance of a rocky cove, on the beach of which stands a house known as Johnson's; to the westward of a large canyon where there is a spring of fresh water and a house occupied (in 1875) by a Spaniard named Hyppolyte A. Higuera. (Note 20, p. 617.)

Cherry (Santa Catalina Island, California, S. Forney, 1875).—On a very conspicuous white bluff point making out from the west side of the second canyon to the westward from Isthmus Cove, known as Cherry Valley (from the wild cherry trees found there in great numbers), and in which there is a well of good water; on the highest point, and close to the bluff. (Note 20, p. 617.)

Quartz (Santa Catalina Island, California, S. Forney, 1876).—On a hill covered with broken quartz; not on the top, but about a quarter of a mile directly toward the shore from the top and at a point where the ground begins to slope more rapidly. (Note 20, p. 617.)

Brush (Santa Catalina Island, California, S. Forney, 1876).—On the top of a brushy hill on the trail that leads east from Cliff △. (Note 20, p. 617.)

Silver (Santa Catalina Island, California, S. Forney, 1877).—On a bare knoll on the edge of a high, bold bluff forming the southern end of the same ridge on which Dakin △ and Lone Tree △ are located, on the east side of Silver Canyon, where a number of deserted mines are located. (Note 20, p. 617.)

Timms (Santa Catalina Island, California, S. Forney, 1876).—On the top of a high, smooth hill a little south of the trail from the isthmus to Dakins Cove and about a half mile east of where the trail up Gallaghers Canyon joins the east and west trail. (Note 20, p. 617.)

Dakin (Santa Catalina Island, California, S. Forney, 1876).—On the high ridge running across the island from north to south, forming the west side of the valley in which Dakin's house is located; about a quarter of a mile south of the top of the hill from the east side of Gallaghers Canyon; on a smooth hill at the northern end of this ridge and about 500 yards south of the trail running from Dakin's house to Catalina and Isthmus Cove harbors. (Note 20, p. 617.)

East Peak (Santa Catalina Island, California, S. Forney, 1876).—On the south end of the last high ridge that runs across the east end of the island from north to south. (Note 20, p. 617.)

East Mountain (Santa Catalina Island, California, S. Forney, 1876).—On the top of the northern end of the last high ridge that runs across the east end of the island from north to south. The trail from Dakins Cove to the south passes near the station. (Note 20, p. 617.)

Lone Tree (Santa Catalina Island, California, S. Forney, 1876).—On the main ridge running north and south, on the top of a rocky peak the next south of a peak with one large bush or tree on the northeast face near its summit. The trail passes around the foot of this peak on the northwest side. (Note 20, p. 617.)

High Mountain (Santa Catalina Island, California, S. Forney, 1876).—On the highest peak of Catalina Island, at the base of which, on the eastern side, a deep canyon runs toward the south side of the island, containing several springs of good water and a great many willow trees. (Note 20, p. 617.)

Freeman (Santa Catalina Island, California, S. Forney, 1876).—In a rolling country to the northeast of Cactus Peak, on the top of the most prominent one of the peaks which are from 150 to 200 feet lower than Cactus Peak. (Note 20, p. 617.)

Round Top (Santa Catalina Island, California, S. Forney, 1876).—On the top of a prominent conical-shaped hill about 150 feet above and to the north of the trail along the ridge from Cactus Peak △ eastward. (Note 20, p. 617.)

Ord (Santa Catalina Island, California, S. Forney, 1876).—On the top of the first prominent peak on the first ridge on the east side of the valley at Dakins Cove. (Note 20, p. 617.)

Whitleys Peak (Santa Catalina Island, California, S. Forney, 1876).—On the top of a high, bold peak, the highest point of the ridge on the east side of Whitleys Valley; the highest peak in sight in a southeasterly direction from Whitley's house. (Note 20, p. 617.)

Corral (Santa Catalina Island, California, S. Forney, 1876).—On the north slope of the ridge forming the east side of a deep canyon known as Gallaghers Canyon; on the third rise from the beach. (Note 20, p. 617.)

North Spur (Santa Catalina Island, California, S. Forney, 1876).—On the top of the hill on the west side of the small cove west of Dakins Cove, the termination of the first large ridge west of Sugarloaf Spur. (Note 20, p. 617.)

Fletcher (Santa Catalina Island, California, S. Forney, 1876).—On a smooth, round hill on the side of the high ridge which runs across the island from north to south, the same ridge upon which Catalina Peak △ and High Mountain △ are located. The hill is north of a dark red knoll which is west of the small canyon directly under Catalina Peak. (Note 20, p. 617, except that the east and west stubs were oak and the latter was 2.4 feet from the △.)

Knob (Santa Catalina Island, California, S. Forney, 1876).—On a high, well-defined point between the canyon whose east fork runs up to East Peak △ and the canyon to the west of it. (Note 20, p. 61.7)

Pot (Santa Catalina Island, California, S. Forney, 1876).—About three-quarters of a mile from the shore, about a hundred yards north of the trail leading from Cliff △ eastward, on a high prominent hill at the head of what is known as Pot Valley, the first high hill eastward from Cliff △. What is called Pot Valley is not really a valley, but is a rolling table-land lying along the shore to the eastward of Cliff △. (Note 20, p. 617.)

Green (Santa Catalina Island, California, S. Forney, 1876).—On a high hill at the east end of Pot Valley about a half mile from the shore. (Note 20, p. 617).

Grape (Santa Catalina Island, California, S. Forney, 1876).—On a bluff a quarter of a mile west of and in sight of Charley Miller's house, across a small canyon with a large grapevine in it. (Note 20, p. 617.)

Carlos (Santa Catalina Island, California, S. Forney, 1876).—On a high bluff about three-quarters of a mile east of Charley Miller's ranch, an old house and corral near the beach. (Note 20, p. 617.)

White Bluff (Santa Catalina Island, California, S. Forney, 1876).—On a white bluff about two miles east of Catalina Harbor and about a half mile west of a small harbor known as Little Harbor, where there is an old house and sheep corral. (Note 20, p. 617.)

Edge (Santa Catalina Island, California, S. Forney, 1876).—On the edge of the sea bluff, which is almost perpendicular on the sea side, about a quarter of a mile from a deep canyon to the east. (Note 20, p. 617.)

Long Point (Santa Catalina Island, California, S. Forney, 1876).—At the edge of the bluff at the first point east from the extreme north point of the island. (Note 20, p. 617.)

White (Santa Catalina Island, California, S. Forney, 1876).—On a bold rugged bluff which forms the east point of Whites Valley, quite close to Frank Whitley's house. The station was marked by a brickbat with leaden bolt and iron spike placed in a crevice in the rock and wedged and held in place by small pieces of rocks. The reference marks were as follows: a lead bolt in a drill hole in the rock 2 feet from the center to the east; copper tacks leaded into drill holes 2.8 feet from the center to the west and 2 feet to the south.

Southeast Point (Santa Catalina Island, California, S. Forney, 1876).—On the extreme southeast point of the island, about 450 yards back from and north of the bluff and about 300 yards from a drain on the east; about 100 yards from the shore under this station is Southeast Rock △. (Note 20, p. 617.)

Northeast Point (Santa Catalina Island, California, S. Forney, 1876).—On the extreme northeast point of the island about 550 yards from the shore to the east and south and about 120 yards back from a small bluff. (Note 20, p. 617.)

Sugar Loaf Spur (Santa Catalina Island, California, S. Forney, 1876).—On the ridge forming the west side of Dakins Cove, of which the high regular-shaped rock at the west point of the cove, called Sugar Loaf Rock, is the prolongation, about 200 yards from the nearest point of the shore. (Note 20, p. 617.)

Black Ridge (Santa Catalina Island, California, S. Forney, 1876).—On the seaward end of the black, brush-covered ridge running to the sea. (Note 20, p. 617.)

SAN NICOLAS ISLAND.

San Nicolas (San Nicolas Island, California, S. Forney, 1879).—On the northern edge of a table-land forming the highest land on the island. (Note 19, p. 617, except that there were 3 stubs around the center stone.) There were also four oblong rocks, buried even with the surface of the ground, to the north, south, east, and west, and equidistant from the center of the station.

Azimuth (San Nicolas Island, California, S. Forney, 1879).—On the point of a shoulder of the hills, about three-fourths of a mile due south of the western one of the two points at the northwest corner of the island; at a point where the incline changes from a gentle slope to a steeper one; about a half mile west by north of a fine spring with a few trees around it, which is about a half mile southwest of a small house on the shore where the claimant of the island lived in 1858. (Note 19, p. 617.)

Slope 2 (San Nicolas Island, California, S. Forney, 1879).—On a long, flat slope which begins at the ridge on the south end of the top and slopes northerly across the top of the island; on the east edge of the slope and about midway between the north and south ends; about due south of Corral Harbor; on an old shell mound. (Note 19, p. 617.)

Summit 2 (San Nicolas Island, California, S. Forney, 1879).—On the highest shell mound on the summit of the island. (Note 19, p. 617.)

Ridge (San Nicolas Island, California, W. E. Greenwell, 1858; S. Forney, 1879).—On the top of the main ridge or backbone of the island, at a point where the ground slopes gently to the eastward and northward; about 200 yards to the east of a small depression in the ground, which is the head of a wide arroyo that falls gently to the northeast. There are traces of an old shell mound around the station. (Note 19, p. 617.)

Port (San Nicolas Island, California, W. E. Greenwell, 1858; S. Forney, 1879).—Near the bluff, on the top of the island, about 2 miles east of Corral Harbor; southwest of a deep gulch which makes up from the north side of the island. (Note 19, p. 617.) There were also four stubs, each with a nail in the top, around the station to the north, south, east, and west, and equidistant from the center.

Bluff (San Nicolas Island, California, W. E. Greenwell, 1858; S. Forney, 1879).—On a dark knoll, one-fourth of a mile from the face of the bluff and on the same table-land as the base line. (Note 19, p. 617.) There were also three stubs, each with a nail in the top, to the north, south, and west of the center.

Cliff (San Nicolas Island, California, W. E. Greenwell, 1858; S. Forney, 1879).—Immediately on the bluff, on a conspicuous chalky-looking knoll of whitish color. (Note 19, p. 617.) There were also three other stubs, each with a nail in the top, to the north, east, and west of the center.

San Nicolas Island North Base (San Nicolas Island, California, W. E. Greenwell, 1858; S. Forney, 1879).—On the high, flat table-land near the east end of the island. The station was marked by a red sandstone 4 inches square, on the top of which were cut the letters U. S. C. S. The reference marks were according to note 19, p. 617.

San Nicolas Island South Base (San Nicolas Island, California, W. E. Greenwell, 1858; S. Forney, 1879).—On the high table-land at the east end of the island, about

200 yards from the northern end of the mesa. It was marked exactly as San Nicolas Island North Base △.

Kelp (San Nicolas Island, California, W. E. Greenwell, 1858; S. Forney, 1879).—On the summit of a round, flat-topped knoll at the east end of the island. (Note 19, p. 617.) There were also four redwood stubs, each with a copper tack in the top, to the north, south, east, and west, about 3 feet from the center.

Spur (San Nicolas Island, California, S. Forney, 1879).—On the edge of a spur leading from the table-land on which the base is located and overlooking the sand beach on the east end of the island. (Note 19, p. 617.)

Bonn (San Nicolas Island, California, S. Forney, 1879).—At the eastern edge of the table-land on which the base line is located. (Note 19, p. 617.)

San Nicolas Island Astronomic Station 2 (San Nicolas Island, California, S. Forney, 1879).—At the southerly end of the sand spit on the east end of the island, 100 yards northeast from the line of a rocky bluff and about 50 yards from the beach. The ground around the station is a level sand bed, which is subject to overflow from the sea during southeast gales. (Note 19, p. 617.)

Spring (San Nicolas Island, California, S. Forney, 1879).—Near the shore line on the extreme southwest point of the island, on a prominent sand dune; about 400 yards north of a spring of slightly brackish water on the face of the sea bluff. The station was marked by a stone, with leaden bolt and copper tack, buried three feet below the surface of the ground. Above this, even with the surface of the ground, was placed a stone with leaden bolt and copper tack; three redwood stubs, with copper nail in each one, were placed to the north, south, and west, 4 feet from the center.

North Head (San Nicolas Island, California, W. E. Greenwell, 1858).—On the northwest end of the island, about 80 feet above and one-fourth mile south of Azimuth △, and about a mile from the shore. (Note 19, p 617.) There were also four redwood stubs, each with a copper tack in the top, to the north, south, east, and west, about 3 feet from the center.

SANTA BARBARA ISLAND.

Mer Slope (Santa Barbara Island, California, A. W. Chase, 1871).—On the trail leading up to the highest part of the island and well up on the ridge. The ground about the station is undermined by the mer, or mutton bird, and filled with holes. (Note 18, p. 617.)

Southwest Ridge (Santa Barbara Island, California, A. W. Chase, 1871).—On the edge of the bluff on the southwest side of the island, about halfway up the hill from the first bench, in a clump of cactus. (Note 18, p. 617.)

Santa Barbara Island South Base (Santa Barbara Island, California, A. W. Chase, 1871).—On the second bench or slope on the eastern face of the island, near a clump of cactus and wild cabbage bushes, a hundred yards southwest of a bare place about midway between the edge of the bank and the bottom of the hill. (Note 18, p. 617.)

Santa Barbara Island North Base (Santa Barbara Island, California, A. W. Chase, 1871).—On the same slope as Santa Barbara Island South Base, in the thorny furze bushes beyond the trail leading up to the ridge, about halfway between the bluff edge and the bottom of the steep hill. (Note 18, p. 617.)

East Mound (Santa Barbara Island, California, A. W. Chase, 1871).—On the summit of the conical hill on the northeast side of the island. (Note 18, p. 617.)

Corral (Santa Barbara Island, California, A. W. Chase, 1871).—On top and at the edge of the first bench above the house, on the left-hand side of the trail leading up from the corral and in the midst of a clump of cactus. (Note 18, p. 617.)

Middle Ridge (Santa Barbara Island, California, A. W. Chase, 1871).—On the small middle hill or mound between the two large ones forming the top of the island, on the right-hand side of the trail leading across the island. (Note 18, p. 617.)

Cave Point (Santa Barbara Island, California, A. W. Chase, 1871).—On a projecting point, the first to the northeast of the landing place, near the edge of the bluff, surrounded by dead wild-cabbage trees. (Note 18, p. 617.)

Fisherman (Santa Barbara Island, California, A. W. Chase, 1871).—On the northwestern side of the island, on the first prominent hillock down the hill from the middle ridge. (Note 18, p. 617.)

SANTA CRUZ ISLAND.

Summit Peak (Anacapa Island, California, O. H. Tittmann, 1876).—On the highest peak of the island. The station was marked by an irregular stone, flat surfaced, with a hole drilled in it.

Dixon (Santa Cruz Island, California, S. Forney, 1874).—On a high peak of the ridge forming the west side of Cañada Posa; not at the highest point, but at the extreme southwest end of the long rather level top. (Note 17, p. 617.)

John (Santa Cruz Island, California, W. E. Greenwell, 1857; S. Forney, 1874).—On one of the peaks forming the high ridge of mountains running through the island from east to west, immediately in front of the north side of the West End ranch house, and about 400 yards from where the trail strikes the top of the ridge. Two stubs were placed 18 inches from the center, to the north and south, and two other stubs 24 inches to the east and west. (Note 17, p. 617.)

Ragged Mountain (Santa Cruz Island, California, W. E. Greenwell, 1857; S. Forney, 1874).—On the highest part of a stony ridge that leads up to the highest mountain on the southwestern part of the island. The best way to get to it is to follow the valley to the eastward from the West End ranch house until you come to the barley field; here the valley forks; take the right-hand fork, and follow it until you strike the first conical peak of large white mountain reached by following down a ridge leading to the south side of the island. Note 17, page 617, but there were no center bottles and the reference bottles were 3 feet from the center; four reference stubs were placed 3 feet from the center, to the north, south, east, and west.

Devils Peak (Santa Cruz Island, California, W. E. Greenwell, 1857; S. Forney, 1874).—On the top of the highest peak on the island. Note 17, page 617, except that a redwood stub, instead of a bottle, marked the center.

Flagstaff (Santa Cruz Island, California, S. Forney, 1874).—Near the West End ranch house, 66.2 feet, north 36° west, from the northwest corner. (Note 17, p. 617.)

Center (Santa Cruz Island, California, W. E. Greenwell, 1856; S. Forney, 1875).—On a red clay knoll in the center of the old wagon road. To reach the station, follow the wagon road from West End ranch house to about 1 mile beyond and east of the last clump of pines; then take the right-hand fork of the road. The station was marked by a redwood stub; the reference marks were bottles, as in note 17, page 617; there were also two large stubs north and south and two small ones east and west, with copper tacks in top, all distant 3 feet 9 inches from center.

Red Peak (Santa Cruz Island, California, W. E. Greenwell, 1857; S. Forney, 1874).—On a high, bold peak covered with red rock immediately in front of the main ranch house, which can be approached by a small brushy ridge on the north face of the valley; about 1½ miles west of the main ranch house. (Note 17, p. 617, except that there was a stub at the center.)

Grouse (Santa Cruz Island, California, W. E. Greenwell, 1856; S. Forney, 1875).—On the top of the main ridge, a little over half a mile east of Shaw △, between where the fourth and fifth ridges from the valley join it, counting eastward from the ridge Shaw △ is on. (Note 17, p. 617, except that the reference marks were redwood stubs, with copper tacks in the top, instead of bottles.) Four other stubs were placed around the station at distances of 36 inches.

Cave (Santa Cruz Island, California, W. E. Greenwell, 1857; S. Forney, 1875).—On the top of a steep, rocky hill on the west side of the mouth of a narrow valley, running south on the east side of which is a large white mountain and in which is a stream of good water and plenty of willows; you will also pass the remains of a brush fence at the ridge about a quarter of a mile west from Center △ which leads down into the valley. This ridge has a well-defined trail leading down it on the east side. The center of the station was marked by a redwood stub, 2 by 3 inches, covered with stones; the reference marks were as follows: a redwood stub to the east 1.8 feet from the center of station; a bottle to the south 2 feet from the center; a bottle to the north 1.4 feet from the center.

Valley Peak 2 (Santa Cruz Island, California, W. E. Greenwell, 1857; S. Forney, 1875).—Thirty yards north of Valley Peak 1 △ (p. 698), on the highest peak of the ridge bordering the valley on the north side, in an easterly direction from the superintendent's house. The station was marked by four stubs, each 3 feet from the center, to the north, south, east, and west.

Harbor (Santa Cruz Island, California, W. E. Greenwell, 1857; S. Forney, 1875).—On the second ridge east of the valley leading from the beach at Prisoners Harbor to the main ranch. To reach the station, follow the trail up the first ridge (east from Prisoners Harbor) until it branches to the left, then up this branch to the main part of the second ridge (east from Prisoners Harbor); then about halfway down this ridge (to the left) toward the sea is the station. (Note 37 p. 618.)

Mount Pleasant (Santa Cruz Island, California, W. E. Greenwell, 1857).—Reported lost in 1875. On a mountain, known as Mount Pleasant, halfway on the trail leading from the main ranch house to the eastern ranch house. The center was marked by a pine pole. There were no reference stubs.

Coche Point (Santa Cruz Island, California, W. E. Greenwell, 1857; S. Forney, 1875).—On a high, perpendicular bluff to the eastward of Prisoners Harbor, known as Coche Point; not immediately on the bluff, but 400 or 500 meters beyond on the second slope, on a little knoll partly free from the thick growth of dwarf oaks with which the point is covered. The station was marked by four reference stubs, to the north, east, south and west, each distant 3 feet from the station.

Ridge (Santa Cruz Island, California, W. E. Greenwell, 1857).—Reported lost in 1875. Halfway along the ridge to the eastward from Mount Pleasant to the high mountain, on a hill covered with red dwarf bushes, on the trail from the main ranch house to the East End ranch house. A willow pole marked the center. There were no reference stubs.

High Mount (Santa Cruz Island, California, W. E. Greenwell, 1857; S. Forney, 1875).—On a peak in a high range of wooded mountains east of Prisoners Harbor, running apparently across the island; immediately on the trail from Scorpion Harbor to the main ranch, at about the highest elevation on the trail before descending the west slope. (Note 17, p. 617, redwood stubs, with copper nails in their tops, being substituted for bottles.) There was also an oak stub 3 feet to the north of the station.

Azimuth Mark (Santa Cruz Island, California, S. Forney, 1874).—About 1 mile west of Mesa △, on the same ridge. The mark was a short pole, supported by three short braces, with a range mark to the west of it about 20 feet.

East Point (Santa Cruz Island, California, W. E. Greenwell, 1857; S. Forney, 1875).—On a smooth, conspicuous hill overlooking the shore, the only high hill near the east point of the island, a few feet down the slope from the highest part of the hill. The station was marked by a stub.

Platts Harbor (Santa Cruz Island, California, W. E. Greenwell, 1857; S. Forney, 1875).—On the eastern headland of Platts Harbor, a point covered with scrub pines. The best approach is from a landing about 1 mile east. The station was marked by a stub, 2 by 3 inches, and four reference stubs, 2 by 3 inches, were placed to the north, south, east, and west of the station and 4 feet from it.

Punta Diablo (Santa Cruz Island, California, S. Forney, 1874).—On a high, bold point of that name about half a mile northwest of the small cove called Frys Harbor; on the east side of the point about 400 feet east of the west end of the north bluff, where the slope changes from a gentle to a steep incline. (Note 37, p. 618.)

Punta Gorda (Santa Cruz Island, California, S. Forney, 1874).—On a broad white point near the sea, about 2½ miles to the east of Santa Cruz △, on an old shell mound. (Note 17, p. 617; reference bottles only.)

Posa (Santa Cruz Island, California, S. Forney, 1874).—On the second ridge to the east of the Posa Landing, about 1 000 yards from the shore line. (Note 17, p. 617; reference bottles only.)

Alta (Santa Cruz Island, California, S. Forney, 1873).—On the highest peak as seen from the West End ranch house looking in a northnortheast direction. The north face of this peak is covered with large oak trees; there are also a few on its summit. (Note 17, p. 617; reference bottles only.)

White Hill (Santa Cruz Island, California, S. Forney, 1873).—On a white-colored hill about halfway between the West End ranch house and Cañada Posa and on the trail between them. (Note 17, p. 617, reference bottles only.)

Black Hill (Santa Cruz Island, California, S. Forney, 1874).—On a brushy, dark-looking hill about halfway between Kinton △ and White Bluff △. (Note 17, p. 617, reference bottles only.)

Gull (Santa Cruz Island, California, S. Forney, 1874).—On a high hill covered with brush and cactus, on a small ridge south of Black Hill △, about 700 yards from the shore line. (Note 17, p. 617, reference bottles only.)

Bluff (Santa Cruz Island, California, S. Forney, 1874).—On the first high, bold bluff southwest from the West End ranch house, near the edge of the sea bluff. About 20 yards from the base of this bluff is a large rock. (Note 17, p. 617.)

Bench Mark (Santa Cruz Island, California, S. Forney, 1874).—On the mesa, at the point of the ridge which forms the south side of the valley at the West End ranch house, about 1 000 yards south 62° west from the northwest corner of the ranch house. (Note 17, p. 617, reference bottles only.)

Kinton (Santa Cruz Island, California, S. Forney, 1874).—On the first bold bluff to the southwest of Bluff △, near the edge of the sea bluff, on the south side of the point. (Note 17, p. 617, reference bottles only.)

Black Point (Santa Cruz Island, California, S. Forney, 1874).—Near the edge of the sea bluff, on the west side of Black Point, the first prominent point to the north and west of the West End ranch house, and formed by a large black rock. (Note 17, p. 617, reference bottles only.)

Mesa (Santa Cruz Island, California, S. Forney, 1874).—On the main ridge running through the island from east to west. (Note 17, p. 617, reference bottles only.)

Toro (Santa Cruz Island, California, S. Forney, 1874).—On the main ridge running through the island from east to west, on a knoll on the north face of the ridge. The station was marked by three stone bottles, each with a hole in the bottom, buried neck down even with the surface of the ground, one to the east and one to the south, each 2 feet from the center of the station, and one to the west 3 feet from the center.

West Point (Santa Cruz Island, California, S. Forney, 1874).—On the south side of the low point which forms the extreme west point of the island, near the sea bluff, which, at this point, runs north and south. (Note 17, p. 617, except that a stub marks the center.)

Valley Peak 1 (Santa Cruz Island, California, W. E. Greenwell, 1856; S. Forney, 1875).—On the top of the highest peak of the ridge bordering the valley on the north side, in an easterly direction from the superintendent's house. (Note 37, p. 618.)

Valley 1 (Santa Cruz Island, California, W. E. Greenwell, 1856; S. Forney, 1875).—At the top of the main ridge bordering the valley (in which are located the main ranch buildings), on the north side, and east of the canyon leading to the beach at Prisoners Harbor, about north of Santa Cruz Island East Base △, but not visible from it. (Note 37, p. 618.)

Valley 2 (Santa Cruz Island, California, W. E. Greenwell, 1856; S. Forney, 1875).—On the east end of the ridge bordering the valley (in which the main ranch buildings are located) on the south; the station was marked by a redwood stub, 2 by 3 inches, and four stubs were placed to the north, south, east, and west, and 2 feet from the center. Two other stubs were placed there in 1856, 2 feet 9 inches from the center; these were found in 1875, and left standing.

Shaw (Santa Cruz Island, California, W. E. Greenwell, 1856; S. Forney, 1874).—Very near the top of the ridge, nearly bare of vegetation, immediately in the rear of the house occupied by Mr. Joyoux (1874). The station was marked by a redwood stub in the top of which a copper tack with a cross on it was driven. Four redwood stubs, each with a copper tack in the top, were placed to the north, south, east, and west, and 2 feet each from the center. There were three other stubs around the center, 44 inches distant.

Santa Cruz Island West Base (Santa Cruz Island, California, W. E. Greenwell, 1856).—Reported lost, 1873.

Santa Cruz Island East Base (Santa Cruz Island, California, W. E. Greenwell, 1856; S. Forney, 1875).—About the center of the valley, 300 meters east of the house occupied in 1874 by the superintendent of the island, Mr. J. B. Joyoux. The station was marked by a granite stone sunk into the ground, and by four reference stubs driven into the ground, one to the east and one to the west, each 2 feet 9½ inches from the center; one to the north and one to the south, each 2 feet 8½ inches from the center.

Santa Cruz West Latitude Station (Santa Cruz Island, California, O. H. Tittmann, 1874).—Near Santa Cruz West △ (p. 631).

SANTA ROSA ISLAND.

Farrell (Santa Rosa Island, California, W. E. Greenwell, 1869; S. Forney, 1872.)—On the top of a conspicuous smooth hill which can be seen, and is prominent, from any part of the west face of the island. Immediately in the vicinity of the station the top of the hill is covered with small shells. West of the station, at the base of the hill, was a board fence which continued on down to the south face of the island. On the north face of the hill, about 200 feet down from the station, was a small spring of good water. The station was marked by a block of limestone, 3 by 3 inches at the top, with a small hole drilled in the center, and the letters U. S. C. S. cut on the top of the stone. Four redwood stubs, with a brass nail with a cross on its head driven into each, were placed to the north, south, east, and west, equidistant from the center.

Brockway (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1873).—On the north face of the island about a quarter mile from the ocean, near the mouth of a canyon on the west, about midway between it and the Cañada Verde on the east. The station was marked by a limestone block, 3 by 3 inches, with the letters U. S. C. S. cut on the top face. Four redwood stubs, 3 by 3 inches, each with a composition tack marked with a cross in the top, were placed north, south, east, and west 4 feet from the center. The three theodolite stubs were left undisturbed, but they bear no tacks.

Gulch (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—On a small hill on the north face of the island, and not more than a quarter mile from the ocean. About 450 meters east of the station was a board fence. (Note 38, p. 618.) The stubs upon which the theodolite tripod rested were left undisturbed.

La Mesa (F) (Santa Rosa Island, California, S. Forney, 1872).—On the top of the eastern and the higher of two isolated mesas about midway of the island east and west, and 1 mile from the north shore of the island; between Cañada Soledad and Cañada Verde. On the slope of the hill, about 1 500 meters south of the station, is a large corral. West of this corral, and close by, in Cañada Soledad, stands an old house; this is the only house and corral on the west end of the island. (Note 36, p. 618, except that the center stub was set into the ground 18 inches.) The three theodolite stubs were left standing; they have no tacks in them.

Black Mountain (Santa Rosa Island, California, S. Forney, 1872).—On the top of a black mountain in plain view from the ranch house at the landing on the east end of the island. The north slope of the mountain is covered with stunted pine and oak trees. (Note 21, p. 617, the stubs being 2 feet from the center.)

Pecho (Santa Rosa Island, California, S. Forney, 1872).—On the northern and higher of two prominent conical shaped peaks close together on the main ridge that runs through the island. (Note 38, p. 618.) The theodolite stubs were left undisturbed, but they bear no nails.

Soledad (Santa Rosa Island, California, S. Forney, 1872).—On the highest peak of the island, at the head of Cañada Soledad. To reach the station, follow Cañada Verde to a small grove of willows surrounding a spring of water. At this point there is a trail leading over a low divide into the next canyon, which is Cañada Soledad; follow this canyon to its head. The station was marked by a 2 by 3 inch redwood stub. Two copper tacks were leaded into holes drilled into the rock in line with the center, northwest 3.35 feet, and southeast 3.85 feet. To the north 3 feet, and to the south two-thirds of a foot, in line with the center, were two redwood stubs, each 2 by 3 inches, with a copper tack in the top. There were but two stubs used at this station for the theodolite tripod; the third leg rested on a rock. These stubs were left undisturbed in the ground.

Summit (Santa Rosa Island, California, S. Forney, 1872).—On the highest peak at the west end of the main ridge of mountains that runs through the center of the island from east to west. (Note 36, p. 618, except the north and south stubs were redwood, the east and west were pine.) The three theodolite stubs were left in the ground undisturbed, but they had no tacks in them.

Divide (Santa Rosa Island, California, S. Forney, 1872).—On a bare, isolated knoll which is part of the only ridge leading from Soledad △ to the south side of the island. (Note 36, p. 618.) The theodolite stubs were left undisturbed in the ground. They had no tacks in them.

Grouse 2 (Santa Rosa Island, California, S. Forney, 1872).—On a rocky hill, about a quarter of a mile from the shore line, at the end of the ridge on which Divide △ is located. The station was marked by a redwood stub, 2 by 3 inches, fitted into a hole cut into the rock. Two redwood stubs were placed to the east and west, in a line with the center, and one to the north. Each stub was 2 feet from the center and had a composition tack in the top, and the head of each tack had a cross cut upon it. The theodolite stubs were left undisturbed.

Alta (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—On the top of a smooth, egg-top hill, the highest in the vicinity of the east point of the island, about 1 200 yards from the shore. (Note 38, p. 618.) The four stubs set in 1860 were found in 1872.

Sand Point (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—To the west of the top of a low, white hill, smooth and grassy on its top, southeast of the anchorage. The station was marked by a stone monument, 3 by 3 inches, with U. S. C. S. cut on it. Four stubs with nails in their tops were placed around the center in 1860, and in 1872 four redwood stubs, each with a composition tack in the top, with a cross cut on the head, were placed alongside the old stubs, north, south, east, and west, in a line with the center of the station and 2 feet from it.

Ridge (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—On the highest part of a conspicuous smooth ridge almost 3 miles south of the anchorage north of the Cañada Corvron, and about 600 meters north of an old corral. The station was marked by a stub with a nail in its top. Four redwood stubs were placed to the north, south, east, and west and equidistant from the center; the ones to the north and east with nails in the tops; those to the south and west with tacks marked with crosses on the heads.

Corral (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—About northwest of the anchorage, on a smooth hill which makes well down to the ocean, at a point southeast of the top. To the south of it stands a ridge of white sand, a distinguishing feature on this part of the island. About east-southeast and distant 600 meters is an old corral and wharf. The station was marked by a stone monument, 3 by 3 inches at the top, with the letters U. S. C. S. cut on it. In 1872 four redwood stubs, each with a composition nail in the top, with a cross cut on the nail, were placed to the north, south, east, and west, in a line with the center of the station and 2 feet from it. Alongside three of these stubs were the stubs of 1860, each with a composition nail in the top.

Black Hill (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—Upon one of the foothills of Black Mountain. It can be found by following up the cañada leading from the anchorage to its head and thence ascending the ridge to the left. The station was marked in 1860 by a stub with a nail in the top, surrounded by four similar stubs. In 1872 four new redwood stubs were placed to the north, south, east, and west, in a line with the center and 2 feet from it, each with a copper tack in the top. The four old stubs were left standing. They each have a composition nail in the top.

Santa Rosa Island West Base (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—At the western end of the level stretch of land (see Santa Rosa Island East Base △), and at the western end of the top of a slight elevation. It was marked exactly like Santa Rosa Island East Base △.

Santa Rosa Island East Base (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—On what is known on the island as the Rodea Ground, a level place where large bands of cattle are collected, almost a thousand meters northwest of a small wooden house near the main anchorage; about the middle of the top of a slight elevation. The station was marked by a red sandstone block sunk 1 foot in the ground and projecting 2 inches, with the letters U. S. C. S. cut on the top. Four redwood stubs, each with a brass nail in the top with a cross cut on it, were placed to the north, south, east, and west, in line with and 2 feet from the center.

Round Top (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—On the top of a conspicuous round-top hill, in the foothills between two cañadas, the one on the west being the Cañada Lobos. The station was marked by a redwood stub with a composition nail in the top, surrounded by four similar stubs. In 1872 new redwood stubs, each with a copper nail in the top, were placed to the north, south, east, and west, in line with the center and 2 feet from it.

La Mesa (G) (Santa Rosa Island, California, W. E. Greenwell, 1860).—Probably lost, 1872; see La Mesa (F) △, page 699.

Lime Point (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—On the extreme northeast point of a rolling table-land northeast of Cañada Verde; almost 480 feet due south of a point on the bluff, 300 feet west of the mouth of a small stream, the first stream west of the Cañada Lobos. (Note 37, p. 618, except that the kind of stub was not stated.)

Spur (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—On the west face of the hill which is the continuation of the same spur on which Farrell △ is located, on the trail that leads over the main ridge of mountains running across the island from east to west. The station was marked by a stub with a composition nail in the top, and by four redwood stubs, each 2 by 3 inches, and with a copper tack in the top, placed to the north, south, east, and west, in a line with and 2.5 feet from the center.

Grouse (Santa Rosa Island, California, W. E. Greenwell, 1860).—Reported lost in 1872.

East Point (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—Within 200 meters of the extreme east point of the island, close to the south bluff. (Note 38, p. 618.) There were four other stubs around the station.

Corvron (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—On a round, smooth-top hill, but not on the summit. To reach the station, follow up the Cañada Corvron to a quagmire. At the present time (1872) there is a large spring of water with some willows around it at the foot of the hill; the water is excellent. The spot can not be mistaken, as these are the only trees on this edge of the island. The station is on the hill overlooking the spring, to the northward and nearly abreast of it. (Note 37, p. 618, except distance from center not given.)

Barton (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—On a smooth-top hill which, in the immediate vicinity of the station, is very stony; about 2 miles from the ocean and about due south of the spring described in Corvron △. The station was marked by three redwood stubs to the east, west, and south, and 2 feet from the center, each with a copper tack in the top.

Vaca (Santa Rosa Island, California, W. E. Greenwell, 1860).—Reported lost in 1872.

Borrego (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—Three hundred meters from the shore, immediately east of a large cañada, which is a prominent feature of this part of the island and in which there is water. (Note 37, p. 618.)

Bald Hill (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—On the top of a steep peak of a ridge making down to Cañada Corral, the highest and boldest peak in the vicinity. (Note 37, p. 618.)

South Point (Santa Rosa Island, California, W. E. Greenwell, 1860; S. Forney, 1872).—On a high and conspicuous ridge which forms the south point of the island. (Note 37, p. 618, except distance from the center was not given.)

Fox (Santa Rosa Island, California, S. Forney, 1872).—On a long narrow point, the fourth spur west of the Cañada Corral. The station was marked by a redwood stub 2 by 3 inches. Four similar stubs, each with a copper tack in the top, were placed to the north, south, east, and west, 4 feet from the center.

Sand (Santa Rosa Island, California, S. Forney, 1871).—On the top of the high sand hill at the extreme west point of the island. The station was marked by four redwood stubs, each 2 by 3 inches, a copper tack in the top of each, placed to the north, east, south, and west, equidistant from the center.

Blunt (Santa Rosa Island, California, S. Forney, 1871).—On a smooth oval-shaped hill on the south face of the island, about a quarter of a mile from the beach and a mile and a half from the west point of the island. The southwest face of the hill on which the station is located is covered with small limestones; to the northwest of the hill is a gulch running about east and west down to the ocean. The station was marked by a 2 by 3 inch redwood stub and secured by four similar stubs, each with a copper tack in its top, placed to the north, east, south, and west, in a line with and equidistant from the center.

Point (Santa Rosa Island, California, S. Forney, 1872).—On the top of the most prominent point at the northwest end of the island, a short distance from Sand △. (Note 38, p. 618.)

West Point (Santa Rosa Island, California, W. E. Greenwell, 1860).—Reported lost in 1872.

SAN MIGUEL ISLAND.

San Miguel 2 (San Miguel Island, California, S. Forney, 1871).—On the highest part of the island. The station was marked by a redwood post, 4 feet 6 inches long, 6 inches square, sunk into the ground. The reference marks were four small copper bolts driven into the corners of the top frame of the frustrum of a pyramid on which the braces of the signal rested. These bolts are equidistant from the center and the diagonal lines connecting them intersect at the center.

Harbor 2 (San Miguel Island, California, S. Forney, 1871).—On the east side of the most prominent point at the north end of the island; also the highest part of this end of the inland, about northwest from the anchorage in Cuylers Harbor; near the edge of the bluff which drops off perpendicularly to within 40 or 50 meters of the water's edge. (Note 38, p. 618.)

Gull Island (near San Miguel Island, California, S. Forney, 1871).—On the top of the island (Prince Island) at the entrance to Cuylers Harbor. (Note 38, p. 618.)

Green Mountain (San Miguel Island, California, W. E. Greenwell, 1858; S. Forney, 1871).—On a ridge running apparently north and south (as seen from Harbor △ or San Miguel △), and presenting a green appearance, differing in this respect from any other on the island; not connected with any other ridge, but standing alone; about 200 meters to the northward of the highest part. (Note 38, p. 618.)

Seal Point (San Miguel Island, California, S. Forney, 1871).—On the highest knob of the extreme northwest point of the island, covered with large rocks. (Note 38, p. 618.)

Brockway 2 (San Miguel Island, California, S. Forney, 1871).—On a prominent sand hill covered with shells; the north end of a small island (Prince Island) off the main island at this point bears west by north one-half north. (Note 38, p. 618.)

Black Point (San Miguel Island, California, W. E. Greenwell, 1858; S. Forney, 1871).—On a dark, undefined point near the bluff at a point where the ground was covered with dark brush, and to the west of a large gulch that makes up in the direction of Green Mountain. (Note 38, p. 618.)

Cape (San Miguel Island, California, W. E. Greenwell, 1858; S. Forney, 1871).—On a conspicuous rocky peak, the first point east of the anchorage. (Note 21, p. 617.)

San Miguel (San Miguel Island, California, W. E. Greenwell, 1858).—About the middle of the top of the highest mountain on the island. (Note 21, p. 617.)

Harbor (San Miguel Island, California, W. E. Greenwell, 1858; S. Forney, 1871).—

On the top of the highest peak in view from Cuylers Harbor; covered with black sage-bushes and cactus. (Note 21, p. 617.)

Cactus (San Miguel Island, California, W. E. Greenwell, 1858; S. Forney, 1871).—On the south side of the island, near the bluff, upon a smooth piece of ground without brush or undergrowth of any kind, and near the foot of the hill as it slopes from San Miguel △, a short distance from a small patch of cactus to the eastward. (Note 38, p. 618.)

San Miguel Island South Base (San Miguel Island, California, W. E. Greenwell, 1858; S. Forney, 1871).—On a slight plateau sloping down to the eastward. On the west the ground rises to San Miguel △. The reference marks were as in note 21, p. 617. The station was marked by a red sandstone monument with the letters "U. S. C. S." on the top.

San Miguel Island North Base (San Miguel Island, California, W. E. Greenwell, 1858; S. Forney, 1871).—On the same plateau as San Miguel Island South Base and marked in an identical manner.

West Point (San Miguel Island, California, S. Forney, 1871).—On the highest hill in the southwest part of the island. (Note 21, p. 617.)

Bench Mark (Near San Miguel Island, California, S. Forney, 1871).—On the southeast face of the island on which Gull Island △ is located. The station was marked by a small hole drilled into the rock.

Brockway (San Miguel Island, California, W. E. Greenwell, 1858; S. Forney, 1871).—On north shore of the west point of the island near the bluff, but not on the extreme point. From Green Mountain △ it is in line with a strip of white sand. (1858.) (Note 21, p. 617.)

New San Miguel Latitude Station (San Miguel Island, California, O. H. Tittmann, 1873).—Near New San Miguel △ (p. 631).

POINT ARGUELLO TO POINT SAL.

Gravel (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On the bluff bank of the sea, which at this place is 80 feet high and very steep, 8 meters from the edge; on the shore, between high and low water marks. The mesa at this place is wider than at any place on the shore for several miles each way. (Note 27, p. 617.)

Spur (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On a spur of the foothills, the third spur going west from the sheep camp near Corral △, about 100 feet below the summit. Between the station and the summit there is quite a deep canyon heading at the foot of a crescent-shaped ridge which connects the spur and the summit. (Note 16, page 616.)

Point Arguello (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On Point Arguello, on a rise of ground about 60 meters in length, about 20 feet above the general level of the mesa, on the western and larger end, 145 meters from the southerly bluff point. (Note 27, p. 617.)

Rustad (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On the foothill that projects farthest to the westward, the natural turning point in carrying the triangulation around the point, and back from the trail about a quarter of a mile. Close by the signal (to the southwest), distant 30 or 40 meters, there is a low scrub oak tree 4 or 5 feet high, covering perhaps 20 feet of ground, the only bush or tree on the hills in this vicinity. The station was marked by a copper tack in a stake.

Sage (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On a long low foothill, which stretches out nearly to the bluff bank of the sea. (Note 16, p. 616.)

Pedrenales (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On the long rolling hill at the foot of hill on which Rustad △ is located, the principal rise of land in going up the coast by the trail. (Note 27, p. 617.)

Alvord (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On the high hill on the left bank of the canyon referred to in the description of Promontory △; 30 meters east of where the greatest rise on the west face terminates and 100 meters from a rocky ledge inland, which forms a downward step in going toward Tranquillon. (Note 27, p. 617.)

Promontory (Santa Barbara County, Cal., W. E. Greenwell, 1874).—On the last or most northerly and westerly of the several rocky points which form the shore for a distance of 3 miles toward Point Arguello. For a distance of 400 meters to the west there is a low mesa, then a deep canyon in which there is a small piece of marsh land and some tules. On the west side of this canyon the long range of sand hills begins and continues on to the Santa Inez River. On this point there are two peaked and abrupt rises from the mesa, about 150 meters apart (from top to top). The station is on the outer one, which is of almost solid rock, and is 6 feet west of a rugged rock about 6 feet in height. The station was marked by a stake 2 feet in length with copper tack in top.

Lompoc (Santa Barbara County, Cal., W. E. Greenwell, 1874, 1878).—About 1 mile inland; on the slope north of Arroyo Honda which is connected, about 2 miles farther back, with the slope on which Powell △ is situated by a lower ridge, whence a deep gulch makes out running toward the shore between these two stations; 100 meters below the highest point at a point where the slope makes a short turn to the northward. From the station a bushy top on a spur of the same slope and Promontory Point are in line; and through the gap just to the right of the brushy top the first bare sand hill north of Promontory Point is fully visible. Three detached rocks to the northward of Promontory Point and a part of the adjoining mainland are in line with the spur south of Arroyo Honda; the extreme outer point of Point Purissima is in line with the first peak of Point Sal; and the reef at Purissima Point is in line with the outer point of Point Sal. (Note 27, p. 617.)

Sand Hill (Santa Barbara County, Cal., W. E. Greenwell, 1874, 1878).—About a mile north of Promontory Point near the mouth of the canyon which divides the slopes upon which Lompoc △ and Powell △ are located; on a small brush-covered sand hill just back of the barrier caused by drift sand. It is about 100 meters east of a bare sand hill, about 60 feet lower, and about 200 meters from shore. From the station the prominent top of a lower sand hill, also covered with sparse brush, makes a line with the outer bluff of Promontory Point and forms almost a horizontal tangent with it. The western abrupt face of the detached rock off Promontory Point is in line with a lesser top of the same sand hill. A bare sand hill, the top of which is about 70 meters to the southward, descends a steep barrier into the canyon; and by looking back from the station through the canyon a gap opens which permits a limited vista to a ridge which extends from the slope upon which Lompoc △ is situated. The view toward Point Sal is obstructed by a higher sand hill about 50 meters from the station. (Note 27, p. 617.)

Powell (Santa Barbara County, Cal., W. E. Greenwell, 1874, 1878).—On the second slope north of Arroyo Honda, or the first one south of Spring Canyon, gradually rising from the house of S. S. Winn, in Spring Canyon. From the station, Point Purissima, the outer end of Point Sal, and the bare sand hill which bars the mouth of Bear Valley are in line. In looking toward the higher part of the first spur south of Arroyo Honda, makes a tangent with the slope on which Lompoc △ is situated; the bare sand hill which bars the canyon south of Sand Hill △ is in full view and due south; the base of a sand hill, a little to the westward of the one just referred to, is in tangent with the height of the station site and a small plateau of the same ridge, upon which the station is situated. Fifty meters back from the station the first knoll rises to a height of about 50 feet above the station; and 3 such knolls are in sight from that position. The gap between the first two knolls is due east. The station was marked by a 2 by 2 inch redwood stub, projecting 4 inches from the ground, with a tack in the top.

Bald (Santa Barbara County, Cal., W. E. Greenwell, 1874, 1878).—On the southwest and broader part of the top of the highest bare dune south of that at the mouth of Bear Valley, opposite and in line with Spring Valley before it makes the short turn to the southwestward, barred by loose sand; about 500 yards north of the mouth of the canyon, where it is closed up by the dunes, and about 400 meters northeast of the mouth of the creek. (Note 27, p. 617.)

Blank (Santa Barbara County, Cal., W. E. Greenwell, 1874, 1878).—On one of the tops of the slope south of Bear Valley, just opposite to one of the crossings of Bear Valley Creek, which is about 400 meters up the canyon from Mr. Walker's house, close to some outhouses belonging to him, and to a spring; on the first rise east of the road where it reaches the top of the grade, about half way between it and a second higher rise farther back. From the station the slope upon which Powell △ is situated is barely visible, while from the next rise that slope is hidden by an intervening spur. A few steps north of the station the creek below is open to view. (Note 27, p. 617.)

Bear Valley (Santa Barbara County, Cal., W. E. Greenwell, 1874, 1878).—On the highest top of the brushy sand hill at the mouth of Bear Valley, west of the laguna formed by the arrested outflow of Bear Valley Creek caused by drift sand, at a distance of about 200 meters from shore, about ¾ mile down the canyon from the house of Mr. Walker. The detached rocks near Promontory Point to the southward form almost a tangent with a prominent sand hill to the north, and the sandspit of Purissima Point is in line with outer Point Sal. (Note 27, p. 617.)

Slope (Santa Barbara County, Cal., W. E. Greenwell, 1874, 1878).—On the first slope southwest of the house of Mr. A. L. Huyck, which stands in a horseshoe-like bend, near a fine spring at the edge of the bottom land of Santa Inez River; on top, the next one being 300 meters farther eastward a little to the westward of the top. (Note 27, p. 617.)

Hammer (Santa Barbara County, Cal., W. E. Greenwell, 1878).—On the highest point of the highest sand hill, about 100 meters back of Mr. Hammer's house and about as far from seashore. It is first prominent hill south of the mouth of Santa Inez River and about 1 mile from it. A bare dune begins at the foot of the sand hill and extends southward for about 300 meters, interrupted only by a covered patch on the north side of a hollow in the dune. Promontory Point is open to view, as also the shore line between it and the station, while the base of Point Sal is covered by Point Purissima so that the last sharp point of the former is in line with the end of Lompoc wharf. (Note 28, p. 617, except one reference stub is to the east instead of north.)

Valley View (Santa Barbara County, Cal., W. E. Greenwell, 1878).—On the rise on the right or north bank of Santa Inez River, about 1 mile from its mouth; near the edge of the hill where the ridge leaves the course of the river and makes a short turn northward parallel with the shore; on the highest part of the rise, a little lower than the plateau, which begins about 500 meters eastward. A round, smooth hill up the Santa Inez Valley, behind which the town of Lompoc is situated (about 6 miles away), makes nearly a tangent with the next higher plateau before referred to. The southern end of the bridge across Santa Inez River is in line with Hammer △, and is about ½ mile away. (Note 28, p. 617.)

Marsh (Santa Barbara County, Cal., W. E. Greenwell, 1878).—Near the mouth and north of Santa Inez River on the highest top of the group of sand hills, which descends abruptly, on its south side, to a fresh-water marsh caused by casual overflow of the river. (Note 28, p. 617.)

Burned (Santa Barbara County, Cal., W. E. Greenwell, 1878).—Near the declivity of the plateau rising a short distance from the shore, between the mouth of Santa Inez River and the landing and is nearly opposite Bluff △, about 50 meters from the edge of the declivity. (Note 28, p. 617.)

Bluff (Santa Barbara County, Cal., W. E. Greenwell, 1878).—On the bluff about halfway between the mouth of Santa Inez River and Lompoc Landing, where it makes out farthest and forms a well-defined point. (Note 28, p. 617.)

Landing (Santa Barbara County, Cal., W. E. Greenwell, 1878).—On the top of a small sand hill thinly covered with shells and flint chips (the remains of a former Indian camp), south of Lompoc wharf, east of the warehouse, and about 50 meters north of a small house; 5 meters from the brink of the bluff. (Note 28, p. 617.)

Chaparral (Santa Barbara County, Cal., W. E. Greenwell, 1878).—Just opposite Lompoc Landing, near the steep edge of the plateau which rises here two-thirds mile from shore. From Landing △, Chaparral △ is cleared to the left, or north, of the warehouse gable within an angle of 10°. (Note 28, p. 617.)

Rancheria (Santa Barbara County, Cal., W. E. Greenwell, 1878).—On the westerly spur of the prominent sand hill three-fourths mile north of Lompoc Landing. To the west the lower spurs of the sand ridge terminate in a rocky shore which, at low water, extends several hundred yards out to sea, forming a reef not so conspicuous and less in extent than the reef at Purissima Point, and to the east is a hollow, parallel with the ridge, through which the Point Sal road passes before following the beach. Near the bluff and a fresh-water spring, about halfway from the landing, are the shell remains of an Indian camp or rancheria. By going as far as possible to the northward to clear the low sandspit of Purissima Point, and also keeping Landing △ open to view, the site of the station will be reached. From the Lompoc warehouse it is but a few degrees to the left of a line with a large rock near Purissima Point. (Note 28, p. 617.)

Tangent (Santa Barbara County, Cal., W. E. Greenwell, 1878).—On a smooth, overgrown flat top among the sand hills a little over 1 mile due north of Lompoc Landing and a little over 1 mile distant westward of a prominent sand hill, nearly bare. (Note 28, p. 617.)

Brown Hill (Santa Barbara County, Cal., W. E. Greenwell, 1878).—Back of Purissima Point and east of the Point Sal road, which, at this point, leads through a hollow about 2 miles north of Lompoc Landing; almost east of the top of a smooth overgrown sand hill. (Note 28, p. 617.)

Gulch (Santa Barbara County, Cal., W. E. Greenwell, 1878).—On the prominent sand hill west of a deep gulch or barranca, the second one south of San Antonio Creek. (Note 28, p. 617.)

Dune (Santa Barbara County, Cal., W. E. Greenwell, 1878).—One mile north of Purissima, about 300 meters from shore, on a prominent bare sand hill, not on the highest point, but on the seaward end of the top. The opposite shore is a sand beach without any rocks for a distance of about 5 miles to the northward, the last ledge being several hundred meters to the south of the station. (Note 28, p. 617.)

Beach (Santa Barbara County, Cal., W. E. Greenwell, 1878).—One and one-fourth miles south of the mouth of San Antonio Creek, on a bare prominent sand hillock near the beach. (Note 28, p. 617.)

Prominent (Santa Barbara County, Cal., W. E. Greenwell, 1878).—On the most prominent sand ridge south of San Antonio Creek, about 1 mile from it; upon a small top nearly in the middle of the ridge west of its highest elevation; near the inland end of the top. (Note 28, p. 617.)

Outer (Santa Barbara County, Cal., W. E. Greenwell, 1878).—About 2 miles from shore and about 2 miles from the mouth of San Antonio Creek, upon the top of the highest ridge southeast of Pond △ and Middle △, and forming almost a line with them. From the locality a fair view is obtained to the northward over a labyrinth of sand hills, which is much obstructed from all other points in the neighborhood. (Note 28, 617.)

Corral (Santa Barbara County, Cal., W. E. Greenwell, 1874).—Three-fourths of a mile east of Point Arguello, on the bluff bank where the shore comes to a bight about 40 meters from the trail; about a quarter of a mile west of a large canyon upon the right or west side of which, and about 350 meters from the shore, there is a small sheep herder's hut, also a corral embracing about 1 acre. The station is not in sight from the sheep camp, a small rise of ground cutting off the view. (Note 27, p. 617.)

Camp (Santa Barbara County, Cal., W. E. Greenwell, 1878).—About 1 mile from shore, to the left or south of the camp or beach road and about 100 meters from it; upon a smooth rise close to and south of San Antonio Creek, and about 300 meters north of a similar low knoll, a little higher than the one upon which the station is located. About 300 meters from the station the road makes a steep descent to the bottom of San Antonio Creek. (Note 28, p. 617.)

Hollow (Santa Barbara County, Cal., W. E. Greenwell, 1878).—About three-fourths mile south of San Antonio Creek and near the shore; upon an overgrown irregular ridge, the western side of which is inclosed by bare sand hills, while toward the east it declines to a sinking flat or hollow about one-fourth mile square; on the southern end of the top. (Note 28, p. 617.)

Middle (Santa Barbara County, Cal., W. E. Greenwell, 1878).—Almost the middle and the top of a sand ridge, about 1¼ miles from shore and 1¼ miles north of San Antonio Creek, nearly in line with Pond △ and Outer △. (Note 28, p. 617.)

Pond (Santa Barbara County, Cal., W. E. Greenwell, 1878).—Upon the highest point of the most prominent of the shore sand hills north of San Antonio Creek and about 1½ miles from it and not more than 200 meters from the beach. Toward the shore the sand hill descends in bare spurs, while back (east) of the station it declines abruptly to a grassy bottom and a small pond, only about 75 meters northeast of it. To the south is a bare dune and close to the north of it is another similar but less prominent sand hill. (Note 28, p. 617.)

Purissima Point (Santa Barbara County, Cal., W. E. Greenwell, 1878).—On the highest of the several small hillocks near the extreme point of the sandspit from which extends the conspicuous reef of Purissima Point; 15 meters from the nearest point of the bluff, 60 meters from the bluff, measured along the ridge of the hill toward the west, and 45 meters from low-water mark.' (Note 28, p. 617.)

POINT SAL TO SADDLE PEAK.

Green Peak (San Luis Obispo County, Cal., L. A. Sengteller, 1872).—On the highest part of a hill about 2½ miles to the westward of Pecho House, on land owned by Mrs. Hilliard. To reach the station follow the first slope covered with chaparral after crossing a large canyon to the westward of Caballo. Below the station, and to the eastward of it, is a prominent rocky point. Passing this, the first top of the mountain is seen, and about one-fourth mile westward of it is the top upon which station was located. (Note 33, p. 618.)

Bare Hill (San Luis Obispo County, Cal., L. A. Sengteller, 1872).—About 2 miles back from the coast, on top of a broad and lone peak, which is nearer to the coast than any other of the prominent peaks of the vicinity, and differs in appearance, rising regularly and gradually, with grass-covered surface, while all others rise abruptly, very rough and broken. The station was marked by a block of redwood 15 inches long and 3 by 4 inches laid flat 3 feet below surface, with a hole drilled in its upper face marking the center of the station.

San Luis Hill (San Luis Obispo County, Cal., L. A. Sengteller, 1871).—On the northwest extremity of the highest part of the hill immediately back of Point San Luis, at a point from which a large white rock up the coast is visible. (Note 22, p. 617.)

Valley View (San Luis Obispo County, Cal., L. A. Sengteller, 1871).—About one-fourth mile north of Mallagh Landing, on the top of the ridge which, commencing just north of the San Luis Obispo West Base, runs parallel with the coast to San Luis Creek, when it makes a sharp turn and follows that creek; on the highest point of the ridge and near its eastern extremity. (Note 22, p. 617.)

Indian (San Luis Obispo County, Cal., L. A. Sengteller, 1872).—On the eastern end of a ridge which appears from Valley View △ or Price △ as a table, or flat ridge, but which is very rough and broken. It may best be reached by way of a little valley to the left of the road up the canyon from Price's ranch. The station was marked by a hole drilled in the natural rock, 2½ feet below the surface; in this a dime was solidly fixed, the center of which is the center of the station.

Price (San Luis Obispo County, Cal., L. A. Sengteller, 1872).—On the top of highest hill northwest of South Point; on land owned by John Price. (Note 33, p. 618, except the distance of the stone below the surface was not stated.)

White Rock (San Luis Obispo County, Cal., L. A. Sengteller, 1871).—Near the highest part of a rock locally known as White Rock. The station was marked by a drill hole in the rock, filled with lead, in which was a copper tack one-fourth of an inch below the surface.

Mallagh (San Luis Obispo County, Cal., L. A. Sengteller, 1871).—On the rocky peak on the top of the ridge rising from near San Luis Obispo West Base; on land owned by D. P. Mallagh. The soil is composed of soft white rock. (Note 22, p. 617.)

San Luis Obispo East Base (San Luis Obispo County, Cal., L. A. Sengteller, 1871).—In a field owned by D. P. Mallagh, just south of where two small breaks or gulches come together and disappear. (Note 22, p. 617.)

San Luis Obispo West Base (San Luis Obispo County, Cal., L. A. Sengteller, 1871).—West of D. P. Mallagh's field in which San Luis Obispo East Base △ is located. (Note 22, p. 617.) Also four stubs were placed each 6 feet from the center.

Meierhoff (San Luis Obispo County, Cal., L. A. Sengteller, 1873).—On the southernmost and highest top of a series of hills about 2 miles northeast of the Pismo ranch house, near the head of the left branch of the first little valley on the right going up the Arroyo Pismo from Price's house; the only eminence that commands both the beach at Arroyo Grande and the hill upon which Price △ is located. (Note 22, p. 617.)

Arroyo Grande (San Luis Obispo County, Cal., L. A. Sengteller, 1873).—About one-third of a mile west of the mouth of the Arroyo Grande, upon one of the sand hills forming the eastern extremity of the higher dunes on that side of the creek. (Note 22, p. 617.)

Nipomo (San Luis Obispo County, Cal., L. A. Sengteller, 1873).—On the northwestern extremity and highest part of a ridge lying to the southward of Arroyo Grande and about a mile and a quarter east of Cienega ranch house. From the station the town of Arroyo Grande may be seen, and by going 5 meters to the westward the Cienega ranch house may also be seen. The hill about the station is covered with thick chaparral, while a little east of the station stand several live-oak trees. The soil is dark sand, strongly intermixed to a depth of about 3 feet with shells and bone remains, the marks of an old Indian rancheria; the land was owned by Steele Brothers. (Note 22, p. 617, except no surface mark was described.)

Avila (San Luis Obispo County, Cal., L. A. Sengteller, 1871; G. Davidson, 1874).—About a quarter mile distant from Mallagh Landing, on the northeastern end of the top of the highest hill west of the road running to Peoples Wharf. Four stubs were placed each 6 feet from center and about 1 foot above surface of ground. The station was occupied for latitude and azimuth in 1874. (Note 22, p. 617.)

Cienega Sand (San Luis Obispo County, Cal., L. A. Sengteller, 1874).—About 3 miles south of the mouth of the Arroyo Grande, 600 meters from the beach, on the highest sand hill formed by drift sand among the irregular bare dunes, about 5 meters south from where the hill falls abruptly; on land owned by Steele Brothers. (Note 25, p. 617.) The soil is loose, drifting sand, making the recovery of the station doubtful. A tangent to Point Sal makes an angle of 115° with a tangent to Point San Luis.

Burnt Sand (San Luis Obispo County, Cal., L. A. Sengteller, 1874).—On the top of the eastern ridge of the first canyon south of Los Berros Creek, about 2 miles from where the county road crosses the creek; on land owned by the Dana Brothers, in the Nipomo grant; nearly at the head of the valley, on the left of a branch road, not well defined, that leads up the left-hand bank of the canyon in a northerly direction for a mile, then almost at a right angle eastwardly to its head. Upon the opposite side of the valley and nearly due south from the station a road leads up the slope. (Note 25, p. 617.) Two scrub oaks were cut down, and in their upper surfaces three tacks in line to the station were driven; one distant 12 meters, magnetic bearing, 59°, the other distant 5 meters, magnetic bearing, 329°. A house in line with the town of Guadalupe and about 2½ miles distant bears 202° (magnetic), and a pond among the cottonwoods, 140° (magnetic).

San Luis Obispo Latitude Station 1852 (San Luis Obispo County, Cal., L. A. Sengteller, 1871).—Near the edge of the bluff at the first valley or break west of Fossil Point and about a half mile from the San Luis Creek. No trace of the marks of 1852 could be found, but from the contracted space which the vicinity admits for locating a station it is not likely that the 1871 station can differ in position from that of 1852 to exceed 10 meters; and, indeed, it is very probable that not more than one-half that discrepancy exists. (Note 22, p. 617.)

Substitute (Santa Barbara County, Cal., W. E. Greenwell, 1878).—Upon the prominent ridge 1¾ miles from shore and about 300 meters west of Lospe △ (p. 629), which is south of a dairy (formerly Lardner's house) and plainly visible from it, being distinctly marked by a monument of rocks. (Note 23, p. 617.)

Cove (San Luis Obispo County, Cal., L. A. Sengteller, 1872).—On a tongue-shaped point with outlying large rocks forming the eastern end of a cove lying between it and the point under Lyon Rock; upon a knob near the point of the bluff, halfway out to the extreme point. (No. 33, p. 618.)

Santa Maria (San Luis Obispo County, Cal., L. A. Sengteller, 1874).—Between the two knobs on the highest point of the bushy sand ridge, on the north bank of Santa Maria River, and about three-fourths of a mile from its outlet, on land belonging to the Guadalupe grant. The hill is covered with wild coffee and chaparral. (Note 25, p. 617.)

Norriss (Santa Barbara County, Cal., L. A. Sengteller, 1874).—On the right edge of the road leading toward the mouth of the Santa Maria, about 700 meters from the road crossing of the road to Point Sal Landing, and 300 meters from Copland's house; on land owned by J. A. Norriss. (Note 25, p. 617.)

Whaler Point (San Luis Obispo County, Cal., L. A. Sengteller, 1871).—At Point San Luis, near the edge of the bluff to the north of the whaling company's houses. (Note 22, p. 617.)

Valdez (San Luis Obispo County, Cal., L. A. Sengteller, 1873).—Upon the sand ridge on the county road from the Arroyo Pismo to the town of Arroyo Grande, on a round top about one-fourth mile east of Price's dairy; not on the top of the hill, but about 60 feet lower, on a point overlooking the little valley on the west side of the ridge. (Note 22, p. 617, except no surface mark was described.)

South Point (San Luis Obispo County, Cal., L. A. Sengteller, 1872).—On the point forming the eastern end of San Luis Bay, about 75 meters east of the extreme point, and 3 meters from the edge of the bluff; on land owned by John Price. The station was marked by a sandstone with a hole drilled in the upper face.

Camp Hill (San Luis Obispo County, Cal., L. A. Sengteller, 1873).—On the highest part of a small and isolated round-top hill rising from the intersection of the county beach road and San Luis Obispo road and about 200 meters west of the Pismo Creek. (Note 33, p. 618.)

Caballo (San Luis Obispo County, Cal., L. A. Sengteller, 1872).—Between the first and second deep canyons west of the Pecho house, nearer the latter; on the top of the slope on the west side of a dry gulch which is close by the eastern one of two large rocks near the edge of bluffs. (Note 33, p. 618.)

West Point (San Luis Obispo County, Cal., L. A. Sengteller, 1872).—About three-fourths of a mile from Green Peak △ upon the same ridge, on the second top to the westward, a smaller and lower one being between the two stations; on land owned by Mrs. Hilliard. (Note 33, p. 618.)

Dune (San Luis Obispo County, Cal., L. A. Sengteller, 1874).—About 1 000 meters from the immediate coast, on the highest top of the brushy sand hills; about 40 meters from the road leading along the shore from Guadalupe to San Luis Obispo Landing and 200 meters west of the meadow where the road enters the dunes; 10 meters west of where the hill descends rapidly to a low ridge stretching toward the meadow; on land belonging to the Guadalupe grant. (Note 25, p. 617.) Distances and compass bearings to various points are as follows: to the road where the meadow begins, about 200 meters, 292° 30′; to the trees in the hollow, about 200 meters, 297° 30′; to a bend of the creek, about 200 meters, 232° 30′; to the second bend of the creek, about 350 meters, 170° 00′.

Steele (San Luis Obispo County, Cal., L. A. Sengteller, 1874).—Upon the highest round-top chaparral sand hill, about three-fourths of a mile east of the county road, at a point where the road crosses a divide and falls rapidly in going to Guadalupe while more gradually toward Arroyo Grande, near the extreme northeast point of the hill, upon the boundary line of the Steele and Dana properties. (Note 25, p. 617.)

Guadalupe (San Luis Obispo County, Cal., L. A. Sengteller, 1874).—About 2 miles northwest from Guadalupe, on the highest point of a flat sand hill upon the extreme inland dune, 50 meters from the edge of the steep descent into the grassy bottom and about 100 meters from the creek emptying into the Santa Maria River; the only point in locality from which Oso Flaco △ may be seen; on land belonging to the Guadalupe grant. (Note 25, p. 617.) The soil is loose drifting sand, and the recovery of the station is therefore doubtful. Distances and compass bearings to various points are as follows: to a bush, 175 meters, 42° 30′ west of north; to the end of a brushy sand ridge (the edge of timber), 330 meters, 255° 00′ west of north; to the nearest edge of the sand bluff, 50 meters; to a sharp bushy corner, 78°, and to a small bush on the edge of the bluff, 29° 30′ west of north.

Oso Flaco (San Luis Obispo County, Cal., L. A. Sengteller, 1874).—About 2 miles northerly from the Santa Maria River and 1 mile southerly from the Arroyo Oso Flaco, 350 meters from the shore, on the top of an isolated sand hill, the most prominent in the vicinity, on land belonging to the Guadalupe grant. (Note 25, p. 617.)

Smith Sand (Santa Barbara County, Cal., L. A. Sengteller, 1874).—About 2¾ miles from the Santa Maria River and 2 miles to the north of the main point of Point Sal, on top of highest sand dune between them. (Note 25, p. 617.) The soil is loose drift sand, and the recovery of the station is doubtful.

Rock (Santa Barbara County, Cal., W. E. Greenwell, 1867; L. A. Sengteller, 1874; W. E. Greenwell, 1878).—On the highest point west of Corralitos Valley, 1¼ miles east of Point Sal Landing, in line with the trend of the point and 3 miles back of it, within 30 meters of the branch road over Point Sal and just above or north of a cut. The station was marked by a copper tack in the top of a redwood stub, and by two similar stubs to the north and west and 3 feet from center.

Peak (Santa Barbara County, Cal., W. E. Greenwell, 1867; L. A. Sengteller, 1874; W. E. Greenwell, 1878).—On the top of the ridge forming the conspicuous part of Point Sal, near its highest peak, almost due north of the landing and in line with the shore in that neighborhood. The station was marked by a redwood stub with a copper tack in the top, and by two similar stubs placed north and west 3 feet from the center.

Green Ridge (Santa Barbara County, Cal., L. A. Sengteller, 1874).—On the northernmost top of a green spur rising with the easterly side of Corralitos Valley at a sharp turn in the graded road that leads through the canyon to Point Sal Landing, about 500 meters below the point where the road crosses the creek, on land belonging to the Guadalupe grant. (Note 25, p. 617.)

Point (Santa Barbara County, Cal., W. E. Greenwell, 1867; L. A. Sengteller, 1874; W. E. Greenwell, 1878).—On a lower but better defined top than Peak △ and halfway between it or the bight (which is opposite the station) in which the landing is situated and the outer point of Point Sal. (Note 13, p. 616, except the length of the stubs was not given.)

Reef 1 (Santa Barbara County, Cal., W. E. Greenwell, 1878).—About a mile and a quarter south of Point Sal Landing, at the point from which a reef makes out, 5 meters from the brink of the bluff, a little west of south of the schoolhouse and a little south of west of Clark's house. (Note 23, p. 617.)

Edge (Santa Barbara County, Cal., W. E. Greenwell, 1878).—About 3 miles from shore on the top of the highest sandy rise at the northern edge or limit of the dunes which terminate here, on the southern side of the prominent Shumans Canyon. Close to and northward of the station the ground becomes hard and the vegetation is of a different character, while south of it grassy flats, overgrown sand hills, and a little farther on bare dunes interchange. The station is best approached from the northern side over the plateau lying between it and Shumans Canyon. (Note 23, p. 617.)

San Antonio (Santa Barbara County, Cal., W. E. Greenwell, 1878).—On a very conspicuous sand hill on the north bank of San Antonio Creek and near its mouth, just opposite the wreck of the U. S. S. *Edith*, on the northwestern of the two small tops. (Note 23, p. 617.)

SADDLE PEAK TO PIEDRAS BLANCAS.

Piedra Blanca (San Luis Obispo County, Cal., C. Rockwell, 1873).—On the Piedras Blancas Light-house reservation, upon the highest ground forming the eastern point, about 35 meters northeast of the large red rock on which the tower of the light-house stands. (Note 9, p. 616.)

Stone (San Luis Obispo County, Cal., S. Forney, 1883).—On the higher or eastern one of two conical peaks, about 3 miles in a northerly direction from the town of Cayucos. About 15 meters from the station, on the west side of the hill, was a stone fence running across the top of the hill from the northwest to the southeast side. The station was marked by a copper tack in a lead bolt driven into a hole 1 inch in diameter drilled into the solid rock. The reference marks were copper tacks in lead bolts driven into three holes drilled into the solid rock, 10 inches below the surface of the ground; to the north, 2 feet 5 inches; to the south, 2 feet 1 inch; to the east, 2 feet 6 inches. Over each a redwood stub 4 by 4 inches was placed, with a copper tack in the top.

Lane (San Luis Obispo County, Cal., S. Forney, 1883).—Take the road leading up Little Cayucos Creek to Buffington's ranch; here take the only road which leads to the left to the first dairy ranch; then take a road leading up to the right, passing up a spur to the top of the high ridge to the eastward of the dairy ranch; follow this road to the top of the ridge. The station will be found to the right, on the top of the first rock ridge, about one-fourth mile from the main road. On the north face of the hill is a rocky bluff. (Note 31, p. 618.) The reference stubs were placed as follows: to the north, 2 feet 6 inches; to the east, 2 feet 4 inches, and to the west, 2 feet 4 inches.

Villa (San Luis Obispo County, Cal., S. Forney, 1883).—On the highest point to the westward of Villa Creek, about 2 miles from the mouth of the creek, on a hill, about 300 meters from the beach, and about the same distance north of a line fence that runs over the hill, approximately east and west; on land of Mr. Logan. (Note 31, p. 618.) The reference stubs were placed as follows: to the north, 2 feet 6 inches; to the south, 2 feet 4 inches, and to the east, 2 feet 5 inches.

Irving (San Luis Obispo County, Cal., S. Forney, 1883).—To reach the station leave the Cayucos and Cambria road at a point about 3 miles below Cambria, and take the road leading eastward up the Santa Rosa Creek Valley until it turns to the south, at the place of Mr. Hearst; then to the eastward, through a narrow canyon for about 1 mile, to a point about 200 meters beyond a dairy ranch belonging to Mr. Bryan and then turn to the left. The station is on the third peak, the second peak being covered with oak trees. The station was marked by a stone bottle buried 3 feet beneath the surface of the ground, neck up. Four witness stubs, each 2 by 4 inches, and 18 inches long, were placed at a distance of 2 feet 5¼ inches from the center of station, to the north, south, east, and west.

Estrada (San Luis Obispo County, Cal., S. Forney, 1883).—A little to the east of the highest point of the second ridge to the southward from Cambria, on the ranch of Mr. Estrada and about three-fourths of a mile to the south of his house. The station was marked by a stone bottle buried 3 feet beneath the surface of the ground, neck up. At a distance of 2 feet 5¼ inches each, and approximately north, south, east, and west, were driven four redwood plugs, 15 inches long and 2 by 4 inches in cross section, each with a copper tack in the top.

Gordon (San Luis Obispo County, Cal., S. Forney, 1885).—On a bare-top hill about 1½ miles northwest of the mouth of San Simeon Creek, on the land belonging to J. Van Gordon, whose house is three-fourths of a mile southwest. About 250 meters in a southeast direction from the station and directly across the canyon is a large rock and two oak trees. (Note 7, p. 616, except the bottles around the center are 3 inches from it.) The three oak theodolite stubs were left standing. The true azimuths of various points are: Cambria Rocks, 62° 50′; Leffingwell Point, 69° 10′; mouth of San Simeon Creek, 80° 00′; J. Van Gordon's house, 100° 20′; mouth of Pico Creek, 122° 20′; Piedras Blancas Light-house, 148° 40′; Pine Mountain (highest tree), 226° 45′.

Field (San Luis Obispo County, Cal., S. Forney, 1885).—On a grassy knoll in a field belonging to Ira Van Gordon, about a half mile northeast of the mouth of San Simeon Creek, 400 meters from the shore line, and about 75 meters south of the main road leading from Cambria to San Simeon Bay. (Note 7, p. 616.)

Gillespie (San Luis Obispo County, Cal., S. Forney, 1885).—On the first point west of Pico Creek, 25 feet from the sea bluff and 150 meters south of the road leading from Cambria to San Simeon Bay; on land belonging to George Hearst. (Note 7, p. 616, except the underground mark was buried 2 feet deep and the surrounding bottles 18 inches.)

Fork (San Luis Obispo County, Cal., S. Forney, 1885).—On a hill forming the ridge that runs toward Rocky Butte, between the east and west forks of Pico Creek, on land belonging to George Hearst, about 600 meters up the hill from the forks of Pico Creek. Piedras Blancas Light-house is almost in range with Conway's hotel at San Simeon Bay. (Note 7, p. 616, except the center mark was 2 feet underground.) The three theodolite stubs were left standing.

San Simeon (San Luis Obispo County, Cal., C. Rockwell, 1871; S. Forney, 1885).—On the top of the first hill northwest of San Simeon Bay landing, on the land belonging to George Hearst. (Note 7, p. 616.) The station was occupied for azimuth observations in 1874 by George Davidson.

Bare Ridge (San Luis Obispo County, Cal., S. Forney, 1885).—On the first ridge west of Little Pico Creek, about a mile and a half east of San Simeon Landing and about 1 mile from the mouth of Pico Creek; on land belonging to George Hearst. (Note 7, p. 616, except the center mark is 2 feet underground.) The three theodolite stubs were left standing.

Pico 2 (San Luis Obispo County, Cal., S. Forney, 1885).—About 500 meters west of the west bank of the Pico Creek and 30 meters west of Pico △; in a cultivated field on the sea bluff belonging to George Hearst; about 300 meters south of the road running from San Simeon Bay toward Cambria. (Note 7, p. 616, except the center mark is 2 feet underground, the surrounding bottles 18 inches, and a fourth redwood stub similar to the others was placed to the west.)

Hearst (San Luis Obispo County, Cal., C. Rockwell, 1871; S. Forney, 1885).—On the top of a hill about 2 miles northeast from San Simeon Landing, and to the east of the eastern branch of the first wooded gulch east of San Simeon Point; on land belonging to George Hearst. (Note 7, p. 616.) The oak theodolite stubs were left in 1885.

Corral (San Luis Obispo County, Cal., C. Rockwell, 1871).—On the first plateau northeast of and about 1½ miles from San Simeon Landing, 260 meters to the east of the first wooded gulch northwest of the landing, and 360 meters west of another gulch. (Note 4, p. 615.)

San Simeon North Base (San Luis Obispo County, Cal., C. Rockwell, 1871; S. Forney, 1886).—On the first plateau northeast of San Simeon Landing, and 1 950 meters distant, 60 meters from the first gulch east of the landing, and 70 meters north of the road which crosses the gulch leading from the point; on land belonging to George Hearst; about 500 yards north of the race course and close to a fence which runs east and west, about 75 yards north of the road leading to the ranch house, and immediately alongside the road leading to the westward. (Note 7, p. 616, except the center mark is 2 feet underground and the reference stubs are to the north, south, and west.)

Leitner (San Luis Obispo County, Cal., C. Rockwell, 1871).—Is 3 000 meters northwest of San Simeon Landing, on the top of a bare, grassy hill, around the foot of which, on the northwest side, curves the second wooded gulch northwest of San Simeon Point. (Note 32, p. 618.)

San Simeon South Base (San Luis Obispo County, Cal., C. Rockwell, 1871) —On the first plateau northeast of and 1 270 meters from San Simeon Landing, about 5 meters from the road leading from the San Simeon Point to Castro's house. (Note 32, p. 618.)

Moro Rock (San Luis Obispo County, Cal., W. E. Greenwell, 1881; S. Forney, 1883).—On the highest point at the north end of the large rock at the entrance of Moro Bay, known as Moro Rock. The center of the station was marked by a hole 4 by 4 inches and 4 inches deep in the rock, in the bottom of which was a small hole marking the center of the station. The reference marks were holes 1 inch in diameter drilled into the rock into which lead bolts were driven, and in the top of each bolt was a copper tack.

Cass (San Luis Obispo County, Cal., S. Forney, 1883).—On the first rocky peak about one-half mile southeast of the town of Cayucos. The center of station was marked by a lead bolt 1 inch in diameter by 1 inch long, in the solid rock, 1½ feet below the surface of the ground. The reference marks were two redwood stubs and one lead bolt, placed at the following distances: northwest, 2 feet 1 inch; northeast 1 foot 11 inches; south, 2 feet 3 inches.

Hall (San Luis Obispo County, Cal., S. Forney, 1883).—On the highest peak between Willow and Toro peaks, about 1½ miles from the beach. (Note 31, p. 618.) The reference stubs were placed as follows: to the northeast, 2 feet 4 inches; to the south, 1 foot 8 inches, and to the northwest, 2 feet 1 inch.

San Simeon Latitude Station 1874 (San Luis Obispo County, Cal., G Davidson, 1874).—Twenty feet west of San Simeon △ (p. 715).

Mack (San Luis Obispo County, Cal., S. Forney, 1883).—On top of the ridge to the south of a small flat on the south side of Willow Creek, in which is situated a windmill and a large water tank. (Note 31, p. 618.) In the neck of the bottle was a peg, into which a nail was driven. The reference marks were placed as follows: to the south, 2 feet, 1 inch; to the east, 2 feet 4 inches, and to the west, 2 feet 9 inches.

Rock (San Luis Obispo County, Cal., S. Forney, 1883).—On the top of a high, rocky hill, directly back of a group of houses to the eastward of the county road beyond Toro Point, and about 80 meters south of a wire fence running approximately east and west. The station was marked by a stone buried 3 feet below the surface of the ground, in which a hole had been drilled and then plugged with a leaden bolt, with a nail driven into it, marking the center of the station. The surface mark and the reference marks were as described in Note 30, page 618.

Toro (San Luis Obispo County, Cal., S. Forney, 1883).—On the top of the ridge south of Toro Creek and about 1½ miles from its mouth. To reach the station, take the road leading up Toro Creek Canyon to the ranch of Mr. Bertholomew, on the south side of the valley; pass through the corral and on to the top of the first main ridge. From here the station is in an easterly direction, distant about one-fourth mile, and 100 meters east of a fence running north and south. The reference marks were three redwood stubs, each with a tack in its top, placed as follows: to the north, 2 feet 1 inch from the center; to the south, 2 feet 5 inches, and to the east, 2 feet 4 inches.

Black Hill (San Luis Obispo County, Cal., W. E. Greenwell, 1881; S. Forney, 1883).—On the first high, isolated peak of a number forming a chain of peaks running east from Moro Rock, about 1 mile south of the road from San Luis Obispo to Moro, on the highest part of a ridge about 1½ miles east of Moro. There is a gradual slope from the bay, but on the east and south sides the ridge is very steep. At the foot of the hill on the south side a fine stream of water empties through a slough about 1 mile long and an average of 20 meters wide. The center was marked by a stub. The reference marks were copper tacks in lead bolts driven into drill holes in rocks, as follows: to the north, 9 feet 5½ inches from the center of station; to the east, 11 feet 3½ inches; to the south, 10 feet 9¾ inches; to the west, 7 feet 7¼ inches. Three redwood stubs, each with a copper tack in the top, were driven in as follows: to the north, 1 foot 8 inches; to the east, 1 foot 8 inches, and to the west, 1 foot 10 inches from the center.

Chaparral (San Luis Obispo County, Cal., W. E. Greenwell, 1881; S. Forney, 1883).—On a spur, the first south of Moro Bay, about 400 meters east of the house of Mr. Orear, which is about one-fourth of a mile to the left of the road leading to the Pecho ranch. (Note 6, p. 616.)

Sand Dune (San Luis Obispo County, Cal., W. E. Greenwell, 1881).—About 50 meters from the shore line, on the highest sand dune, about one-half of a mile north of Mr. Hazard's house. (Note 6, p. 616.)

Hazard (San Luis Obispo County, Cal., W. E. Greenwell, 1881).—On the second prominent ridge south of Moro Bay, not on the extreme summit of the slope, but about 100 meters to the westward; about 1½ miles up the ridge to the east from Hazard's house, and 30 meters east of a wire fence running north and south. (Note 6, p. 616.)

Valencia (San Luis Obispo County, Cal., W. E. Greenwell, 1881).—About 1½ miles from the shore line or mouth of Valencia Creek. To reach the station, follow the coast road to Islay Creek, then up the creek about one-fourth of a mile, thence take the right-hand trail to the foot of the highest peak visible, distant about 2 miles. The trail passes to the left of the station. (Note 6, p. 616.)

Oats (San Luis Obispo County, Cal., W. E. Greenwell, 1881).—On the ridge running nearly north and south from Islay Creek and about 2 miles distant from the same, and about one-half mile to the east of Valencia Creek. The canyon in which are the Pecho Hot Springs skirts around the east slope of the hill. (Note 6, p. 616.)

Last (San Luis Obispo County, Cal., W. E. Greenwell, 1881).—About 1½ miles along the spur of the ridge from where Valencia Creek crosses the coast road leading from Moro Bay. (Note 6, p. 616.)

Scott (San Luis Obispo County, Cal., S. Forney, 1885).—On the land owned by John Scott, about a half mile northwest of his house, near the road leading up Santa Rosa Creek from Cambria, on a very prominent, high, rocky, pine-wooded peak, the highest peak west of a high pine-covered peak, on which a large rock is conspicuous. (Note 7, p. 616, except that the center stone was 2½ feet underground and no bottles were buried.)

Rosa (San Luis Obispo County, Cal., S. Forney, 1885).—On the first wooded hill east of the mouth of Santa Rosa Creek and distant about three-quarters of a mile from it, on the land owned by Lee Johnson. (Note 7, p. 616.) The three theodolite stubs were left at the station.

Pecho (San Luis Obispo County, Cal., L. A. Sengteller, 1872; G. H. Wilson, 1881).—Upon the southern of two round hills about north of Cove △, on the west side of a gulch running from the westward of Cove △, on land owned by Mrs. Hilliard; a stump is almost due south 47 meters distant from the station. (Note 22, p. 617, except only a drill hole in the center stone.)

Beach (San Luis Obispo County, Cal., W E. Greenwell, 1881; S. Forney, 1883).—About one-half mile from the south end of Moro Bay, on a sand hill about one-fourth of a mile from the beach. (Note 6, p. 616.)

Schumacher (San Luis Obispo County, Cal., L. A. Sengteller, 1872; G. H. Wilson, 1881).—Upon the ridge formed by the divide of the canyon west of Cove △, on the top of the peak next the highest one on the ridge; on land owned by Mrs. Hilliard. (Note 22, p. 617.)

Castro (San Luis Obispo County, Cal., C. Rockwell, 1871).—On the first prominent point on the coast northwest of Castro's house, 30 meters from the shore. (Note 4, p. 615.)

Oak Knoll (San Luis Obispo County, Cal., C. Rockwell, 1872).—Is 1 200 meters from the coast at an elevation of 408 meters above high-water mark, on the top of a hill covered with small oak trees, the highest point of the ridge running from Castro's house up the coast; about 2 000 meters beyond Castro's house, and on the coast road from San Simeon Landing. The station was marked by a bottle buried 3 feet below the surface of the ground and by a surface mark and reference marks as in note 32, page 618.

Blank (San Luis Obispo County, Cal., C. Rockwell, 1871).—About 1½ miles northwest of San Simeon Landing and 170 meters from the road leading from the landing to Castro's house, on a bare, grassy hill, around the foot of which, on the northeast side, curves the first wooded gulch northwest of San Simeon Point. (Note 4, p. 615.) The reference stubs are to the north, east, and west.

Pico (San Luis Obispo County, Cal., C. Rockwell, 1871).—On a bare, grassy mound 2 620 meters east of San Simeon Landing, 60 meters from the coast, and 310 meters from the road leading from the San Simeon Point to Cambria. (Note 32, p. 618.)

Fairview (San Luis Obispo County, Cal., C. Rockwell, 1872).—On the highest part of the same hill as Chaparral Hill △ (p. —). The station was marked by a glass bottle buried 3 feet deep, and by a surface mark and reference marks as in note 32, page 618.

Buryar (San Luis Obispo County, Cal., C. Rockwell, 1872).—On the first prominent point 1⅛ miles southeast of Piedras Blancas Light-house, nearly abreast of a large rock, and on cultivated land claimed in 1872 by Mr. Buryar and owned in 1873 by Frank Miomy. The station was marked by a bottle buried 3 feet deep, and by a surface mark and reference marks as in note 32, page 618.

Chaparral Hill (San Luis Obispo County, Cal., C. Rockwell, 1872–73).—Is 1 720 meters from the coast, on a hill covered with small oak trees and chaparral, almost directly back of Point Piedras Blancas, 1½ miles northeast of the light-house; 220 meters from the head of a gulch which passes within 20 meters of Buryar's house (the third gulch on the coast road beyond Castro's house); 510 meters from the road on right-hand side, and a little to the east of the top of the hill; on uncultivated ground belonging to Peter Gillis. The station was marked by a bottle buried 3 feet beneath the surface of the ground, and by a surface mark and reference marks as in note 32, page 618.

Point (San Luis Obispo County, Cal., S. Forney, 1883).—About 1 mile to the southeast of Willow Creek, on the most easterly point in view when looking toward Cayucos from the mouth of Willow Creek. Off the point there is a large rock bearing about south from the station and about 150 meters distant. The station was marked by a stone bottle buried 3 feet below the surface of the ground, neck up. Above this was placed a redwood stub 2 by 2 inches, its top even with the surface of the ground. The reference marks were lead bolts driven into holes drilled in the solid rock, each with a copper tack in the top, the bolts being located as follows: to the north, distant 2 feet 4 inches; to the south, 3 inches; to the east, 10 feet, and to the west, 1 foot 9¾ inches.

Red Rock (San Luis Obispo County, Cal., S. Forney, 1883).—On a prominent red rock on Cayucos Point, about 100 meters from the beach and one-fourth mile to the westward from John Kerr's house. The station was marked by a rectangular hole in the rock. The reference marks were lead plugs, with copper tacks in the top, in the solid rock, as follows: to the north, 1 foot 7½ inches; to the east, 3 feet 3 inches, and to the west, 3 feet 10½ inches.

Black Rock (San Luis Obispo County, Cal., S. Forney, 1883).—The highest point of a rock about 1 mile west of Cayucos wharf and about 100 meters from the beach.

Cayucos (San Luis Obispo County, Cal., S. Forney, 1883).—On the first ridge to the westward of Cayucos, about halfway up and about 100 meters east of a telegraph pole. The station was marked by a square hole in a solid rock; in the bottom of this hole a round hole was drilled, into which a lead plug was driven, marking the center. There were three reference marks, as follows: a lead plug driven into a drilled hole in the solid rock, northeast from the station 6 feet 7 inches; a redwood stub, 18 inches long and 2 by 2 inches, placed even with the surface of the ground, approximately south from the station, and a redwood stub approximately west, distant 2 feet 8¾ inches. Each stub had a copper tack in the top.

Cayucos Presbyterian Church (San Luis Obispo County, Cal., S. Forney, 1883).—A small pole on the top of the steeple of the only church (1883) in Cayucos.

Willow (San Luis Obispo County, Cal., S. Forney, 1883).—On a knoll on the south bank at the mouth of Willow Creek, about 10 meters from the beach and about 15 meters from the edge of the bluff at the mouth of the creek. The station was marked by a stone bottle, buried 3 feet beneath the surface of the ground neck up. On top of this is placed a redwood stub 2 by 2 inches, even with the surface of the ground. Four redwood stubs, 2 by 4 inches, 2 feet long, each with a copper tack in its top, were placed, even with the surface of the ground, to the north, south, east, and west, each 2 feet 10 inches from the center of the station.

Whale Rock (San Luis Obispo County, Cal., S. Forney, 1883).—The eastern and higher of two peaks of a rock about 300 meters from the shore and about 1 000 meters to the westward of the mouth of Old Creek.

Ring (San Luis Obispo County, Cal., S. Forney, 1883).—Just below and to the west of the top of the first high hill east of Toro Point, about one-fourth mile from the beach. (Note 24, p. 617, the center bottle being buried 3 feet deep, and the reference stubs being 4 feet from the center.)

Merrill (San Luis Obispo County, Cal., S. Forney, 1883).—On the bluff about 20 meters north from the mouth of Little Willow Creek, near high-water mark. (Note 30, p. 618.)

Fisherman (San Luis Obispo County, Cal., W. E. Greenwell, 1881).—About one-half mile south from Islay Creek and one-half mile south from the northern boundary of the Pecho ranch, about 15 feet from the edge of the bluff. (Note 6, p. 616.)

Buckhorn (San Luis Obispo County, Cal., W. E. Greenwell, 1881).—On the Pecho ranch, about three-fourths mile from the shore line, east of the crossing of Valencia Creek, 400 or 500 meters southeast of a clump of scrub pine on the west slope of the spur. (Note 6, p. 616, except no center stub was described.)

Buchon (San Luis Obispo County, Cal., W. E. Greenwell, 1881).—On Point Buchon, the most westerly point between Point San Luis and Moro Rock; about one-half mile south of the mouth of Valencia Creek, and 20 meters from the shore. (Note 6, p. 616.)

Rocky Peak (San Luis Obispo County, Cal., C. Rockwell, 1873).—Six and one-half miles from San Simeon Bay, a little to the east of Bare Hill.

Creek (San Luis Obispo County, Cal., S. Forney, 1885).—On the first prominent point southeast from the mouth of Santa Rosa Creek, just below the top and at the seaward of a rocky elevation at the end of the sand beach; about 75 meters south of a private wagon road, on land belonging to Lee Johnson. The center marks and the reference bottles were as in note 7, except the underground marks were buried 2 feet and there were no reference stubs.

Leffingwell (San Luis Obispo County, Cal., S. Forney, 1885).—About a half-mile west of the old Leffingwell wharf and about a mile east of San Simeon Creek; 12 meters toward the coast from the road leading to San Simeon Bay, on the land belonging to Mrs. Leffingwell. (Note 7, p. 616.)

Murphy (San Luis Obispo County, Cal., S. Forney, 1884).—On the highest point of the third ridge to the southward of Cambria, on the ranch of Mr. Estrada. The reference marks were stubs with copper tacks in the top placed approximately north, south, east, and west from the center of the station and distant from it 2 feet 6 inches.

Perry (San Luis Obispo County, Cal., S. Forney, 1884).—On the flat top of a hill south of Cambria, about 200 meters from the beach. The station was marked by a stone bottle, neck up, over which was placed a 2-inch redwood stub 2 feet long, the top of which is even with the surface of the ground. The reference marks were stubs placed at the following distances: to the north, 2 feet 6 inches; to the south, 2 feet 7 inches; to the east, 2 feet 5 inches; to the west, 2 feet 7 inches.

Allen (San Luis Obispo County, Cal., S. Forney, 1884).—On the first high peak south of Cambria, about 300 meters from the beach and about 300 meters west of a fence running approximately north and south. The station was marked by a stone bottle buried neck up, on top of which was placed a 2-inch redwood stub 2 feet long, the top of which is even with the surface of the ground. The reference marks were stubs placed at the following distances: to the north, 2 feet 2 inches; to the south, 2 feet 1 inch; to the east, 2 feet 2 inches; to the west, 2 feet 2 inches.

White (San Luis Obispo County, Cal., S. Forney, 1883).—Upon what is known as White Point, on the east shore of Moro Bay, forming the northern point of the entrance to the eastern portion of the bay. The station was marked by a square hole drilled into the solid rock. In the bottom of this hole was drilled a hole 1 inch in diameter into which a leaden bolt was driven. The reference marks were leaden bolts with copper tacks in the tops driven into holes drilled in the solid rock; to the east, distant from center 8 feet 7 inches; to the southeast, 7 feet 11 inches, and to the south, 11 feet 4½ inches.

Larsen (San Luis Obispo County, Cal., S. Forney, 1883).—On the east shore of Moro Bay, on the highest part of a point on the south side of a large indentation in the shore. (Note 30, p. 618.)

Baker (San Luis Obispo County, Cal., S. Forney, 1883).—On the highest sand dune on the peninsula separating the west shore of Moro Bay from the ocean, about 500 meters in a southerly direction from the house of Mr. Baker. (Note 30, p. 618.)

Pine 2 (San Luis Obispo County, Cal., S. Forney, 1885).—A tree with the limbs trimmed off for 20 feet down from the top and with a blazed triangle 4 feet from the ground; on land belonging to Mr. Phelan, on the hill northwest of Mr. Miner's house and overlooking the town of Cambria; distant from the Proctor House in a northerly direction about 400 meters.

Lone Tree (San Luis Obispo County, Cal., C. Rockwell, 1872).—Three miles from San Simeon Bay.

Oak Top Hill (San Luis Obispo County, Cal., C. Rockwell, 1873).—Three and one-fourth miles due north from San Simeon Bay.

Pine Top Hill to eastward (San Luis Obispo County, Cal., C. Rockwell, 1873).—Five and three-fourths miles a little to the east of north from San Simeon Bay.

Bare Top Hill (San Luis Obispo County, Cal., C. Rockwell, 1873).—Three and one-fourth miles nearly due north of San Simeon Bay.

Castle Top Hill (San Luis Obispo County, Cal., C. Rockwell, 1873).—Eight miles southeast from San Simeon Bay.

Lone Pine (San Luis Obispo County, Cal., C. Rockwell, 1873).—Four and one-third miles northeast from Point Piedras Blancas.

San Simeon Latitude Station 1852 (San Luis Obispo County, Cal., G. Davidson, 1852).—In San Simeon, Cal., on the beach about 15 yards to the west of the first break in the bank going from the west end of the beach. Reported destroyed in 1871.

Tepusquet Latitude Station (Santa Barbara County, Cal., J. S. Lawson, 1882).—A concrete pier, 67.78 feet from Tepusquet △ (p. 629), in azimuth 152° 14′ 38″.

Lospe Latitude Station (Santa Barbara County, Cal., J. S. Lawson, 1883).—A brick pier, 5.210 feet from Lospe △ (p. 629), in azimuth 89° 55′.

PIEDRAS BLANCAS TO POINT SUR.

Silver Peak (Monterey County, Cal., S. Forney, 1887).—On the highest point of a high, bushy ridge, the highest point of the Coast Range in this locality. The center of station was marked by an Indian stone mortar, buried 1 foot below the surface of the ground, with a hole drilled in the bottom, and filled with lead. This lead plug had a hole in it, which marked the center of the station. Three flat stones, each having a lead bolt with a cross in the top, were buried 1 foot below the surface of the ground, ranging approximately north, south, and east from center of station, and each 3 feet distant.

Cone Peak (Monterey County, Cal., A. F. Rodgers, 1890).—On the summit of a sharp, rocky peak, one of the so-called Lion Peaks, 3½ miles from the nearest point of the ocean at Portland Lime and Lumber Company's landing and 2 miles east of the nearest point of the San Antonio trail from Jolon village.

Rock Slide (Monterey County, Cal., A. F. Rodgers, 1890).—About 1¾ miles from the ocean, 3⅓ miles east southeast of Anderson Landing, 2 miles east of the mouth of Hot Springs Canyon; on the summit of the westerly point of the mountain at the head of Dolans Canyon, one-fourth mile west of the highest point of the mountain. Marked by a stone with a drill hole at the center, buried 18 inches below the surface. Four witness stubs, each with a tack in the top, were driven 6 feet from the center to the north, south, east, and west. An oak stump 7 feet high was 8 feet 10 inches west of the station.

Pico Blanco (Monterey County, Cal., A. F. Rodgers, 1875, 1890).—On the summit of Pico Blanco Mountain, 5 miles east of Point Sur. The station was marked by a hole drilled in a surface rock and filled with lead, on which cross lines marked the center of the station.

Santa Lucia West (Monterey County, Cal., A. F. Rodgers, 1890).—Upon the sharp, rocky peak of Santa Lucia Mountain, about 150 meters west of the primary station Santa Lucia (p. 617). A large flat stone with a center hole drilled three-fourths inch deep, set 4 inches below the rocky surface, marked the station. The witness marks were made by crosses cut in the rock; north, 8 feet 2 inches; south, 7 feet 7 inches, and east 5 feet 3 inches, distant from center.

Anderson (Monterey County, Cal., A. F. Rodgers, 1890).—Upon a conical summit, on the ocean side of which the coast or mountain trail from Posts, Monterey County, passes; the highest summit about a mile north of Swending's house. The subsurface mark, which was placed 20 inches underground, was a flat stone with a center hole drilled three-fourths inch in diameter and 1 inch deep. Two surface witness marks were driven, each 6 feet, east and west of the center, and a cross cut in a large rock north of and 5 feet distant from the center.

Manuel (Monterey County, Cal., A. F. Rodgers, 1890).—Near the southern end of a grassy ridge, upon which there are outcropping rocks, about two-thirds of a mile south of the summit of the ridge, 2 miles southeast of Cabego Prieto, and 3½ miles northeast by east of Pfeiffers Point. Michael, Frank, and John Pfeiffer know the location. The station was marked by a flat rock placed 18 inches below the surface, with a hole drilled at the center, which was filled with lead marked with a cross.

Pfeiffers Point (Monterey County, Cal., A. F. Rodgers, 1890).—Upon the land of Michael Pfeiffer, about one-half mile southwest of his house, on the prominent headland or knoll, the foot of which is washed by the ocean. The ocean face of the knoll has been so eroded and water-washed that upon that face the slope is precipitous. The station was marked by a hole one-half of an inch in diameter, and 1 inch deep, drilled in the rock 1 foot below the surface. The hole was filled with lead with cross lines drawn to mark the center.

Coopers Southeast Corner (Monterey County, Cal., A. F. Rodgers, 1890).—Upon the land of Michael Pfeiffer, upon a well-defined ridge, about a mile and a half north northwest from Pfeiffer's house. Cooper's line fence runs along the ridge and the southeast corner of the Sur Rancho is within 30 feet of the station. The position is well known to the Pfeiffer family. The station was marked by a bottle buried 2 feet below the surface of the ground and by a stub cut from the foot of signal pole.

Sur River (Monterey County, Cal., C. Rockwell, 1875).—Near and north of the mouth of the so-called Big Sur River and on the northwest side of the top of a sandy hill on the land of John B. Cooper, about 35 meters from the shore and 100 meters distant from a ledge of jasper which crops out of the soil. (Note 9, p. 616, except no center stub is described.) The true azimuths of various points are as follows: Coopers Point, 329°; Cooper's ranch house, 252°; rock 100 meters distant, 293°.

Little River Hill (Monterey County, Cal., A. F. Rodgers, 1875, 1890).—On the summit of the first hill to the east northeast of Point Sur and 1¾ miles distant. The county road runs one-half mile east of the station, and the Sur Rancho fence line is one-half mile north. (Note 8, p. 616.)

San Martin Top (Monterey County, Cal., S. Forney, 1887).—On the top of the first wooded knoll east of Cape San Martin. To reach the station, ascend the ridge north of Cruikshank's mine and follow it down to the ocean. The station is on the second wooded knoll from the ocean. The station was marked by a flat stone with a half-inch hole drilled into it, buried 18 inches below the surface of the ground.

Alder Top (Monterey County, Cal., S. Forney, 1887).—On the top of the highest peak of the Coast Range between Rocky Butte and Cone Peak, at the head of Alder Creek, about 1 mile in an easterly direction and in a direct line from the Cruikshank mine located on the west fork of Alder Creek, and 2 miles by trail from the mine on the south end of a ridge running north and south and near a ledge of rocks. The station was marked by a stone with a hole drilled in it three-fourths inch in diameter and 1 inch deep, buried 18 inches below the surface of the ground.

Lion Peak (Monterey County, Cal., S. Forney, 1887).—On the top of the highest and most western of three prominent cone-shaped peaks, at the head of Salmon Creek, and about three-fourths mile in a direct line from the coast. The station was marked by a hole drilled into the solid rock. Three reference holes were drilled into the solid rock and filled with lead as follows: south, 3 feet 9½ inches; southeast, 5 feet 1 inch, and east, 2 feet 10½ inches.

Soda (Monterey County, Cal., S. Forney, 1887).—On a large rock near the top of a high rocky point 1 mile in an easterly direction from Leonard Holmes's cabin, on the Buckeye ranch. The station was marked by a drill hole in the solid rock, 6 inches below the surface of the ground. Three holes were drilled in the solid rock as reference marks; east, 3.6 feet; south, 2.7 feet, and west, 2.93 feet.

Gate Pine (Monterey County, Cal., S. Forney, 1888).—On a prominent, timbered hill, on land owned by Byron Plaskett. (Note 5, p. 616.) The reference marks were stones, buried 3 feet from the center, to the north, south, and east. The signal tree was cut off 21½ feet above ground and the stump was left standing near the center.

Salmon Top (Monterey County, Cal., S. Forney, 1887).—Near the top of the highest bush-covered peak east of Salmon Creek, about 1 mile back from the coast. To reach the station, follow the main ridge extending west from Bald Top. The station was marked by a stone, with a ¾-inch hole drilled into it, one-half inch deep, buried 15 inches below the surface of the ground. The three theodolite stubs were left.

Lopez (Monterey County, Cal., A. F. Rodgers, 1890).—Upon what is known as the Lopez Point ridge. A bridle path leads from Lopez's house down the ridge and passes close to the station. The coast trail going north and south passes Lopez's house 300 meters north of the station. A trail also leads up the ridge from Lopez's house and connects with the San Antonio trail to Jolon village. The underground mark was a stone 8 inches below surface, with a drill hole at the center filled with lead.

Lopez Point (Monterey County, Cal., A. F. Rodgers, 1890).—Upon a well-defined point called Lopez Point, about half a mile from Lopez's house. The station was selected in 1888 and probably marked underground, but no description of the marking was given.

Borondá (Monterey County, Cal., A. F. Rodgers, 1890).—Upon a grass-covered ridge about half a mile northwest from Lopez's house and 50 meters seaward from the fence of the settler named Boronda, and about 600 meters southwest from his house. Philip Smith, who lives near Lopez Pine △, and the Lopez family know the location. The coast trail leading from Lopez's place to Gamboa's passes 300 feet below and about 250 meters distant from station. The underground mark was a stone placed 18 inches below the surface, with a hole drilled at the center, one-half inch in diameter and 1 inch deep.

Dolan (Monterey County, Cal., A. F. Rodgers, 1890).—On the summit of a high, prominent knoll, bare of timber and quite rocky, about 200 meters above and east of the main coast trail leading from S. Gamboa's place to Dolan's home place. The location of the station is well known to S. Gamboa, to P. Dolan, on whose land it is, and to "Rocky the Hunter." The station was marked by a rock buried 20 inches below the surface, with a hole drilled at the center one-half inch in diameter and 1 inch deep, filled with lead marked with a cross.

Anderson Point (Monterey County, Cal., A. F. Rodgers, 1890).—Upon a ridge between McWay's and Anderson's places (the place formerly owned by Anderson, now owned by T. B. Slate of Slate's Hot Springs); about one-fourth mile from the rocky beach and close to a trail leading from the lower coast trail at Anderson's to Swending's. The location is known to ——— Swending, Christopher McWay, and to T. B. Slate. A glass bottle was placed 14 inches below surface of the ground, with four witness stubs 6 feet from the center, to the north, south, east, and west.

Bald Top (Monterey County, Cal., S. Forney, 1887).—On the highest peak west of the mouth of the San Carpoforo Creek and 1½ miles back from the coast. The station was marked by a sandstone rock, with a hole one-half inch in diameter and one-half inch deep, buried 3 feet below the surface of the ground. Four redwood reference stubs, 2 by 3 inches, were driven into the ground, each 3 feet from the center, and ranging approximately north, south, east, and west.

Jones Top (Monterey County, Cal., S. Forney, 1887).—Five miles from the coast, on the top of the highest bushy mountain, in a northerly direction from George Jones's ranch house (on the middle fork of the San Carpoforo Creek), and about three-fourths of a mile in a direct line from his house. The station was marked by a ¾-inch hole drilled into the solid sandstone rock, 1 foot below the surface of the gronnd. Above this was placed a stub with a copper tack in its top, which marks the center of the station. Three flat stones were buried 6 inches below the surface of the ground, ranging approximately north, east, and south, each 3 feet from the center of the station. Each of these stones had a hole drilled into it and filled with lead. There were also four charred cedar stubs buried even with the surface of the ground, each with a copper nail in the top, ranging approximately north, south, east, and west, and distant 4 feet from the center of station. The three stubs on which the theodolite legs rested were cedar, and were left undisturbed.

Pine Top (Monterey County, Cal., S. Forney, 1887, 1888).—On the summit of the high wooded peak east of the San Carpoforo Creek, 2½ miles from the seashore. To reach the station, follow the trail from Hitchcock's house, on the San Carpoforo, up the main ridge to the top. The station was marked by a copper nail driven into the top of a stump, which is 3 feet 4 inches high. About fifty trees were cut down around the station.

Ragged Point (San Luis Obispo County, Cal., C. Rockwell, 1873).—On a ragged looking flat point, about one-half mile south of the mouth of the San Carpofero, on land claimed by Don Juan Castro; about 140 meters from the seashore, which is a perpendicular, rocky bluff, and about 30 meters to the east of a large pile of rocks about 12 feet high. (Note 9, p. 616.) The azimuths of the various points are as follows: rock off point of the coast, 200°; Valenzuela's house, 148°; bare top mountain, 106°; pile of rocks, 72°; woody top mountain, 55°; Hildebrandt's house, 17°; pile of rocks, distant 30 meters, 264°; end of point, 214°.

China Gulch (San Luis Obispo County, Cal., C. Rockwell, 1873; S. Forney, 1887).—On a hill 150 meters west of China Gulch, which is the next gulch above the Arroyo La Cruz; about 5 meters back from the edge of the bluff, toward the sea. (Note 24, p. 617, bottle buried neck up, 3 feet below the surface of the ground.) The three oak theodolite stubs were left.

Yellow Hill (San Luis Obispo County, Cal., C. Rockwell, 1873; S. Forney, 1887).—On top of a high, grassy hill, about 1 mile north of the Arroyo La Cruz, and nearly the same distance from the seacoast, on land claimed by Don Juan Castro. A washed place near the station shows the soil bright yellow at a distance. (Note 24, p. 617, bottle buried 3 feet below the surface of the ground.)

Rico (Monterey County, Cal., A. F. Rodgers, 1890).—Upon the land of the Rico Brothers, on the western end of a ridge which runs down to Pfeiffers Point, and 1½ miles east of the point. The station is well known to Michael and Frank Pfeiffer and to Frank Rico, whose house is northeast and one-fourth mile distant from the station. It was marked by a glass bottle buried 18 inches below the surface and by a center stub of redwood, the top even with the surface.

Castro (Monterey County, Cal., A. F. Rodgers, 1890).—Upon a rather small projecting spur, the second well-defined ridge south of the point at which the mountain trail from Posts reaches the coast summit and turns south, and about 200 meters coastwise from the trail. There are two trails from Posts southward, one known as the "coast trail" and the other as the "mountain trail." The station is best reached by the mountain trail. The station was marked by a stub with a tack in the center about 2 feet in the ground and the top level with the surface, covered with a pile of rocks.

Timber Top (Monterey County, Cal., A. F. Rodgers, 1890).—On a spur of the ridge running parallel to the coast, and about 1½ miles south of the point where the trail from Posts first reaches the backbone of the coast ridge and turns south; about 200 meters seaward or west from the mountain trail from Posts, upon the same ridge as the house of John Grimes, known as Grimes's rancho. The station was marked underground by a rock with a ½ inch hole drilled 1 inch deep, filled with lead, marked with cross lines.

Gamboa (Monterey County, Cal., A. F. Rodgers, 1890).—Upon a smooth, round, grass-covered knoll, about 1 000 meters from the nearest point of coast, upon the land of S. Gamboa, and 500 meters from his house. Reached from Jolon village by the San Antonio Mission trail. The underground mark was a glass bottle, neck down, the center of the bottom of which marked the center of the station.

Helam (Monterey County, Cal., S. Forney, 1887).—On a bushy ridge in a southeast direction from Silver Peak △ and about one-fourth of a mile from it. To reach the station follow the main ridge from Silver Peak △ toward the sea. The station was marked by a flat stone with a hole drilled in it, buried 1 foot below the surface of the ground, and surrounded by three flat stones buried 1 foot below the surface, ranging approximately north, south, and east, and distant 3 feet. Each stone had a hole drilled in it and filled with lead, with a cross cut on top of the lead.

Trail (Monterey County, Cal., S. Forney, 1888).—About three-fourths of a mile from the ocean, and 1 640 feet above it, on the land owned by Henry Mansfield, on the top of the hill northwest from his house, and about 40 meters west of the trail running from Pacific Valley to Jolon. (Note 5, p. 616.) The reference marks are on stones, buried 3 feet distant from the center, to the north, south, and east.

Plaskett Hill (Monterey County, Cal., S. Forney, 1888).—On the west slope of a high hill, on the land owned by Byron Plaskett, 1 mile east of his house. (Note 5, p. 616.) The reference marks are on stones to the north, east, and west, and distant 3 feet from the center.

Mansfield (Monterey County, Cal., S. Forney, 1888).—On the extreme northwest point of Pacific Valley Landing, on land owned by Henry Mansfield. (Note 5, p. 616.) The reference marks are on bowlders; to the north, distant 5 feet 5 inches, to the southwest, distant 7 feet 5 inches, and to the west, distant 12 feet 2 inches.

Fancher (Monterey County, Cal., S. Forney, 1888).—About three-fourths of a mile from the shore, near the top of a prominent hill on the south side of Willow Creek, on the land owned by A. Fancher, about three-fourths of a mile east of his house, and 75 meters east of the wagon road leading to it. (Note 5, p. 616.) The reference marks are on stones, to the north, south, and east, each distant 3 feet from the center. The three stubs on which the theodolite legs rested were left undisturbed.

Rock (Monterey County, Cal., S. Forney, 1888).—About 1 mile from the ocean, on land owned by B. Plaskett, on a rocky knoll of the ridge along the north side of Willow Creek. (Note 5, p. 616.) The reference marks are in the solid rock, as follows: To the south, distant 1 foot, and to the northeast, distant 3 feet 3 inches. Twenty-seven feet 6 inches east of the center of the station is a white-oak stump with a triangle cut on the west face, with four copper tacks, one in the center and one in each apex of the triangle.

Jellison (Monterey County, Cal., A. F. Rodgers, 1890).—On the land of Mrs. Parkington, whose house is about one-fourth of a mile northeast of station. The underground mark was a glass bottle, 18 inches below the surface, and above it a stub, with top 2 inches above surface of the ground.

Peter (Monterey County, Cal., A. F. Rodgers, 1890).—Upon quite a prominent round knoll, close to the ocean and about 3¾ miles southeasterly from Pfeiffers Point, upon the land of David Castro, and one-fourth of a mile south from his house. A stub marked the center of the station.

Slate (Monterey County, Cal., A. F. Rodgers, 1890).—Upon the sharp, steep grass ridge north of T. B. Slate's Hot Springs. The springs are near the shore line and about

60 miles south of Monterey. The station was marked by a stone placed 18 inches below surface of ground, with a hole drilled at the center, filled with lead marked with cross lines.

Olmstead (Monterey County, Cal., A. F. Rodgers, 1890).—Upon a tongue of land or spur making northward from the Santa Lucia Mountain, and having deep, rocky gorges upon the north, east, and west. It is isolated from all ordinary travel and difficult to reach. The location is known to Swending and Rocky the Hunter. The underground mark, which was placed 18 inches below the surface, was a rock, with center hole ½ inch in diameter and ¾ inch deep. Four witness stubs placed north, south, east, and west, each distant 6 feet from center.

No Name (Monterey County, Cal., C. Rockwell, 1875).—On the ridge going south from the mouth of Sur River, on top of the second summit on the trail from the river down the coast and about 100 meters from it; on bare, open ground at the southern part. The first deep canyon below Sur River forms the east and south sides of the ridge. (Note 9, p. 616, except no center stub is described.)

La Cruz (San Luis Obispo County, Cal., C. Rockwell, 1873).— Near the mouth of the Arroyo La Cruz, about 1 mile from the stream and one-half mile from the seashore, on top of the first hill forming the south bank. (Note 9, p. 616.)

Cinnabar (San Luis Obispo County, Cal., C. Rockwell, 1873).—About 3 miles above Point Piedras Blancas, near the foot of the mountain, on the high ground opposite the great bend of the Arroyo La Cruz and at least one-half mile from that stream. (Note 9, p. 616.)

Coopers Point (Monterey County, Cal., C. Rockwell, 1875).—On the first prominent point below Point Sur, on the summit of the inner one of three semidetached knolls worn away by the seas, the outer one of which is a sharp pinnacle of rock. (Note 6, p. 616, except no center stub is described.)

Coopers Pinnacle (Monterey County, Cal., A. F. Rodgers, 1890).—The most prominent of several knobs or knolls, and the terminal of what is locally known as Coopers Ridge, down which extends the south line fence of Cooper's ranch.

Black Mountain (Monterey County, Cal., A. F. Rodgers, 1890).—Five meters west of Post Summit △. (Note 8, p. 616.)

Post Summit (Monterey County, Cal., A. F. Rodgers, 1890).—A prominent rock on the apex of the summit of Cabeyo Prieto; just beyond the limits of the fences of the Sur ranch. The summit is covered with a dense growth of chaparral.

Square Black Rock (Monterey County, Cal., A. F. Rodgers, 1890).—About 1 mile southwest from Dolan △ and 300 meters distant from the shore. As seen from most directions it appears as a square black rock, but when east or west of it a cleft appears.

Lopez Rock (Monterey County, Cal., A. F. Rodgers, 1890).—The highest point of a prominent rock about 1 mile west from Lopez Point and 40 meters distant from the nearest point of the shore line. As seen from the northwest or southeast it looks like a schooner under sail, close hauled.

Little Lopez Rock (Monterey County, Cal., A. F. Rodgers, 1890).—The top of the lowest of the three rocks called Lopez Rock.

Slate Rock (Monterey County, Cal., A. F. Rodgers, 1890).—Quite a prominent offshore detached rock, the top 20 feet above ordinary high-water mark; one-fourth mile offshore and one-half mile westerly from Slate's Hot Springs.

Pfeiffers Little Pinnacle (Monterey County, Cal., A. F. Rodgers, 1890).—The highest rock in a group quite close to the shore line off Pfeiffers Point, and from the seaward not especially noticeable as a distinct rock.

Pfeiffers Rock (Monterey County, Cal., A. F. Rodgers, 1890).—The largest detached rock under Pfeiffers Point.

San Martin Rock or *Great White Rock* (Monterey County, Cal., S. Forney, 1888).—The highest point of an isolated, sharp-pointed rock, the largest and inner one of four rocks lying off Cape San Martin.

Middle San Martin Rock (Monterey County, Cal., S. Forney, 1888).—On the highest part of the larger one of the two rocks between San Martin Rock and Outer San Martin Rock.

Outer San Martin Rock (Monterey County, Cal., S. Forney, 1888).—The sharp point of the summit of a white pointed rock, the outer one of the group of four rocks lying off Cape San Martin.

Limekiln Rock (Monterey County, Cal., A. F. Rodgers, 1890).—A small rock under the bluff at Rockland Lime and Lumber Company's landing, close to the beach. It can be made out through the mouth of Rockland Canyon.

Limekiln Smokestack (Monterey County, Cal., A. F. Rodgers, 1890).—The stack of a hoisting engine on the Rockland bluff, not over 10 feet high, and distant 10 meters from the Rockland Lime and Lumber Company's warehouse.

Limekiln Warehouse (Monterey County, Cal., A. F. Rodgers, 1890).—The flagpole on the ocean gable of the warehouse of the Rockland Lime and Lumber Company, a whitewashed building 90 feet long, upon the ocean bluff.

Mansfield Cone (Monterey County, Cal., S. Forney, 1888).—A conical-shaped rock on the extreme point of the shore line at the northwest end of Pacific Valley Landing, Twin Peak Cove, on land owned by Henry Mansfield.

Mansfield's house (Monterey County, Cal., S. Forney, 1888).—The top of the chimney of Mansfield's house, which stands on an old Indian shell mound, about one-third of a mile north of the schoolhouse and about the same distance east of Pacific Valley Landing.

Plaskett Rock (Monterey County, Cal., S. Forney, 1888).—The highest point of a large white rock at the southwest end of Pacific Valley Landing, Twin Peak Cove.

White Rock 1 (Monterey County, Cal., S. Forney, 1887).—The highest point of a prominent white rock projecting about 39 feet above high water, one-half of a mile west of the mouth of Salmon Creek, one-half of a mile from the shore, and 170 meters inside a breaker. The station was not marked.

San Martin Point (Monterey County, Cal., S. Forney, 1887).—On the sea face of Cape San Martin, about one-fourth mile from the shore, on land claimed by A. Fancher; on the southeast point of a bench or table running approximately northwest and southeast; at the edge of the bluff just south of the pines. The station was marked by a flat stone with a ½-inch hole drilled in it, buried 2 feet below the surface of the ground, surrounded by four redwood stubs, each with copper tack in top, buried even with the surface of the ground, and ranging approximately north, east, south, and west, and each distant 4 feet from the center of the station.

Buckeye (Monterey County, Cal., S. Forney, 1887).—About three-fourths mile from the shore on the land claimed by William Cruikshank; on the end of the highest ridge in a northwesterly direction from Leonard Helam's cabin, in Buckeye Valley, at the point where the ridge drops off abruptly; on a ledge of cinnabar rock. The station was marked by a ¾-inch hole drilled in the solid rock, 1 inch deep, surrounded by three ¾-inch holes drilled in the solid rock and filled with lead, as follows: to the east, 1 foot 6 inches; to the south, 2 feet 7½ inches; to the west, 2 feet 5 inches.

Willow Peak (Monterey County, Cal., S. Forney, 1888).—On Government land, 5 miles from the seacoast, on the top of an isolated peak on the summit of the Coast Range at the headwaters of the main branch of Willow Creek. The station was marked by a large bowlder with a ¾-inch hole drilled 2 inches deep in it. (Note 5, p. 616.) The reference marks were in bowlders, as follows: to the northwest, distant 8 feet 1 inch from the station; to the northeast, distant 2 feet, and to the southwest, distant 2 feet 2 inches.

Mortar (Monterey County, Cal., S. Forney, 1888).—Three-fourths mile from the ocean on the land owned by B. Plaskett; on the second spur west of Willow Creek, about 400 feet above the coast trail on the point of the ridge, and about 50 feet above a large bowlder on the side of the hill. The station was marked by an old Indian mortar, with a ¾-inch hole drilled in the bottom of it, buried 14 inches below the surface of the ground. The reference stones were as in note 5, p. 616, and each distant 3 feet to the north, south, and east of the station.

Corral (Monterey County, Cal., S. Forney, 1888).—On the top of a high rocky knoll, on land belonging to Henry Mansfield, about one-half mile to the north of his corral, about two-thirds of the way up the mountain, just west of the trail leading to Jolon, and about 300 meters down the ridge toward the ocean from a point where a fence crosses the ridge. (Note 5, p. 616.) The reference marks are in bowlders, as follows: to the north, distant 2 feet 7 inches from the station; to the south, distant 4 feet 8½ inches; to the east, distant 8 feet 1 inch.

Gonzales (Monterey County, Cal., S. Forney, 1887).—About three-fourths mile from the ocean and 1 mile from the San Carpoforo Creek, on the first ridge southeast from Mr. Thorndyke's house, on land claimed by him; about 1 mile to the north of Valenzuela's house, one-fourth mile west of Bordel Gonzales' house and on a little bench on the third rise of the ridge from Thorndyke's house. The station was marked by a stone with a ¾-inch hole drilled one-half inch deep in it, and buried 3 feet below the surface of the ground, surrounded by four redwood stubs 2 by 3 inches, 2 feet long, each with a copper tack in the top, driven into the ground, and ranging approximately north, south, east, and west, at a distance of 4 feet from the center of station.

Soda Point (Monterey County, Cal., S. Forney, 1887).—About one-fourth mile from the coast, on the end of the eastern ridge running down toward the ocean from Soda △, the first ridge west of Frank Numma's cabin. The first clump of redwood trees on the trail up the coast from Salmon Creek is in the first canyon west of the station. The station was marked by a stone with a ¾-inch hole drilled 1 inch deep, buried 1 foot below the surface of the ground, surrounded by four stubs of pine, each with copper tack in top, placed approximately north, south, east, and west from the center, at a distance of 4 feet.

Thorndyke Top (Monterey County, Cal., S. Forney, 1887).—Near the trail and on the top of the main ridge running from Bald Top to Salmon Top. The station was marked by a piece of sandstone with a ¾-inch hole drilled in it, buried 18 inches below the surface of the ground, and surrounded by four redwood stubs, 2 by 3 inches, each with a copper tack in the top, buried even with the surface of the ground, ranging approximately north, south, east, and west, and each distant 4 feet from the center of the station.

Prize Pine (Monterey County, Cal., S. Forney, 1887).—A tree 26 inches in diameter, trimmed down, but leaving a bushy top, with a triangle cut on the south face, situated on a mining claim called the Grand Prize, located on a ridge about three-fourths of a mile in a northwesterly direction from the Cruikshank mine.

Spur (Monterey County, Cal., S. Forney, 1888).—One-half mile from the ocean on the end of the first spur north of Trail △, on land owned by Henry Mansfield. (Note 5, p. 616.) The reference stones are distant 3 feet to the north, south, and east.

Plaskett Point (Monterey County, Cal., S. Forney, 1888).—On a prominent rocky point of land at the southern end of Pacific Valley, on land owned by Byron Plaskett and about 300 meters southwest from his house. (Note 5, p. 616.) The center stone was 8 inches below the surface. The reference marks were on bowlders, as follows: to the north, 8 feet 3¼ inches from the center; to the south, 6 feet 2½ inches, and to the west, 4 feet 10 inches.

Mound (Monterey County, Cal., S. Forney, 1888).—On a rocky mound on the coast, on land owned by Henry Mansfield, in the last field northwest of his house. (Note 5, p. 616.) The reference marks were on solid bowlders, as follows: to the north, 6 feet from the center; to the south, 4 feet 8 inches, and to the east, 1 foot 7 inches.

Willow Point (Monterey County, Cal., S. Forney, 1888).—One-fourth of a mile from the ocean and 100 yards south of the coast trail, on the second point northwest of Willow Creek, on land owned by Byron Plaskett. (Note 5, p. 616.) The reference marks are on stones buried each 3 feet distant from the station, to the north, south, and west.

San Carpoforo (San Luis Obispo County, Cal., C. Rockwell, 1873).—About 1 mile from the coast, on the first sharp, narrow ridge south of San Carpoforo Creek, on a small sloping bench overlooking the canyon, about one-fourth of a mile north of a deep gulch with a large stream of water in it; on land owned by Don Juan Castro; very near a cattle trail from the coast to the top of the hill. (Note 9, p. 616.)

Gillis (San Luis Obispo County, Cal., C. Rockwell, 1873).—Twenty-three meters from the seashore, 1 850 meters northwest from Piedras Blancas Light-house, 260 meters south of the mouth of two small streams, and on Gillis' land, 635 meters from his house. (Note 9, p. 616, except no center stub is described.)

Valenzuela (San Luis Obispo County, Cal., C. Rockwell, 1873).—On a narrow bench of land between the foot of the mountain and the seacoast and about three-fourths of a mile north of the Arroyo San Carpoforo, about 20 yards east of the trail from San Carpoforo Creek up the coast, on land claimed by Mr. Valenzuela. A stream of water runs in a gulch about 100 yards to the north, beyond which the land rises very abruptly, as it does to the east of the station. Near the station the soil is disintegrated rock washed from the mountain. From the station Valenzuela's house and the small hill at the mouth of Arroyo La Cruz are in range; also a group of rocks in the bight south of the mouth of San Carpoforo Creek. (Note 9, p. 616, except no center stub is described.) The azimuths to various points are as follows: Hildebrandt's house, 11°; Valenzuela's house, 357°; end of point, 348°; top of hill, 126°.

Brushy Knob (San Luis Obispo County, Cal., C. Rockwell, 1873).—About 1 mile from the seashore on the top of a very peculiar round knob projecting above the ridge forming the south bank of the Arroyo La Cruz, about one-half of a mile from it, on land claimed by Don Juan Castro. The top of the knob is a kind of sandstone or hardpan, and is covered with low brush. (Note 9, p. 616.)

Sierra Nevada (San Luis Obispo County, Cal., C. Rockwell, 1873).—About 650 meters west of the mouth of the Arroyo La Cruz, on a sharp, narrow little point of land, about 20 meters from the edge of the bluffs toward the sea, on land claimed by Don Juan Castro. (Note 9, p. 616, except that no center stub is described.)

La Cruz Rock (San Luis Obispo County, Cal., C. Rockwell, 1873).—The top of a rock 50 feet high, 330 meters from the mouth of the Arroyo La Cruz.

White Rock 2 (Monterey County, Cal., C. Rockwell, 1873; S. Forney, 1887).—The highest point of a rock, about 64 feet above high water, 130 meters offshore at the mouth of the first canyon west of Salmon Creek that has redwood trees growing in it.

Cone Pine (Monterey County, Cal., A. F. Rodgers, 1890).—A trimmed pine upon the ridge which culminates at Cone Peak. Cone Pine △ and Cone Peak △ are on twin summits.

Dolans Cone Rock (Monterey County, Cal., A. F. Rodgers, 1890).—Is about one-half of a mile west of Dolan's, close under the coast bluffs.

Lopez Lone Tree (Monterey County, Cal., A. F. Rodgers, 1890).—On one of the spurs of Lopez ridge, 1 mile north by east of Lopez Point.

Lopez Pine (Monterey County, Cal., A. F. Rodgers, 1890). Upon the main ridge traveled in going from Jolon village to Lopez Point, one-fourth of a mile south of the house of Philip Smith. The tree is quite prominent when looking from north or south, and has been stripped of branches with exception of a tuft at top. Location known to S. Zamboa, Philip Smith, and Kiel Dani.

Digges Pine (Monterey County, Cal., S. Forney, 1888).—On the summit of the Coast Range, 25 meters south of the trail leading from Pacific Valley to Jolon, on land owned by Henry Mansfield; a tree 3 feet 2 inches in diameter, with a brush top 20 feet high and a triangle cut on the north side, with a copper tack in the center and at each apex. To reach the station follow the trail from the corral near Corral △, passing an old barn and cabin south of the trail, to a cabin in a small flat to the north of trail. The station is one-fourth of a mile to the northeast.

Post's house (Monterey County, Cal., A. F. Rodgers, 1890).—The white chimney of the house of William B. Post, postmaster, 38 miles from Monterey, and at end of wagon road.

Pine Anderson (Monterey County, Cal., A. F. Rodgers, 1890).—A trimmed tree on the ridge above what is known as the Anderson place, owned by Slate.

Gamboa Point (Monterey County Cal., A. F. Rodgers, 1890).—A conical rock at the end of the small sandy bight and beach under Gamboa △, and as seen from Dolan △ and Rock Slide △ appears to be a projection of the shore line.

Little Pyramid Rock (Monterey County, Cal., A. F. Rodgers, 1890).—A small pyramid-shaped rock, in a group of rocks, close under the bluffs which flank the ocean side of the knoll on which Peter △ is located.

Mansfield Pine (Monterey County, Cal., S. Forney, 1888).—A tree, trimmed down, on land belonging to Henry Mansfield, on the high hill immediately back and east of his house.

Harlan Rock (Monterey County, Cal., A. F. Rodgers, 1890).—A rock, about 2 miles east of Lopez Point and 1 mile west from Rockland Lime and Lumber Company's landing, in a bight, projecting about 8 or 10 feet at high water.

Deer Pine (Monterey County, Cal., S. Forney, 1887).—A tree 17 inches in diameter, trimmed down, leaving a bushy top, in a clump of oak and pine trees, on the first ridge west of Salmon Creek, and about three-fourths of a mile east from Deer Flat.

Cabin Pine (Monterey County, Cal., S. Forney, 1888).—A tree, trimmed down, leaving a bushy top 10 feet high, on land owned by Byron Plaskett, near the summit of the ridge extending upward from his house. The tree was 3 feet 3 inches in diameter, and has a triangle cut on the south face, with copper tack in center and at each apex. In the gulch on the east side of this tree is a cabin and mining claim owned by Mr. Goodrich.

Salmon Pine (Monterey County, Cal., S. Forney, 1887).—A tree, trimmed down, leaving a bushy top 10 feet high, with a cross cut on the west face, on the first long ridge south of and about 1 mile from Salmon Top △.

Lone Pine (Monterey County, Cal., S. Forney, 1888).—A tree 30 inches in diameter, trimmed down, leaving a bushy top 10 feet high, with a triangle cut on its south face, near the trail on the ridge extending from William Plaskett's house to the summit of the Coast Range and to Jolon.

Ridge Pine (Monterey County, Cal., S. Forney, 1888).—A tree 20 inches in diameter, trimmed down, with a triangle cut on the east side, on land owned by William L. Plaskett, on a spur of the main coast ridge, about midway between Gate Pine and Diggs Pine.

Big Tree (Monterey County, Cal., C. Rockwell, 1873).—About a half mile from the mouth of the Arroyo La Cruz and the same distance from the pine top hill north of Point Piedras Blancas.

Rocky Butte Latitude Station (San Luis Obispo County, Cal., J. S. Lawson, 1885).—A concrete pier 5.13 feet west of Rocky Butte △ (p. 628).

Castle Mount Latitude Station (Monterey-Fresno Counties, Cal., J. S. Lawson, 1885).—A concrete pier 1.6 meters due east of Castle Mount △ (p. 605).

Hepsedam Latitude Station (San Benito County, Cal., J. S. Lawson, 1885).—A concrete pier, 5.15 feet east of Hepsedam △ (p. 605).

Santa Lucia Latitude Station 1885 (Monterey County, Cal., G. Davidson, 1885).—A concrete pier 44 feet 1 inch from Santa Lucia △ (p. 627), in azimuth 227° 28′.

Santa Lucia Eclipse Station (Monterey County, Cal., G. Davidson, 1880).—Five hundred and forty-six feet two inches from Santa Lucia △ (p. 627), in azimuth 102° 33′.

Santa Lucia Latitude Station 1880 (Monterey County, Cal., G. Davidson, 1880).—A pine post 22 inches in diameter, 67.25 feet, azimuth 193° 48′, from Santa Lucia Eclipse Station; 56 meters north and 158 meters west of Santa Lucia △ (p. 627).

Santa Lucia U. S. Naval Observatory Station (Monterey County, Cal., E. Frisby, 1880).—$167^{m}.87$ west and $46^{m}.90$ north of Santa Lucia △ (p. 627).

POINT SUR TO MONTEREY BAY.

Sierra Hill (Monterey County, Cal., A. F. Rodgers, 1875, 1890).—On the top of the first hill to the north of Little Sur River and three-fourths of a mile from it; three-fourths of a mile from the shore, and 400 meters west of the coast road. (Note 8, p. 616.)

Bonifacio Hill (Monterey County, Cal., A. F. Rodgers, 1875).—The station was marked according to note 8, p. 616.

Point Sur (Monterey County, Cal., C. Rockwell, 1875).—On highest part of the mound forming the extremity of Point Sur. The ground is very rocky, and the top of the mound is barely large enough for a signal. The center was marked by a drilled hole, filled with lead, in a sandstone rock buried about 2 feet underground. Witness stubs of redwood were placed as follows: one west, 6 feet; one east, 7 feet, and one south, 6 feet. Reported probably lost in 1890. (See Point Sur 2 △, p. 737.)

Dry Hill (Monterey County, Cal., C. Rockwell, 1875).—On highest part of the southern end of a dry-appearing ridge about 2 miles east by south of Point Sur, on the Cooper ranch, and nearly a mile from the ocean. The ridge is immediately north of a creek and the road leading from the coast trail to a dairy house up the valley. (Note 9, p. 616, except no redwood stub at the center.) The true azimuths of certain points are as follows: high rocks on a point of the coast, 336°; Cooper's ranch house, 329°; a log cabin in a canyon (visible 10 feet from station), 264°; a rock 250 meters down the ridge, in range with a bog hole in the center of the flat, 47°.

False Sur (Monterey County, Cal., C. Rockwell, 1875).—On the summit of a small rounded hill known as False Sur. (Note 9, p. 616, except no redwood stub at the center.)

Oliviers Mount (Monterey County, Cal., A. F. Rodgers, 1875).—On the southwest side of a mountain the summit of which is 2 miles northeast by north from Kaslers Point and 1 mile from the shore line. The station is 130 feet below and 200 meters from the summit. (Note 8, p. 616.)

Cushings Mount (Monterey County, Cal., A. F. Rodgers, 1875).—On the west end of a ridge about 2 miles southeast of Kaslers Point and one-half mile from the shore line. The ridge is sloping, and the summit is 600 meters west of and 200 feet above the station. (Note 8, p. 616.)

Kaslers Point (Monterey County, Cal., A. F. Rodgers, 1875).—On top and near the edge of a bluff about 160 feet high 250 meters southeast of most westerly point of Kaslers Point. The bluff rises from the water's edge. (Note 8, p. 616.)

Soberanes Point (Monterey County, Cal., A. F. Rodgers, 1875).—On top and near the edge of bluff 40 feet high on the south end of a rocky point one-half of a mile south of Exequil Soberanes' house and 3 miles south-southeast of Yankee Point. (Note 8, p. 616.)

Rocky Ridge (Monterey County, Cal., A. F. Rodgers, 1875).—On the southwest side of a small knob on the west side of a hill 1 800 feet high 2½ miles southeast of Yankee Point. The station is 400 feet below and 600 meters west of the summit.

Gutres Knoll (Monterey County, Cal., A. F. Rodgers, 1875).—One and one-half miles south-southeast of Yankee Point, 200 meters east of and 190 feet above the beach; on the west side of a small knoll on the west slope of a hill, 20 feet below the top of the knoll. (Note 8, p. 616.)

Waters Ridge (Monterey County, Cal., A. F. Rodgers, 1875).—On the west slope of ridge 1 mile east of Yankee Point, 1 250 feet above sea level, and 550 meters northwest of and 320 feet below the top of the ridge. (Note 8, p. 616.)

Yankee Point (Monterey County, Cal., A. F. Rodgers, 1875).—On top of knoll about 110 feet high near the most westerly part of Yankee Point, 100 meters southwest of the highest part of Yankee Point. (Note 8, p. 616.)

Whalers Knoll (Monterey County, Cal., A. F. Rodgers, 1875).—On the summit of the knoll one-fourth of a mile west of the whalers' landing at Carmel Cove and ½ mile east-southeast of the most westerly point of Point Carmel. The signal flagstaff of the whalers is 15½ feet S. 65° E. of station. The mark is a drilled hole, filled with lead, in the surface rock, and covered with a large pile of stones.

Greggs Hill (Monterey County, Cal., A. F. Rodgers, 1875).—On the summit of the first high hill south of Carmel River, three-fourths of a mile southeast of Greggs' ranch and 1 mile east of the mouth of San Jose Creek. (Note 29, p. 618.)

Pescadero Point (Monterey County, Cal., A. F. Rodgers, 1875).—On the outer extremity of the low rocky point which forms the northern headland of Carmel Bay; on the south side of the point, about 100 meters from the edge of the timber. (Note 29, p. 618.)

Monterey Hill (Monterey County, Cal., A. F. Rodgers, 1875).—Two miles south of Monterey, on a round top knoll near the west end of a high bald ridge; about 300 yards north of the board fence extending east and west along the south side of the ridge. (Note 29, p. 618.)

Loma Alta (Monterey County, Cal., A. F. Rodgers, 1875).—Near the summit of the high bald ridge about 2 miles south of the town of Monterey and within about 400 yards of the timber line on the east side of the ridge. The summit of this ridge consists of two small round knobs; the station is on the southern knob about 50 yards west of its apex. (Note 29, p. 618.)

Sand Hill 2 (Monterey County, Cal., A. F. Rodgers, 1875).—The station was marked according to note 8, p. 616. Reported lost in 1904.

Monterey Bay 2 (Monterey County, Cal., A. F. Rodgers, 1875).—The station was marked according to note 8 p. 616.

Luces Point (Monterey County, Cal., A. F. Rodgers, 1875; F. Swift, 1904).—On a point of rocks about 600 meters northeast of Point Pinos Light-house and a quarter of a mile east of a small pond or lake near the beach at the northern part of the point. The station was marked by a hole drilled in the rock and filled with lead. The reference marks were two similar holes in the rock, each 6 feet from the station, to the north and south.

Rocky Point 2 (Monterey County, Cal., A. F. Rodgers, 1875).—On the first prominent point northwest of the town of Monterey, about half a mile distant from the old custom-house wharf and about 300 yards below the Point Pinos Light-house road, in the field directly in front of Milton Little's house. (Note 29, p. 618.) A hole was drilled in a large bowlder and filled with lead, 26 feet northwest from the station.

Mussel Point (Monterey County, Cal., A. F. Rodgers, 1875; F. Swift, 1904).—One and one-half miles north-northwest of Salinas City wharf, on top of a small knoll on the northwest part of Mussel Point, about 50 meters from shore line. (Note 8, p. 616.)

White Rock (Monterey County, Cal., A. F. Rodgers, 1875).—About 700 meters northwest of Point Pinos Light-house, on a large white-looking rock lying off Point Pinos, about 300 yards outside the bluff line. It can only be reached at very low tide. The station is marked by a hole drilled in the rock and filled with lead.

Moss Beach (Monterey County, Cal., A. F. Rodgers, 1875).—On the low sandy point that makes out about midway along the beach, locally known as Moss Beach, about 1½ miles south of Point Pinos Light-house. The road from Monterey to Point Cypress passes close to the station on the east side. (Note 29, p. 618.)

Pyramid Point (Monterey County, Cal., A. F. Rodgers, 1875; F. Swift, 1904).—On a sharp, pyramid-shaped rock on the northwest extremity of the point locally known as Sawmill Point; about 2 miles south of Point Pinos Light-house; about 300 meters west of the road from Monterey to Point Cypress. The station was marked by a hole drilled in the rock and filled with lead, and by three witness marks, also holes drilled in the rock, two in line north and south and the other at a right angle to these, each 6 feet distant from the station.

Timber Ridge (Monterey County, Cal., A. F. Rodgers, 1875).—Three and one-half miles from Monterey and 2 miles north of Carmel River on the southern end of the first hill with a round top to the west of the road from Monterey to Carmel and about 500 yards from where the road issues from the timber and begins to descend the hill toward Carmel River; about 90 feet above and 100 meters west of the road. (Note 29, p. 618.)

Carmel River (Monterey County, Cal., A. F. Rodgers, 1875).—On the top and southern end of a low flat point, northwest of and 500 meters from the mouth of Carmel River, and 1 000 meters west by south of Carmel Mission; 150 meters north of where the sand beach joins the rocks on the southern end of the point. (Note 29, p. 618.)

Huckleberry Hill (Monterey County, Cal., A. F. Rodgers, 1875).—On a round, bare knoll on the high ridge or hill, about 1¼ miles east of the whale fishery at Carmel Cove; about 150 meters south of the road from Carmel to the Mal Paso coal mine. (Note 29, p. 618.)

Yankee Knoll (Monterey County, Cal., A. F. Rodgers, 1875).—On the top of the knoll on the western slope of a hill, one-fourth of a mile east of the most northerly part of Yankee Point; 270 feet above sea level. (Note 8, p. 616.)

Point Cypress (Monterey County, Cal., A. F. Rodgers, 1875).—On the summit of the round knoll at the outer extremity of Point Cypress. (Note 29, p. 618.)

Timber Point (Monterey County, Cal., A. F. Rodgers, 1875).—On a large rock at the outer southwest extremity of the timbered point that makes out about halfway between Point Cypress and Pescadero Point. The station was marked by a hole drilled in the rock and filled with lead.

Point Lobos (Monterey County, Cal., A. F. Rodgers, 1875).—On the top of a small, conical hill, about 110 feet high, 60 meters from beach and 12 miles south-southeast of most northerly part of Point Carmel. (Note 8, p. 616.)

Frank (Monterey County, Cal., A. F. Rodgers, 1875).—On the western slope of a hill, 2¼ miles northeast of Point Cypress, 400 meters from end of the point to northwest, 25 feet above sea level, and about 50 meters from the edge of timber. (Note 8, p. 616.)

Pelican Point (Monterey County, Cal., A. F. Rodgers, 1875).—On a low, flat point about 1½ miles north of Point Cypress and about 150 yards north of the mouth of a small creek; about 40 meters from the shore line. A group of large white rocks lies a few hundred yards off the point. (Note 29, p. 618.)

Lone Rock (Monterey County, Cal., A. F. Rodgers, 1875.)—On west slope of a hill, 2 miles northeast of Point Cypress, at the edge of timber, 30 feet above and 250 meters east of the shore line, and 250 meters north of a small knob on the side of the hill near the edge of timber. (Note 8, p. 616.)

Black Ridge (Monterey County, Cal., C. Rockwell, 1875).—One and one-eighth miles northeast of Point Sur and one-half of a mile east of the north end of a sand beach extending from Point Sur up the coast; on a high ridge on Cooper's ranch a little west of the highest part of the ridge; 80 meters southeast and 18.3 meters below it is a steep sandstone cliff. (Note 9, p. 616, except no stub over bottle).

Cooper (Monterey County, Cal., C. Rockwell, 1875).—About 1¼ miles nearly east of the north end of Point Sur and 1 mile north of False Sur, on a ridge extending from the plains at Point Sur to the first range of hills. The end of the sand beach where it joins the north side of the rock at Point Sur is in range with a ledge of rocks about 100 meters from the station. The outer pinnacle of Coopers Point is nearly in range with the highest part of a hill near the mouth of Sur River. A high rock on a point of the coast bears 330° (true). (Note 9, p. 616, except no stub over center.)

Point Sur South Base (Monterey County, Cal., C. Rockwell, 1875).—Two-thirds of a mile nearly due east of the south end of Point Sur Rock, 150 meters from the nearest point of a gulch to the southeast, and 150 meters from the shore line, close to the edge of the drifting sand. (Note 9, p. 616, except no stub over the center bottle.)

Point Sur North Base (Monterey County, Cal., C. Rockwell, 1875).—On the plain two-thirds of a mile nearly northeast of Point Sur Light-house and one-third of a mile from the beach, about 5 meters from the edge of the sandy level. True azimuths are as follows: to the west end of Point Sur Rock 66°; to a sandstone cliff 210°. (Note 9, p. 616, except no stub over the center bottle.)

Vierra Knoll (Monterey County, Cal., A. F. Rodgers, 1875).—On the top of a small knoll, about 250 meters a little north of west of the house of John P. Vierra, at a point on the coast about midway between Point Lobos and Yankee Point, off which there are a number of rocks. (Note 8, p. 616.)

Bushy Ridge (Monterey County, Cal., A. F. Rodgers, 1875).—One and one-half miles southeast of Yankee Point and three-fourths of a mile from the shore, on northwest end of a long, sloping ridge; about 1 000 feet above sea level, and 800 feet below and 1 mile northwest of the top of the ridge. (Note 8, p. 616.)

Soberanes Ridge (Monterey County, Cal., A. F. Rodgers, 1875).—On the western end of a sloping ridge one-half of a mile southeast of Soberanes Point, about 1 000 feet above sea level and 1 mile west of the top of the ridge. Three hundred meters west of station is a small knoll about 40 feet high. (Note 8, p. 616.)

Portuguese Ridge (Monterey County, Cal., A. F. Rodgers, 1875).—On a small spur on the western end of a ridge, 1½ miles north-northeast of Kaslers Point, one-third of a mile from shore and about 960 feet above sea level. (Note 8, p. 616.)

Palo Colorado Ridge (Monterey County, Cal., A. F. Rodgers, 1875).—On the highest point of the first ridge east of Kasler's house, about 600 meters from it, 1 300 meters southeast of Kaslers Point, and one-half of a mile north of the mouth of Palo Colorado Canyon. (Note 8, p. 616.)

Division Knoll (Monterey County, Cal., A. F. Rodgers, 1875).—About 100 meters southwest of and 20 feet below the summit of a steep knoll, about 5 miles north of Point Sur and 2½ miles south of Kaslers Point; 250 meters from the shore and 400 meters from the end of a rocky point making out at this place. Castle Rock is nearly west of the station. (Note 8, p. 616.)

Algers Ridge (Monterey County, Cal., A. F. Rodgers, 1875).—The station was marked according to note 8, page 616.

Las Piedras Ridge (Monterey County, Cal., A. F. Rodgers, 1875).—On the summit of a hill 1¼ miles east by south of Castle Rock and 1 mile southeast of A. Alger's house. (Note 8, p. 616.)

Widow Heaths Hill (Monterey County, Cal., A. F. Rodgers, 1875).—On the summit of the northwest end of first ridge north of Little Sur River. One-half mile from the shore and 1½ miles due north of the mouth of Little Sur River. (Note 8, p. 616.)

Point Sur 2 (Monterey County, Cal., A. F. Rodgers, 1890).—Very near Point Sur △ (p. 733). Probably marked according to note 8, page. 616.

Santa Ana Latitude Station (San Benito County, Cal., G. Davidson, 1885).—A concrete pier, 37 feet 6 inches from Santa Ana △ (p. 626), in azimuth 129° 07′ 01″

COMPUTATION, ADJUSTMENT, AND ACCURACY OF THE ELEVATIONS OF THE TRIANGULATION OF CALIFORNIA.

GENERAL REMARKS.

In connection with the adjustment of the transcontinental triangulation, and in order to connect one of the most important longitude stations in that arc, Mount Hamilton (Lick Observatory), four of the stations* of this primary triangulation became fixed in elevation, viz, Sierra Morena, Loma Prieta, Santa Ana, and Mount Toro.

For the foundation of the hypsometric measures along this triangulation there are, in addition to these four stations, the lines of spirit levels which connect five stations with tidewater of the Pacific Ocean in Santa Barbara Channel. The profile of the Los Angeles Base,† which was an incident to its measurement, added another fixed elevation to the hypsometry of this triangulation.

In January and February, 1874, Assistant S. Forney ran two lines of spirit levels from Santa Cruz West △ to the sea, differing 0.326 foot (or 0.102 meter), with a result for the elevation of the ground at the station of 715.87 feet (218.19 meters).

In November and December, 1873, Assistant O. H. Tittmann ran two lines from New San Miguel △ to the sea, differing 0.158 foot (0.048 meter), with a result for the ground at the station of 809.12 feet (246.62 meters).

In May and June, 1875, Assistant Tittmann ran a single line of spirit levels from Gaviota △ to the sea, which gave a result for the elevation of the ground at the station equal to 2 457.076 feet (748.91 meters).

The zenith distances over the three lines connecting these stations gave an opportunity to examine the effect on the coefficient of refraction where the lines of sight are over the deep water of Santa Barbara Channel. Only one zenith distance was observed over two of the lines, but a value for the coefficient of refraction, *m*, was computed

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* The adjustment and the resulting heights for these stations will be found in Special Publication No. 4, pp. 299–304.

† A description of the leveling to obtain this profile and the height of Los Angeles Northwest Base from the sea will be found on p. 497.

which would reconcile the measured zenith distance with the difference of level as obtained by the spirit levels, with the following results:

Santa Cruz West to Gaviota	$m=0.100$
Santa Cruz West to New San Miguel	$m=0.108$
New San Miguel to Santa Cruz West	$m=0.078$
New San Miguel to Gaviota	$m=0.080$
Mean	$m=0.092$

Such large values would cast doubt upon the spirit leveling if it were not possible to check them by similar lines over this same arm of the Pacific Ocean.

Eleven lines were selected where the line of sight for at least two-thirds of its length would lie over the water and connecting stations at which reciprocal zenith distances were observed. The coefficient of refraction, m, and its weight, p, for each line were computed by the usual formulæ—

$$m=0.5-\frac{\rho \sin 1''}{2s}(\zeta_1+\zeta_2-180^\circ) \text{ and } p=\frac{n_1 n_2}{n_1+n_2}\cdot\frac{s^2}{10^{10}}$$

where ζ_1 and ζ_2 are the observed reciprocal zenith distances at the ends of a line of length s, and radius of curvature ρ, and n_1 and n_2 represent the number of days observation at the two ends of the line. The following results were deduced:

Stations	m	p
Santa Cruz East to Laguna	0.125	0.63
Santa Cruz East to Santa Clara	0.120	0.72
Santa Cruz East to Chaffee	0.126	0.44
Santa Cruz East to Santa Barbara	0.099	0.60
Santa Cruz West to Santa Barbara	0.122	0.26
Santa Cruz West to New San Miguel	0.093	0.55
San Pedro to Niguel	0.092	1.41
Niguel to Soledad	0.097	3.59
Laguna to San Pedro	0.103	1.23
Santa Barbara to Chaffee	0.123	0.35
Santa Barbara to Laguna	0.131	0.67
Weighted mean	0.105	

By the use of the same formula the value of the coefficient of refraction, m, was computed from twenty-three lines to the northward of Santa Barbara Channel, each of these lines being over land. The weighted mean value of m which resulted was 0.080, the minimum value was 0.066, and the maximum 0.090. It is therefore certain that the value 0.092, computed from the fixed elevations at the stations Gaviota, New San Miguel, and Santa Cruz West, points which lie at the junction of the sections which give the high value 0.105 and the low value 0.080, corroborates the elevations from spirit levels, which may now be adopted as absolute. All the observations here treated were made in daytime. It is also evident that lines over water have a tendency to have large coefficients of refraction.

ADJUSTMENT OF THE ELEVATIONS.

The zenith distances directly observed at each station were first computed and were corrected for height of object observed and of instrument, so as to refer them all to the station marks.

The difference of elevation of each pair of stations in the main scheme where zenith distances had been observed was then computed from the observations over the line joining them by the formula—

$$h_2 - h_1 = s \tan \tfrac{1}{2} (\zeta_2 - \zeta_1) \left[1 + \frac{h_2 + h_1}{2 \rho} + \frac{s^2}{12 \rho^2} \right]$$

in which h_2 and h_1 are the elevations of the stations, ζ_2 and ζ_1 are the measured zenith distances, s is the horizontal distance between the stations, and ρ is the radius of curvature.

As there were always two or more lines to each new station, many rigid conditions existed between the observed differences of elevation, even if the connections with the precise leveling were ignored, and the least square adjustment furnishes the readiest accurate means of deriving the required elevations.

The elevations from the stations Santa Ana and Mount Toro, to and including Soledad and Cuyamaca near the Mexican boundary, were adjusted in three sets of equations.

The first adjustment involved all stations in the main primary scheme from the first two stations, Santa Ana and Mount Toro, to and including the three fixed elevations at Gaviota, New San Miguel, and Santa Cruz West.

The second adjustment involved all the stations of the main primary scheme from San Pedro to Soledad and Cuyamaca.

The third adjustment involved the stations of the main primary scheme from Gaviota and Santa Cruz West to Wilson Peak and San Pedro.

In the following tabulation the observed differences of elevation treated in the first adjustment are shown, together with their adjusted values. The weight, p, assigned to each observed difference of elevation is inversely proportional to the square of the length, s, of the line between stations in meters and was conveniently computed by the formula $\log p = 10 - 2 \log s$. The observed difference of elevation is given the sign of the elevation of the second station named, minus the elevation of the first. The quantity contained in the last column but one is the correction to be applied to an observed difference of elevation to obtain the adjusted difference of elevation.

Station 1	Station 2	Weight p	Observed difference of elevation h_2-h_1	Adjusted difference of elevation h_2-h_1	Adj.—Obs. v	pv^2
			m.	*m.*	*m.*	
Mount Toro	Hepsedam	1.82	282.47	283.24	+0.77	1.08
Mount Toro	Santa Lucia	4.82	700.26	702.94	+2.68	34.62
Santa Ana	Santa Lucia	1.36	688.08	682.74	−5.34	38.78
Santa Ana	Hepsedam	1.78	264.31	263.04	−1.27	2.87
Hepsedam	Santa Lucia	3.12	421.67	419.71	−1.96	11.99
Castle Mount	Santa Lucia	1.00	460.28	458.97	−1.31	1.72
Rocky Butte	Santa Lucia	2.57	739.71	740.40	+0.69	1.22
Castle Mount	Hepsedam	2.75	41.33	39.26	−2.07	11.78
Rocky Butte	Hepsedam	1.77	320.44	320.69	+0.25	0.11
Rocky Butte	Castle Mount	1.94	281.69	281.43	−0.26	0.13
San Luis	Rocky Butte	2.57	174.33	174.52	+0.19	0.09
Rocky Butte	San Jose	1.50	107.23	105.72	−3.51	18.48
San Luis	Castle Mount	1.73	460.52	455.95	−4.57	36.13
San Jose	Castle Mount	2.07	175.03	175.71	+0.68	0.96
San Luis	San Jose	13.82	280.02	280.24	+0.22	0.66
Lospe	San Luis	5.46	370.21	369.81	−0.40	0.87
San Luis	Tepusquet	3.53	120.18	120.78	+0.60	1.27
Lospe	San Jose	3.20	650.88	650.05	−0.83	2.20
Tepusquet	San Jose	4.82	158.18	159.47	+1.29	8.02
Lospe	Rocky Butte	1.11	547.98	544.33	−3.65	14.79
Lospe	Tepusquet	6.79	489.47	490.59	+1.12	8.52
Lospe	Gaviota	*0.91	249.01	249.50	+0.49	0.22
Lospe	Arguello	*2.49	159.82	160.16	+0.34	0.29
Gaviota	Tepusquet	4.87	241.84	241.09	−0.75	2.74
Arguello	Tepusquet	*1.20	330.31	330.43	+0.12	0.02
Arguello	Gaviota	*2.52	87.72	89.34	+1.62	6.61
Santa Cruz West	Arguello	*0.45	445.52	441.38	−4.14	7.71
New San Miguel	Arguello	*0.77	406.12	412.95	+6.83	35.92

In the first adjustment, of which the direct results are indicated above, the elevations of the stations Mount Toro and Santa Ana were fixed, by a previous adjustment in connection with the adjustment of the transcontinental triangulation, at the values 1 081.2 and 1 101.4 meters, respectively. Three other elevations were fixed by spirit leveling, viz, Gaviota, 748.91 meters; New San Miguel, 246.62 meters, and Santa Cruz West, 218.19 meters.

The elevations of the nine remaining stations connected by the observations are the unknowns to be determined by least squares from the twenty-eight observed differences of elevation indicated above.

In the case of those lines whose weights are indicated by an asterisk it is necessary to explain that the lack of any observations at the station Arguello compelled the introduction of these lines to this point over which zenith distances were observed in one directon only. The value 0.092 for m, the coefficient of refraction, was used for the lines over water and the value 0.080 for the lines over land. The weight, p, for these lines was multiplied by 0.3 as the nearest approximation possible, when comparing zenith distances in one direction with zenith distances in both directions over a line.

The probable error of an observation of weight unity derived from the adjustment is ±2.45 meters. In other words, the reciprocal observations over a line 96 kilometers (60 miles) long, this being the length of the line corresponding to unit weight, deter-

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*These are lines over which there are observations in one direction only and are used with reduced weight; see text.

mined the difference of elevation of two points with such a degree of accuracy that it is an even chance whether the error is greater or less than 2.45 meters. The probable errors for lines of other lengths were assumed to be proportional to their lengths.

The probable errors of the elevations of the three stations fixed by spirit leveling may be assumed as about ±0.05 meter, one elevation depending upon a single line of levels only. The probable error approaches this value for stations adjacent to those fixed by leveling and is greatest for the most remote stations. Station San Jose was assumed to be the one least accurately determined, and its probable error was therefore computed as a limiting value and was found to be ±0.91 meter from the vertical angle measures alone, and, when combined with the probable error of the elevations fixed by the spirit leveling, it was not changed.

In other words, for the least accurately determined station in the main scheme between the transcontinental triangulation and the Santa Barbara Channel, there is an even chance that the elevation is correct within 0.91 meter, or 2.99 feet, and for most of the stations in the main scheme the accuracy is greater than this.

The results of the second adjustment, in which the stations concerned are those from San Pedro and the Los Angeles base to Soledad and Cuyamaca, follow.

Station 1	Station 2	Weight p	Observed difference of elevation h_2-h_1	Adjusted difference of elevation h_2-h_1	Adj.—Obs. v	pv^2
			m.	*m.*	*m.*	
Los Angeles NW. B.	Wilson Peak	8.69	1 697.90	1 699.63	+1.73	26.01
Los Angeles SE. B.	Wilson Peak	4.16	1 706.12	1 705.93	—0.19	0.17
San Pedro	Wilson Peak	2.90	1 290.32	1 287.84	—2.48	17.83
San Juan	Wilson Peak	4.82	1 199.52	1 196.88	—2.64	33.59
Santiago	Wilson Peak	1.78	2.65	3.93	+1.28	2.92
Niguel	Wilson Peak	1.40	1 452.39	1 452.80	+0.41	0.24
Los Angeles NW. B.	San Juan	11.48	502.87	502.75	—0.12	0.12
Los Angeles SE. B.	San Juan	18.62	509.80	509.05	—0.75	10.43
San Pedro	San Juan	2.94	87.98	90.96	+2.98	26.11
San Juan	Santiago	11.56	1 192.45	1 192.95	+0.50	2.89
San Juan	San Jacinto	1.03	2 762.93	2 759.44	-3.49	12.54
Wilson Peak	San Jacinto	0.54	1 567.79	1 562.56	—5.23	14.77
Santiago	San Jacinto	1.56	1 561.58	1 566.48	+4.90	37.46
Cuyamaca	San Jacinto	1.07	1 319.43	1 318.28	—1.15	1.41
San Pedro	Santiago	1.81	1 283.96	1 283.91	—0.05	0.00
Niguel	Santiago	12.11	1 447.97	1 448.87	+0.90	9.81
Santiago	Cuyamaca	0.68	242.52	248.20	+5.68	21.94
Soledad	Santiago	1.00	1 492.57	1 489.74	—2.83	8.01
Niguel	San Pedro	2.64	164.80	164.95	+0.15	0.05
Niguel	Cuyamaca	0.67	1 704.64	1 697.08	—7.56	38.29
Soledad	Niguel	1.32	38.71	40.87	+2.16	6.16
Niguel	Jan Juan	5.05	256.69	255.91	—0.78	3.08
Soledad	Cuyamaca	2.64	1 737.96	1 737.95	—0.01	0.00

In this second adjustment the elevations of three stations were taken as fixed, namely: San Pedro, Los Angeles Northwest Base, and Los Angeles Southeast Base. The elevations of San Pedro and Los Angeles Northwest Base, had been determined by spirit leveling as 450.80 and 39.00 meters, respectively, and that of Los Angeles Southeast Base was computed at the time of the measurement of the base to be 32.70 meters. The elevations of the seven remaining stations connected by the observations are the seven unknowns determined by least squares from the twenty-three observed differences of elevation given in the above table.

The probable error of an observation of weight unity derived from the adjustment is ±2.79 meters. Unit weight corresponds to reciprocal observations over a line 96 kilometers (or 60 miles) long.

The probable error of the elevations of the stations fixed by spirit leveling may be assumed to be not greater than ±0.05 meter. The probable errors of elevation vary from this to ±1.63 meters at station Cuyamaca, as explained in connection with the first adjustment.

The results of the third adjustment, in which the stations concerned are those between Gaviota and Santa Cruz West and the Los Angeles base net, follow:

Station 1	Station 2	Weight p	Observed difference of elevation h_2-h_1	Adjusted difference of elevation h_2-h_1	Adj.—Obs. v	pv^2
			m.	*m.*	*m.*	
Santa Barbara	Gaviota	*1.44	612.90	608.87	−4.03	23.39
Santa Barbara	Santa Cruz West	5.88	80.99	78.15	−2.84	47.43
Santa Cruz East	Santa Barbara	5.89	45.62	45.15	−0.47	1.30
Santa Barbara	Laguna	2.14	295.05	297.55	+2.50	13.38
Santa Barbara	Chaffee	7.23	194.71	196.71	+2.00	28.92
Santa Cruz East	Chaffee	8.28	242.58	241.85	−0.73	4.41
Santa Cruz East	Laguna	4.62	339.97	342.69	+2.72	34.18
Santa Cruz East	Santa Clara	3.08	591.48	590.29	−1.19	4.36
Chaffee	Santa Clara	13.71	346.74	348.44	+1.70	39.62
Chaffee	Laguna	9.48	102.43	100.84	−1.89	23.96
Laguna	Santa Clara	17.10	247.82	247.60	−0.22	0.82
Laguna	San Pedro	1.62	13.05	13.20	+0.15	0.04
Laguna	Castro	*4.48	419.87	421.27	+1.40	8.78
Santa Clara	Castro	7.98	172.78	173.67	+0.89	6.32
Castro	San Fernando	9.77	277.87	277.98	+0.11	0.12
Castro	Wilson Peak	2.13	876.68	879.77	+3.09	20.34
San Pedro	Castro	3.18	409.85	408.07	−1.78	10.07
San Fernando	Wilson Peak	*1.15	599.94	601.79	+1.85	3.94
San Pedro	San Fernando	2.09	689.83	686.05	−3.78	29.86
Santa Clara	San Fernando	6.15	450.20	451.65	+1.45	12.93

In this third adjustment the elevations of four stations were taken as fixed, namely: Wilson Peak, fixed by the previous adjustment, its elevation being 1 738.63 meters; and the stations, Gaviota, Santa Cruz West, and San Pedro fixed by spirit leveling, their elevations being 748.91, 218.19, and 450.80 meters, respectively. The elevations of the seven remaining stations connected by the observations are the seven unknowns determined by least squares from the twenty observed differences of elevation given in the above table.

In the case of those lines whose weights are indicated by an asterisk the same explanation is necessary as that made for the first adjustment.

The probable error of an observation of weight unity derived from the adjustment is ±3.32 meters. Unit weight corresponds to reciprocal observations over a line 96 kilometers (60 miles) long.

The probable error of the elevations of the stations fixed by spirit leveling may be assumed not to exceed ±0.05 meter. The probable errors of elevations vary from this to 1.00 meter at station Santa Clara, as explained in connection with the first adjustment.

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* These are lines over which there are observations in one direction only and are used with reduced weight; see text.

TABLE OF ELEVATIONS.

The datum for all the elevations is mean sea level.

The stations are in three classes: first, those fixed directly by the spirit leveling, and of which the elevations are subject to a probable error of ±0.05 meter; second, the primary stations fixed by reciprocal measures of vertical angles and which are subject to probable errors varying from ±0.3 to ±1.6 meters; and third, the tertiary stations, of which the elevations are fixed by measurements of vertical angles which are not reciprocal, the tertiary stations not being occupied, and whose elevations are subject to probable errors which may be as great as ±10 meters in some cases.

The accuracy with which each elevation in the main scheme is determined depends mainly upon the remoteness of that station from the nearest one of which the elevation is fixed by spirit leveling, as indicated in class 1 of the following table. Station Cuyamaca is probably least accurately determined of all the stations to the southward of the transcontinental triangulation whose elevations have been adjusted, its probable error being ±1.63 meter.

For a table to be used for converting feet to meters, or vice versa, see page 538.

Table of elevations.

Station	Point to which elevation refers	Elevation
Class 1		*meters*
Ross Mountain		672.23
Mount Diablo	Copper bolt	1 173.10
Yolo Southeast Base		21.66
Yolo Northwest Base		46.66
Gaviota		748.91
New San Miguel		246.62
Santa Cruz West	Ground	218.19
San Pedro	Station mark	450.80
Los Angeles Northwest Base	Copper bolt	39.00
Los Angeles Southeast Base	Copper bolt	32.70
Santa Cruz Azimuth Station	Station mark	109.48
Class 2		
Round Top	Ground	3 165.6
Mount Conness	Ground	*3 835.8
Mount Lola	Ground	2 786.8
Mocho	Ground	1 248.1
Mount Helena	Ground	1 322.08
Mount Tamalpais	Ground	790.74
Vaca	Ground	729.75
Monticello	Ground	932.39
Snow Mountain West	Ground	2 145.66
Mount Sanhedrin	Ground	1 884.62
Cold Spring	Ground	833.97
Great Caspar	Ground	320.86
Two Rock	Ground	837.59
Paxton	Ground	1 037.15
Gavilan	Ground	858.2
Marysville Butte	Ground	644.5

*This elevation is not reliable on account of the weakness of connecting observations with the main series of heights. United States Geological Survey gives 12 556 feet and United States Engineers 12 552 feet. See Special Publication No. 4, p. 341.

Table of elevations—Continued.

Station	Point to which elevation refers	Elevation
Class 2—Continued		*meters*
Pine Hill	Ground	627.6
Sierra Morena	Ground	735.9
Loma Prieta	Ground	1 157.5
Santa Ana	Ground	1 101.4
Mount Toro	Ground	1 081.2
Hepsedam		1 364.4
Santa Lucia		1 784.1
Rocky Butte		1 043.7
Castle Mount		1 325.2
San Luis		869.2
San Jose		1 149.5
Lospe		499.4
Tepusquet		990.0
Arguello		659.6
Santa Barbara		140.0
Santa Cruz East		94.9
Chaffee		336.8
Laguna	Ground	437.6
Santa Clara	Ground	685.2
Castro	Ground	858.9
San Fernando	Ground	1 136.8
Wilson Peak	Top of pier	1 738.6
San Juan	Top of pier	541.7
Santiago	Ground	1 734.7
Niguel		285.8
Soledad		245.0
Cuyamaca		1 982.9
San Jacinto		3 301.2
Cahto		1 290.2
King Peak		1 246.5
Mount Lassic		1 791.6
Chemise Mountain		791.8
Pajaro Mouth		5.8
Class 3		
Fisher	Ground	682.6
Saddle Peak		554.5
Los Cerritos		108.4
Las Bolsas		27.7
San Miguel		778.5
Tecate	Ground	1 180.1
Point Loma Light-house (old)	Railing	133.6
Otay Mountain	Top	1 084.6
Laguna Mountain	Top	1 914
Cajon Mountain	Top	1 418
Lions Head	Top	1 141
San Onofre Mountain	Top	523.7
San Gabriel Peak	Top	1 878
San Bernardino East Peak	Top of cairn	3 313
San Bernardino Meridian		3 246
Old Baldy Peak	Top of cairn	3 065
Old Grizzly Mountain		3 503
Old Town	Ground	93.1
San Diego Latitude Station 1851	Ground	61.6
Indian Point	Ground	10.9
Table Mountain, south end Mex.	Ground	684
Dome Mountain	Top	1 236.7
San Rafael Mountain or McKinley, U. S. G. S.	Top	1 894.9
Silver Peak		1 066.8

Table of elevations—Continued.

Station	Point to which elevation refers	Elevation
Class 3—Continued		*meters*
Cone Peak		1 571.2
Rock Slide		1 139.6
Pico Blanco		1 121.7
Santa Lucia West		1 828.8
Pine Mountain	Top of highest tree	1 121.5
Zaca Peak	Top of highest tree	1 338.3
Santa Inez Peak	Top	1 310
Hollister Peak	Top	429.6
Fremont Peak *	Top	966.0
Cuyama Peak	Top	1 563.4
San Luis Obispo 2	Top	470.5
Santa Cruz Peak	Top	1 892.0
Chalone Peak	Top	1 009.6
Estrella Mountain	Top	951.8
Chiches Mountain	Top	1 103.9
Centre Peak	Top	1 382.0
Mount Lowe	Top	1 705.3
Toro Mount	Top	2 652.1
Old Baldy Southwest Peak	Top	3 041.6
Stone (Sketch 18) *	Ground	324.4
Peak 26	Top	1 693
Sharp Peak or Strawberry Peak *	Top	1 819
Smith Mountain, high peak	Top	1 857
Ontario Peak	Top	2 638
Mount Islip	Top	2 553
Mount Disappointment	Top	1 830
Santiago Northwest Peak	Top	1 663
Waterman Mountain	Top	2 340
Telegraph Peak	Top	2 702
White Cone or North Baldy	Top	2 838
Black Knob or Iron Mountain	Top	2 377
San Antonio Mountain, north peak	Top	2 727
Saddle Mountain 1	Top	852

Index to positions, descriptions, and elevations.

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* No check on this elevation.

Index to positions, descriptions, and elevations—Continued.

Index to positions, descriptions, and elevations—Continued.

Index to positions, descriptions, and elevations—Continued.

Index to positions, descriptions, and elevations—Continued.

Index to positions, descriptions, and elevations—Continued.

Index to positions, descriptions, and elevations—Continued.

Index to positions, descriptions, and elevations—Continued.

Index to positions, descriptions, and elevations—Continued.

*Not described. Mad River △ described on page 642 is a different point.

Index to positions, descriptions, and elevations—Continued.

Index to positions, descriptions, and elevations—Continued.

Index to positions, descriptions, and elevations—Continued.

Index to positions, descriptions, and elevations—Continued.

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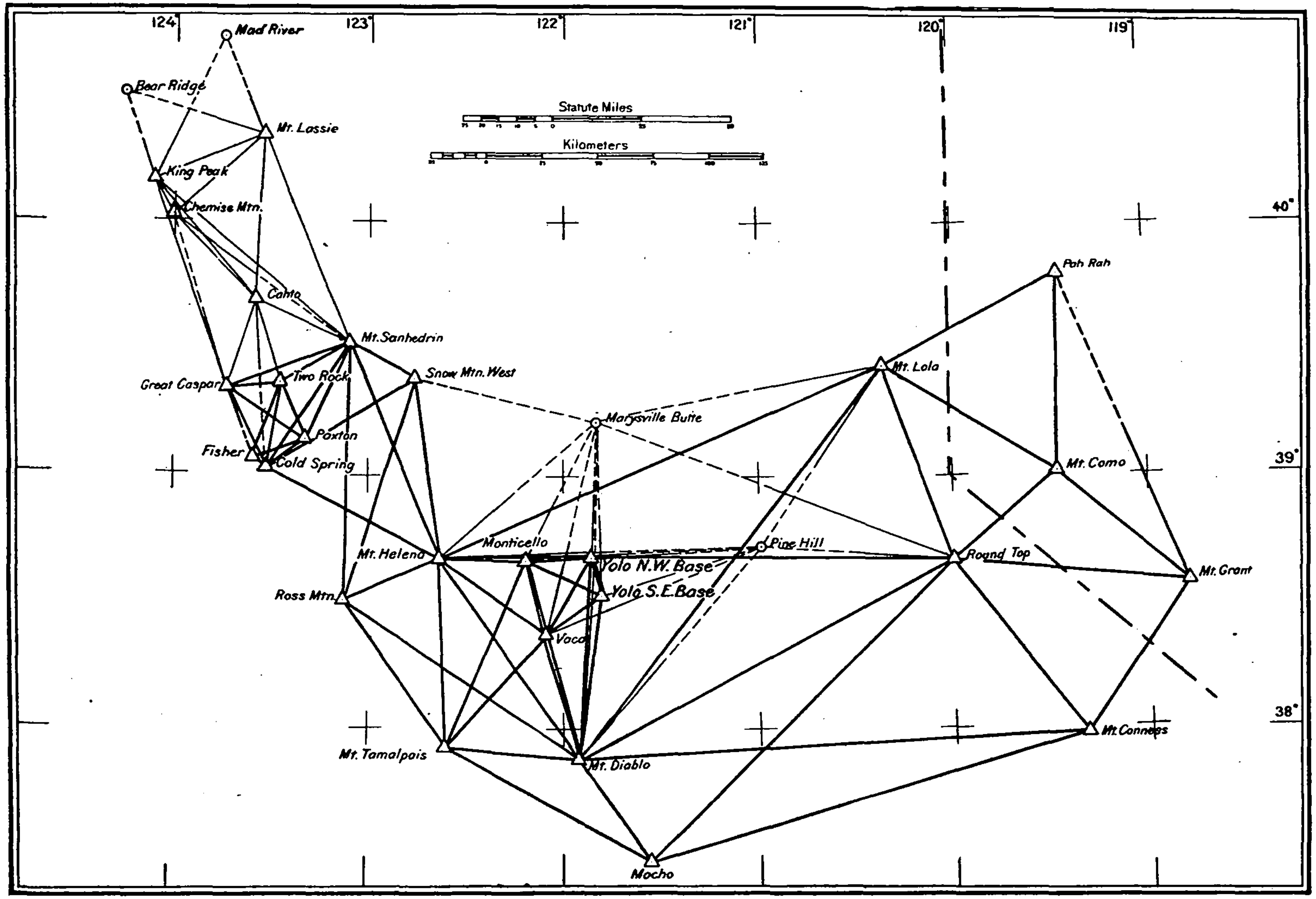
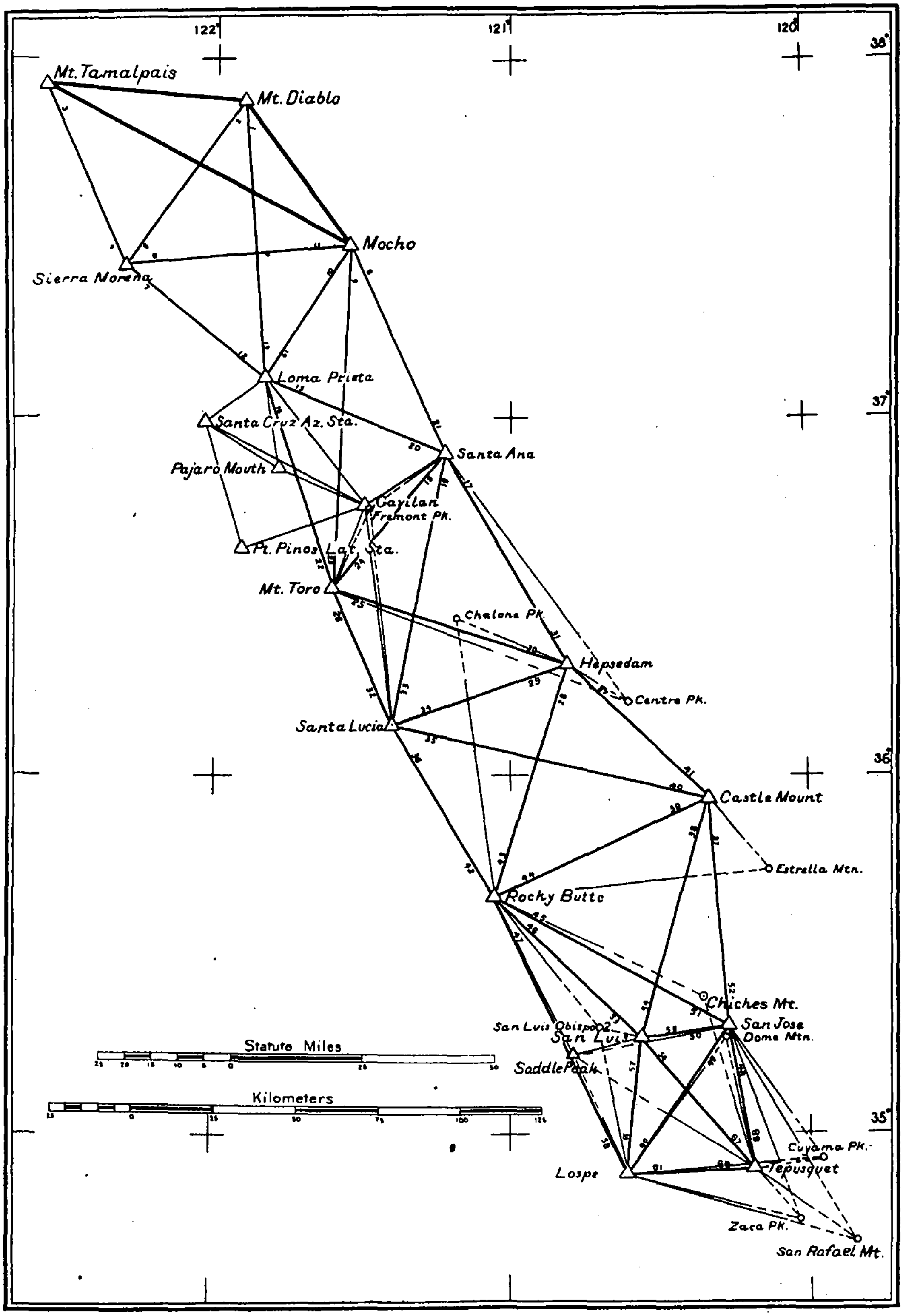
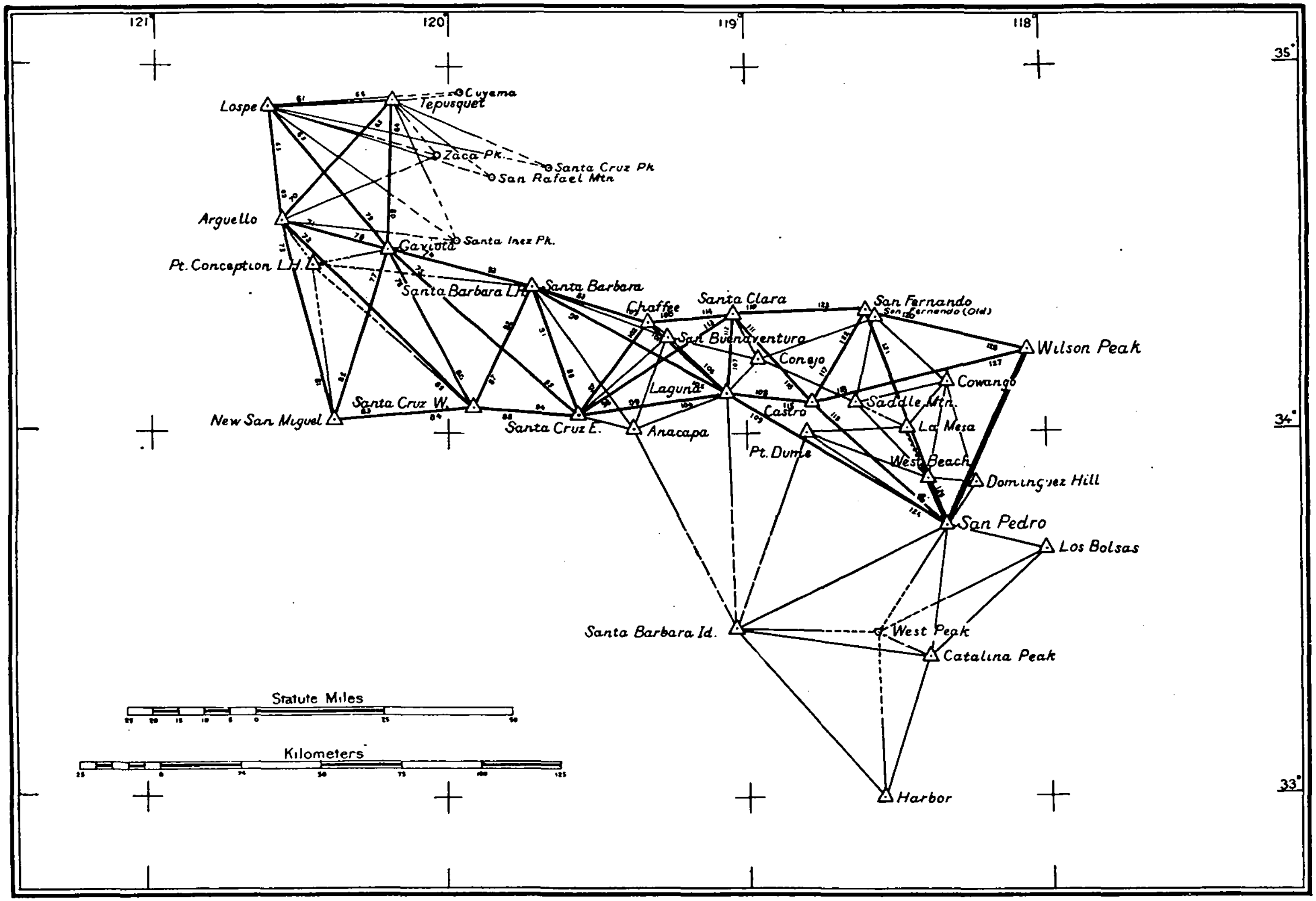


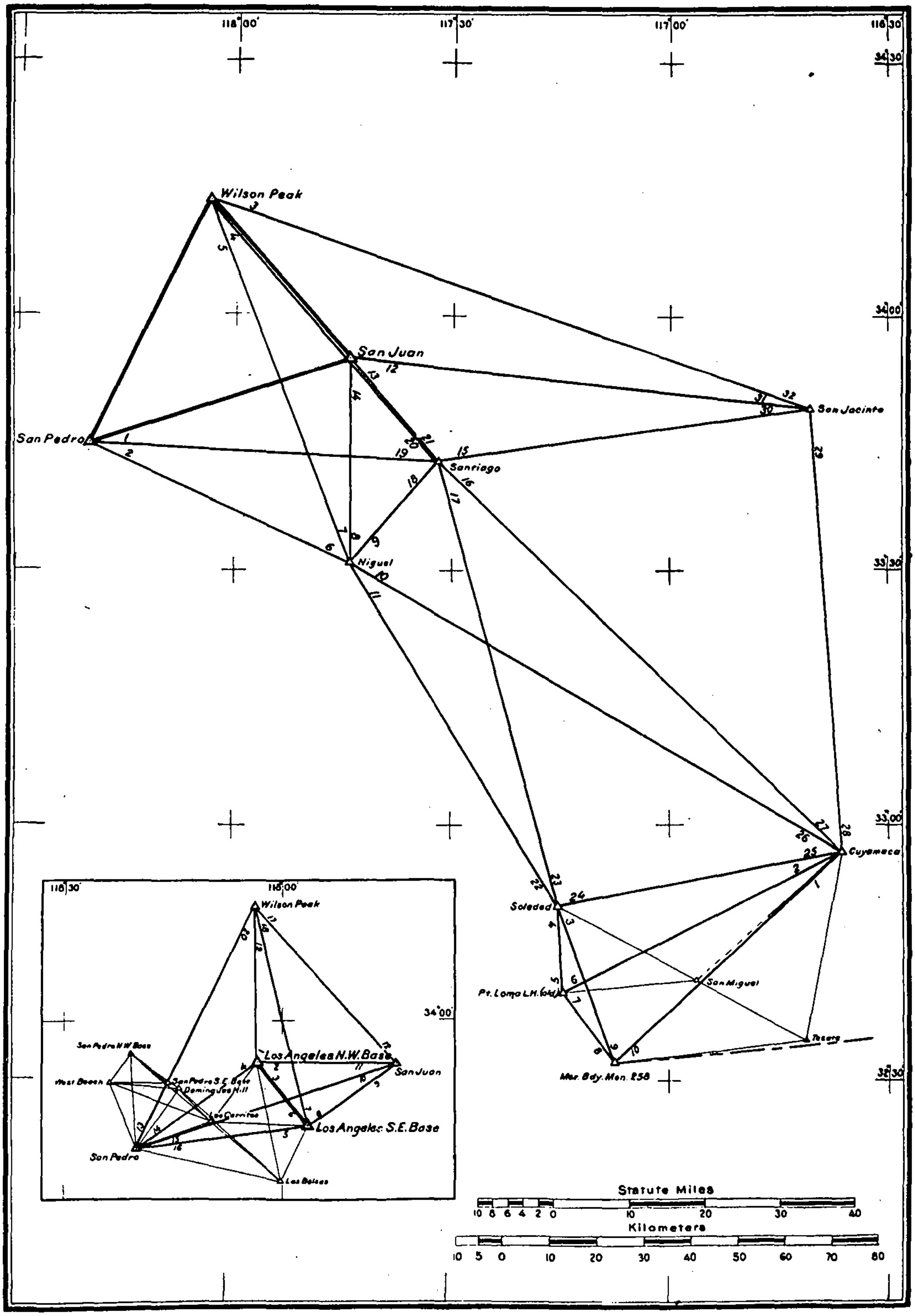
Primary triangulation, transcontinental and northward.



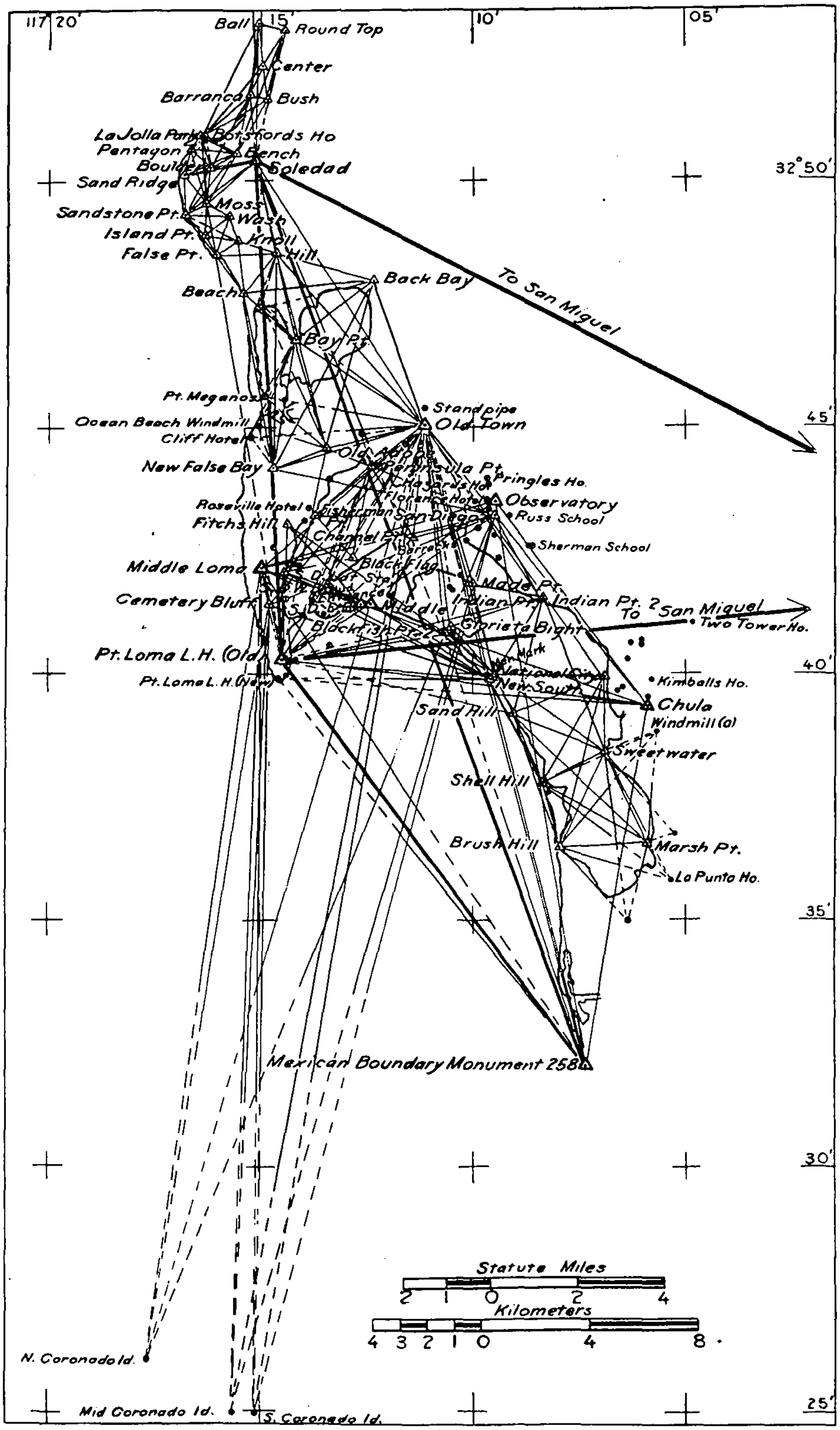
Primary triangulation. Yolo base net to Los Angeles base net. Upper part.



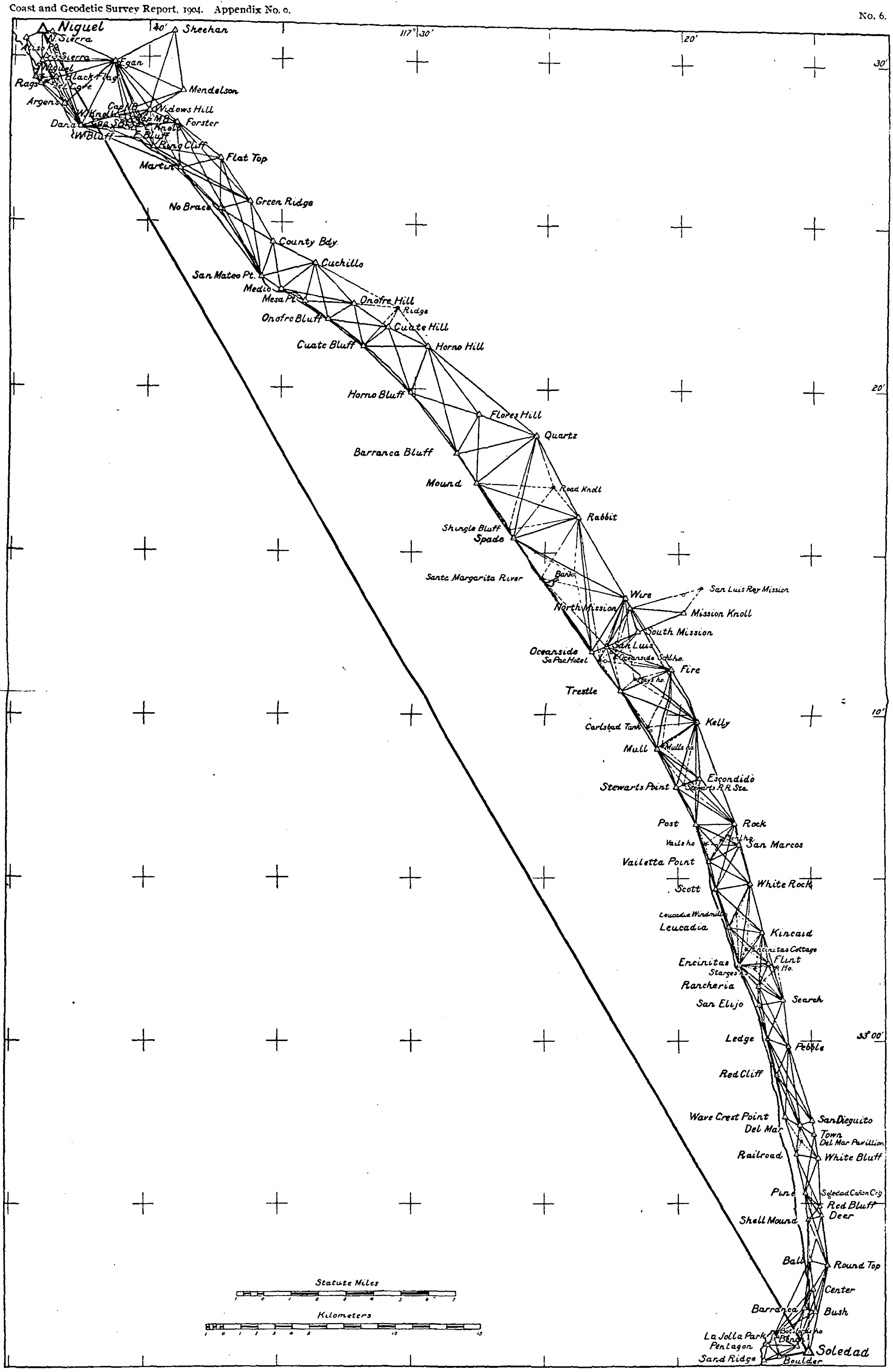
Primary triangulation. Yolo base net to Los Angeles base net. Lower part.



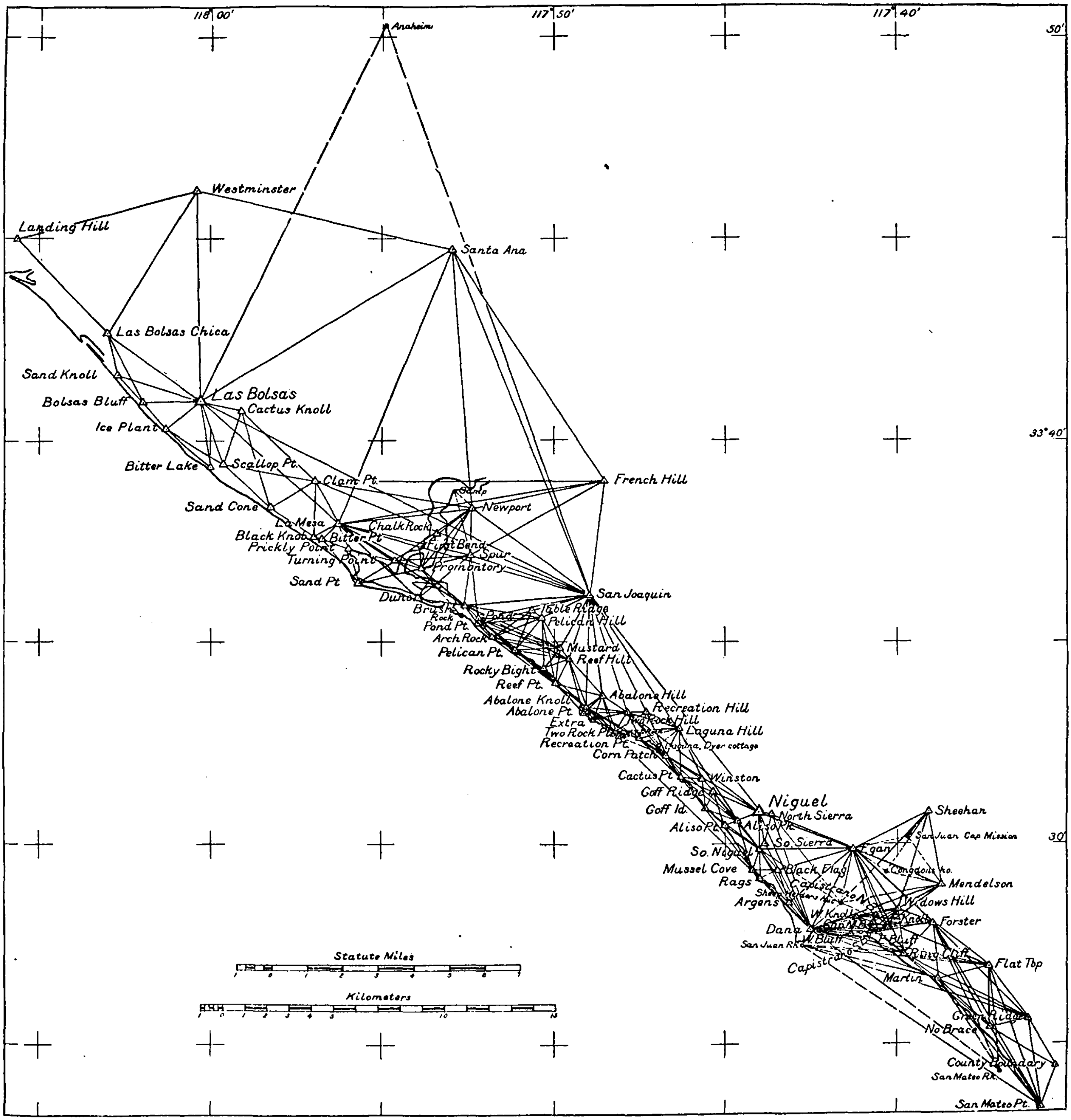
Primary triangulation. Los Angeles base net to Mexican boundary.



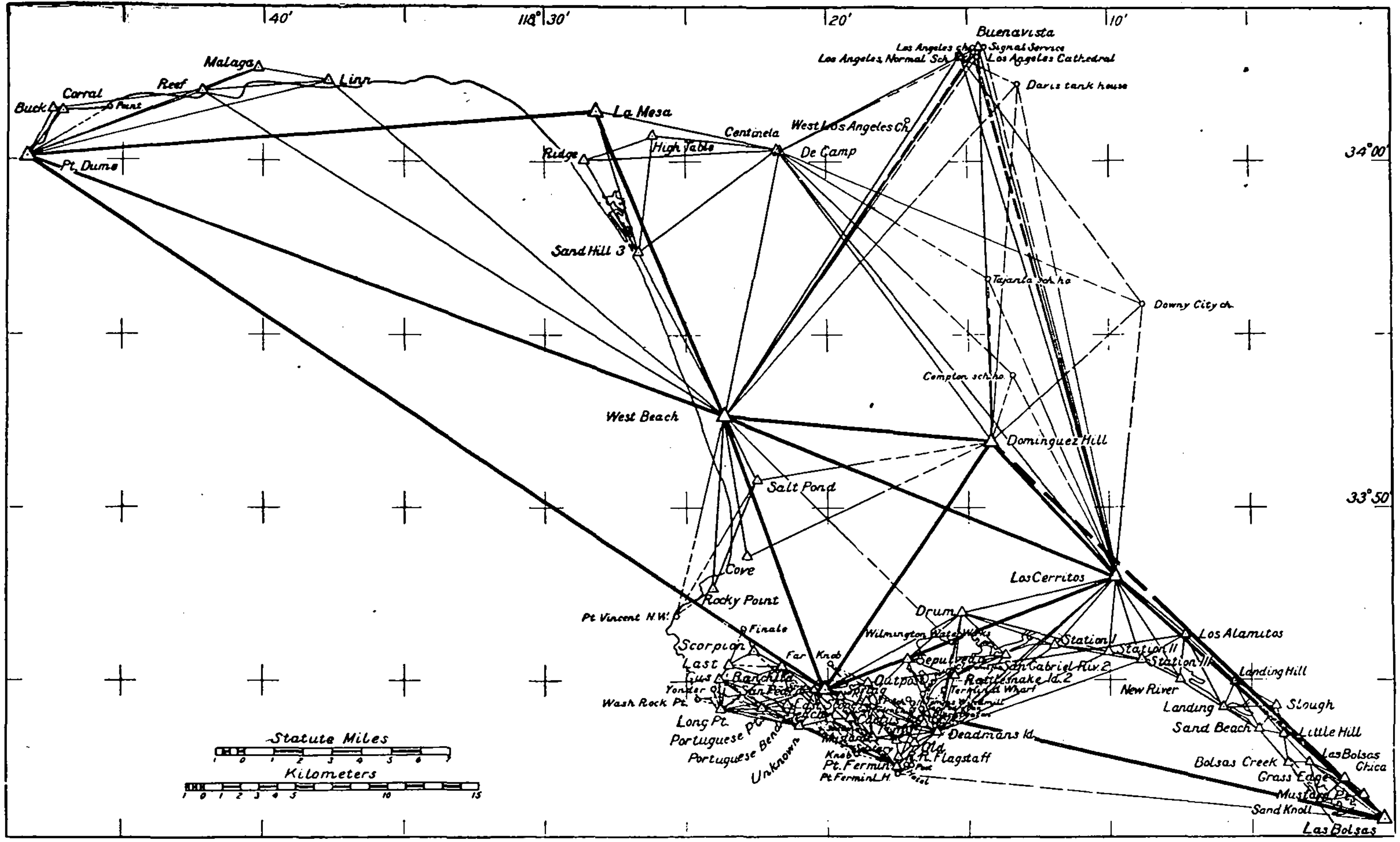
Mexican boundary to Point La Jolla.



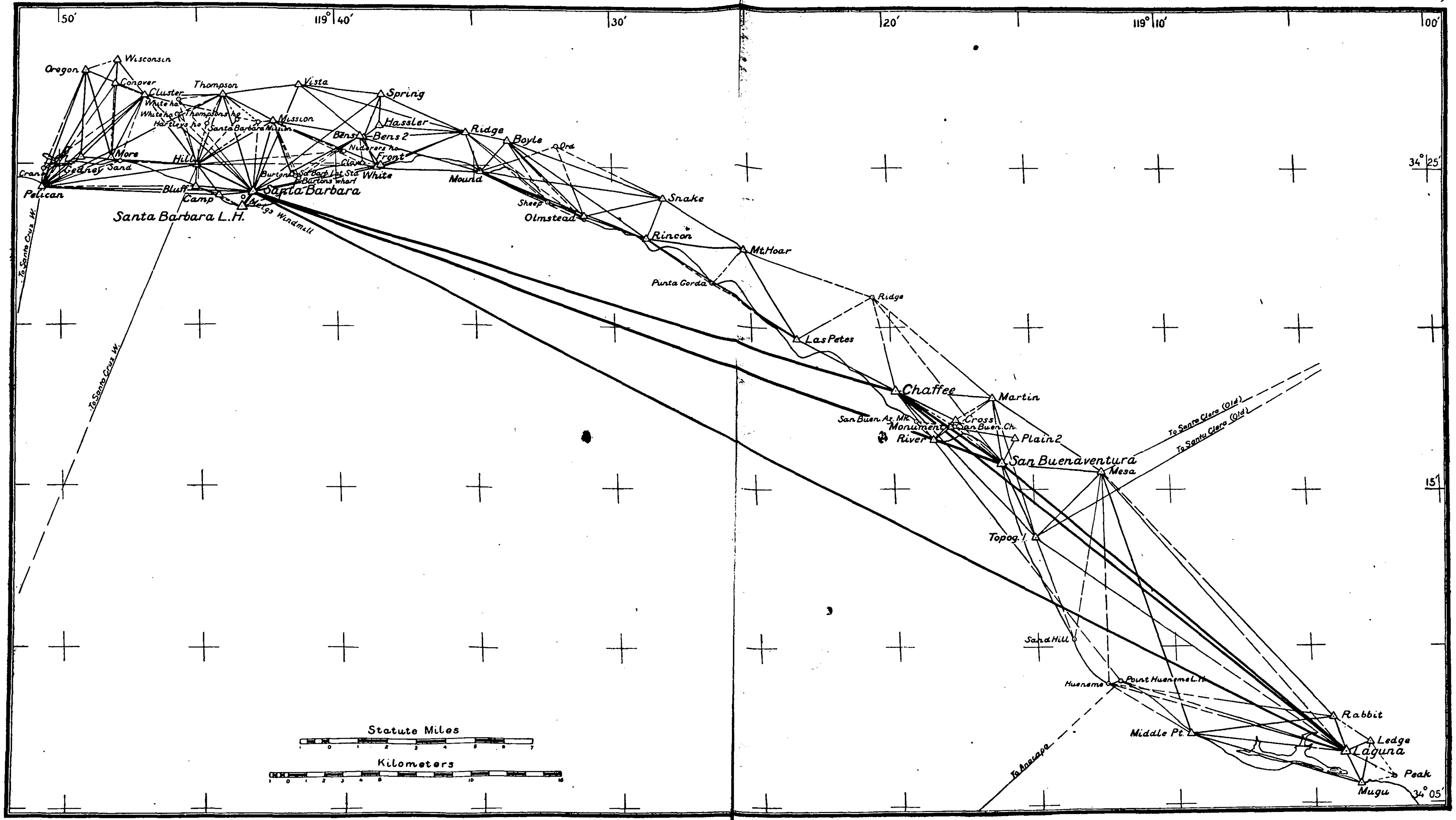
Point La Jolla to San Mateo Point.



San Mateo Point to Newport Bay.

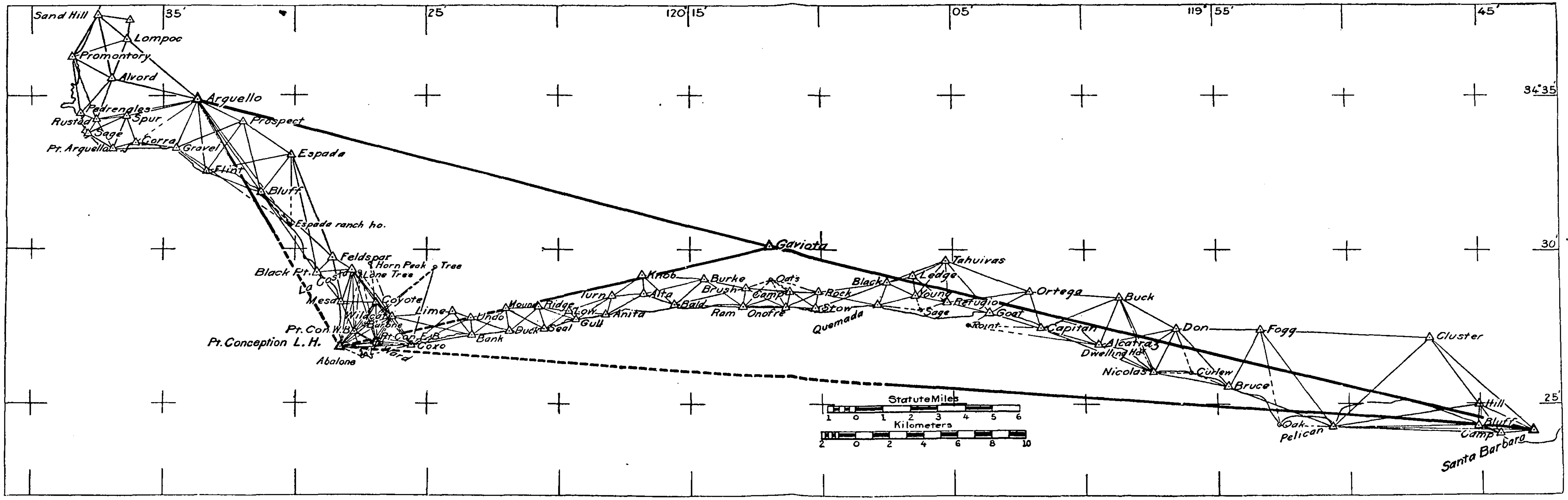


Newport Bay to Point Dume.

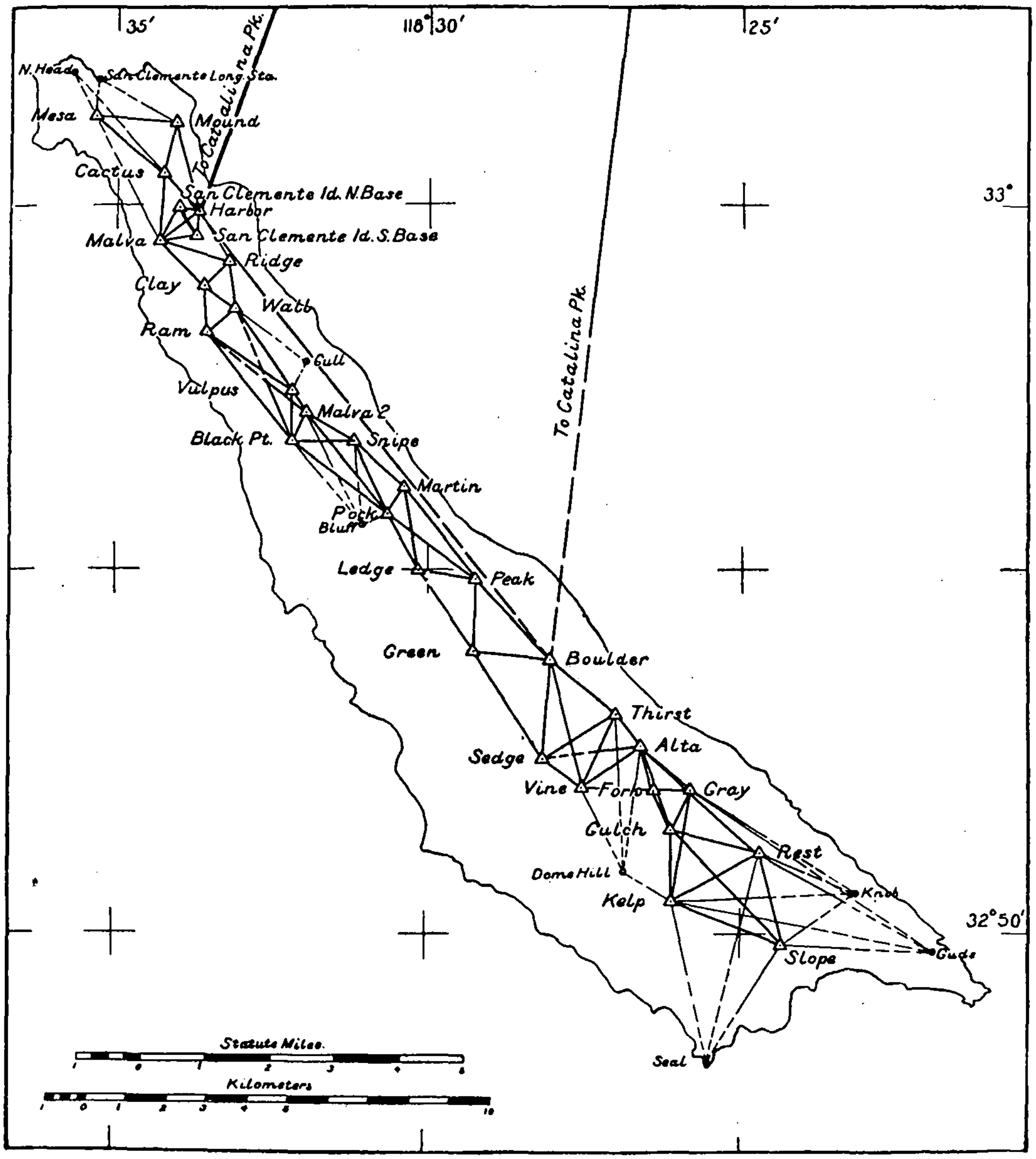


Point Dume to Santa Barbara.

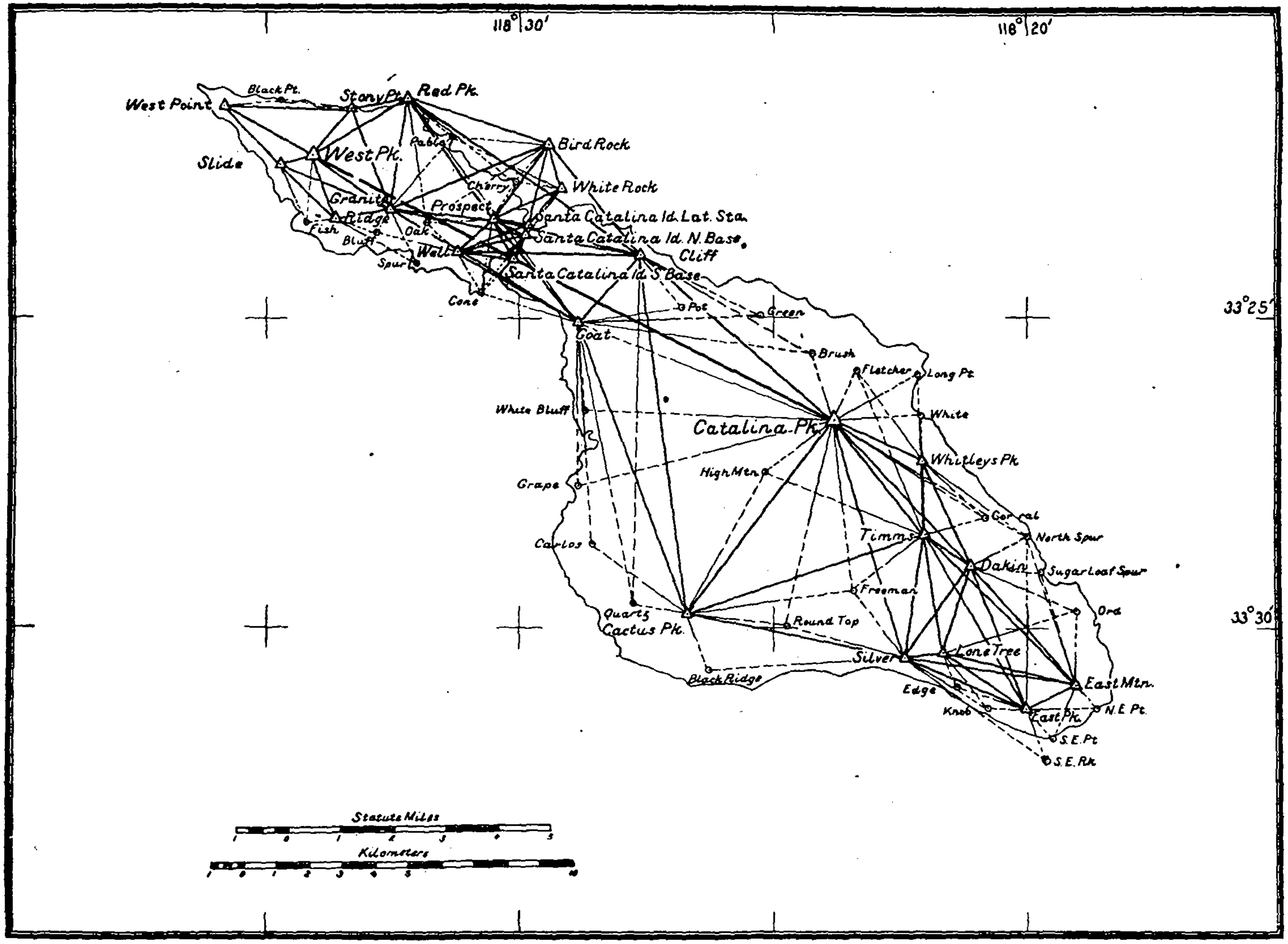
No. 10.



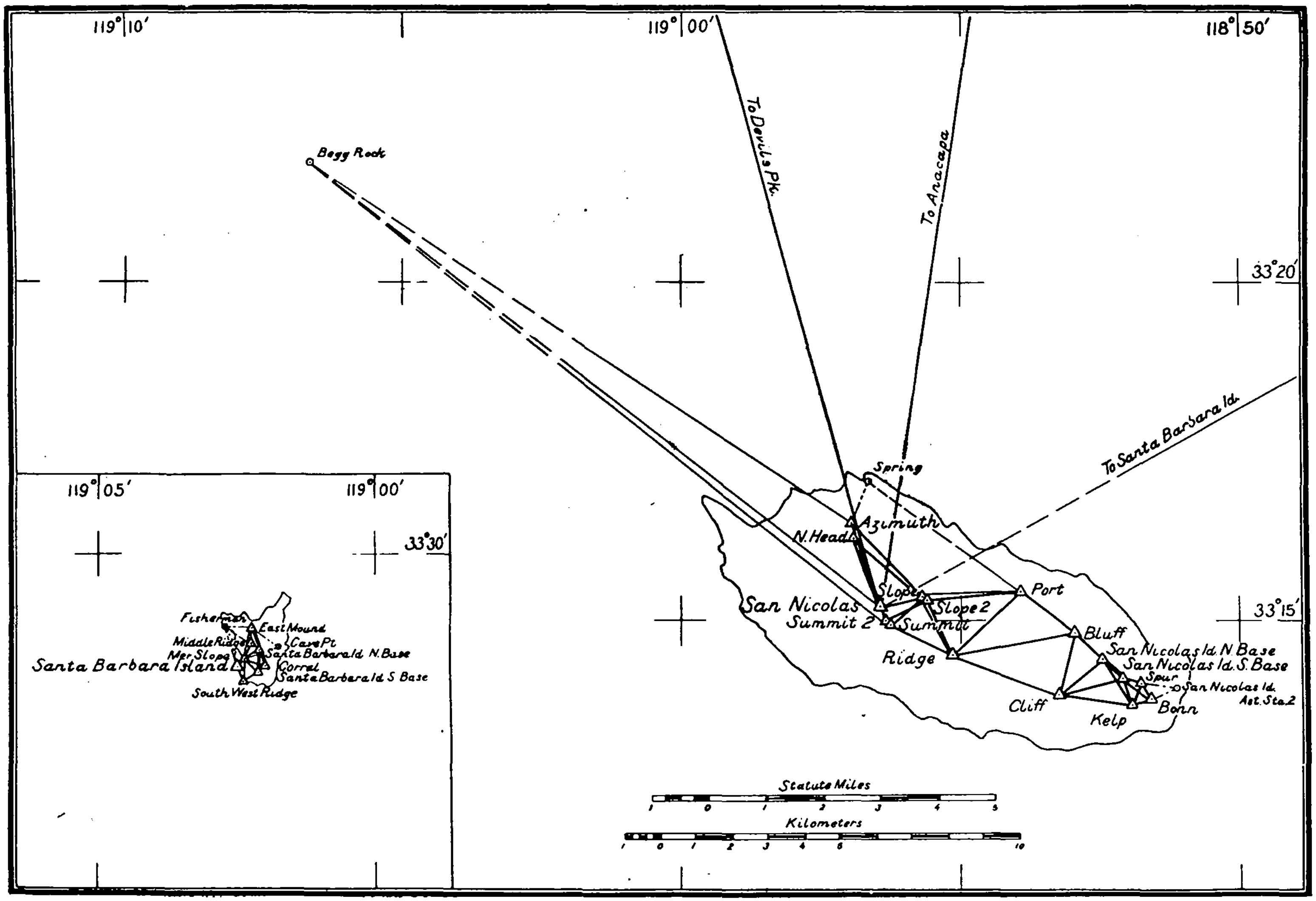
Santa Barbara to Point Arguello.



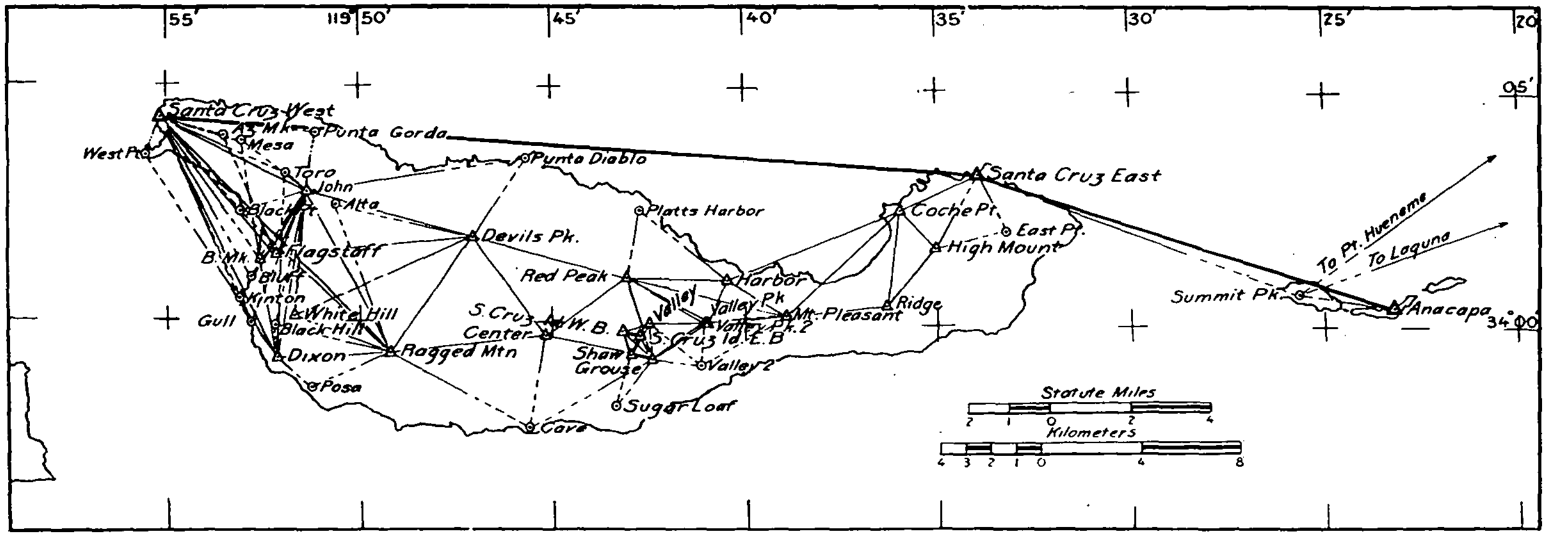
San Clemente Island.



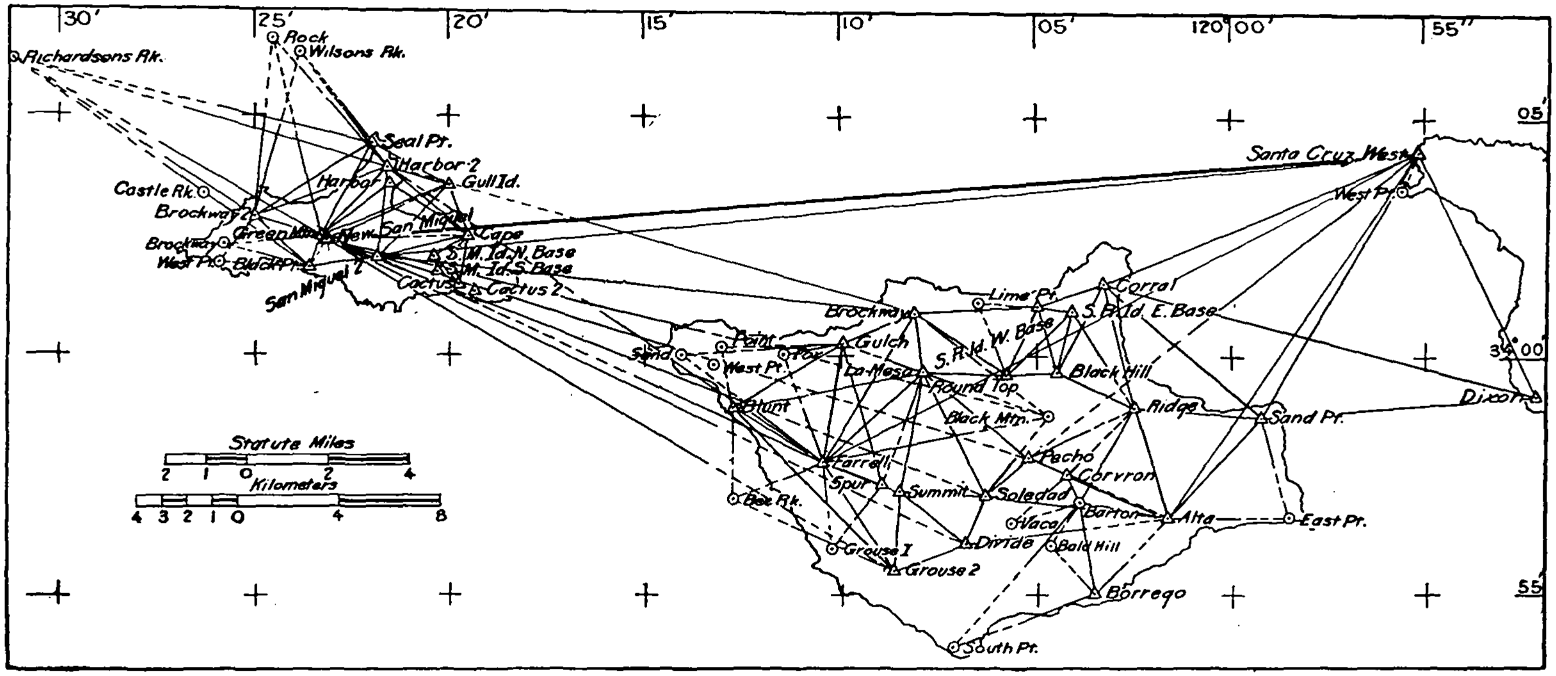
Santa Catalina Island.



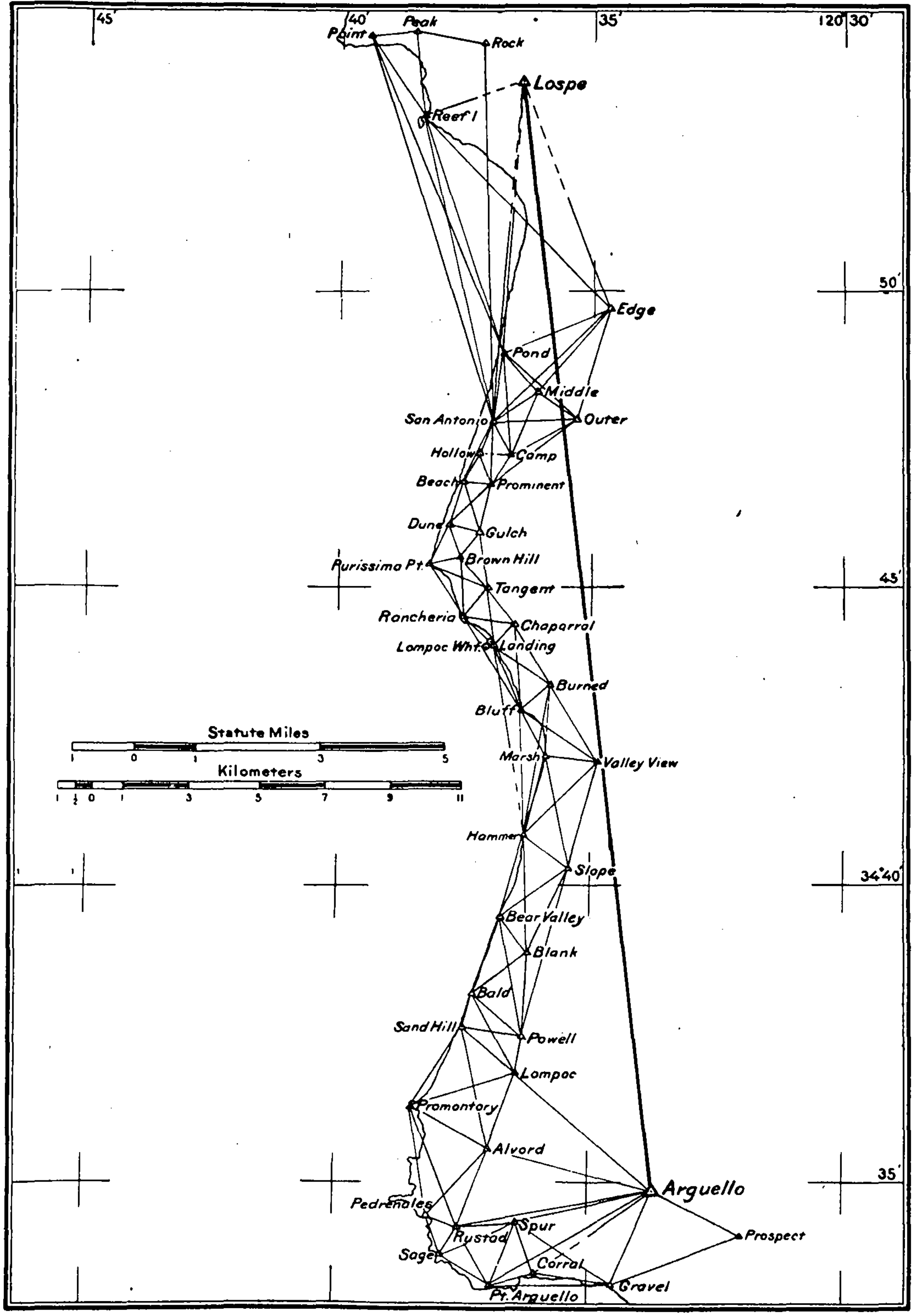
San Nicolas and Santa Barbara islands.



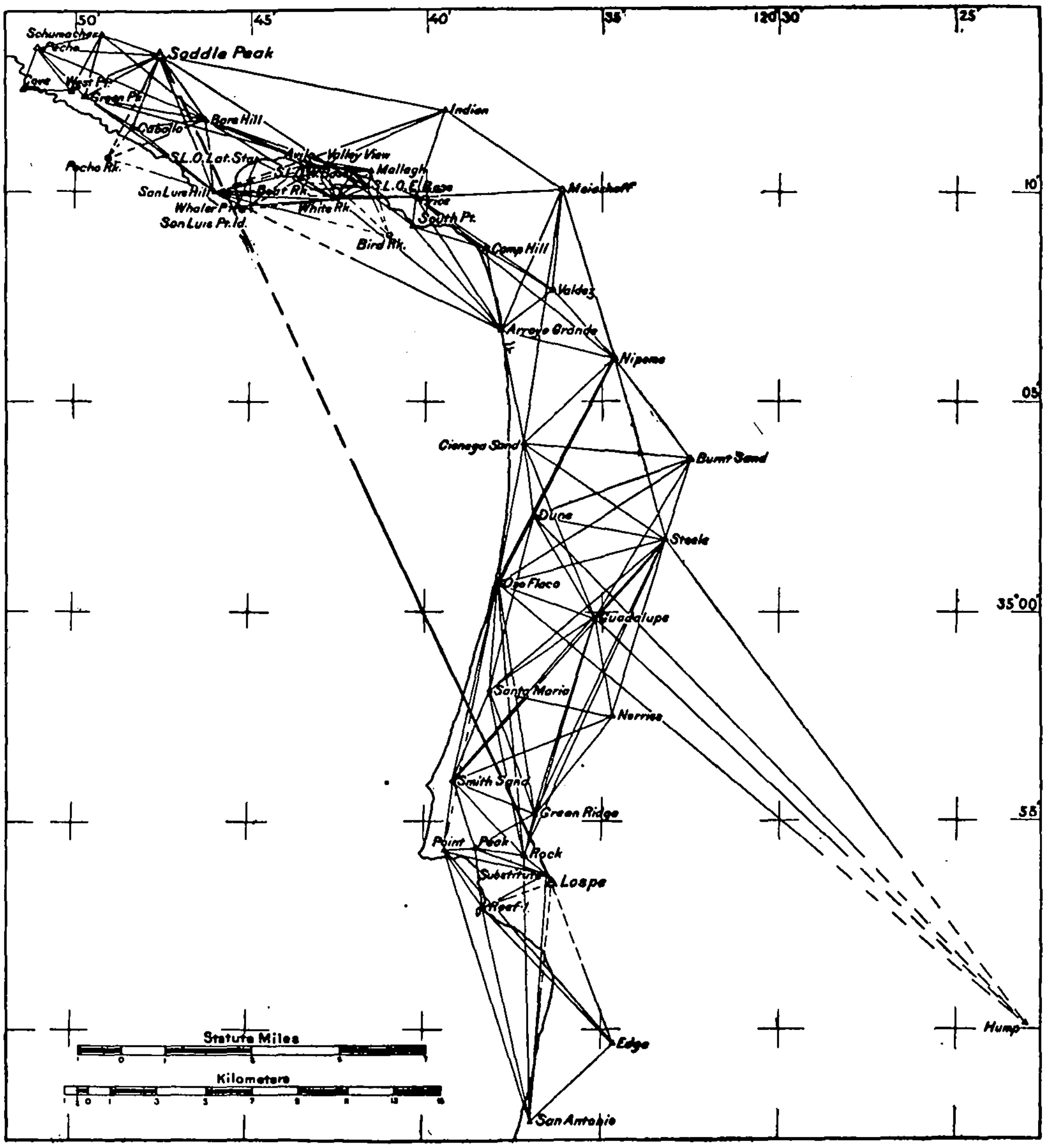
Santa Cruz Island.



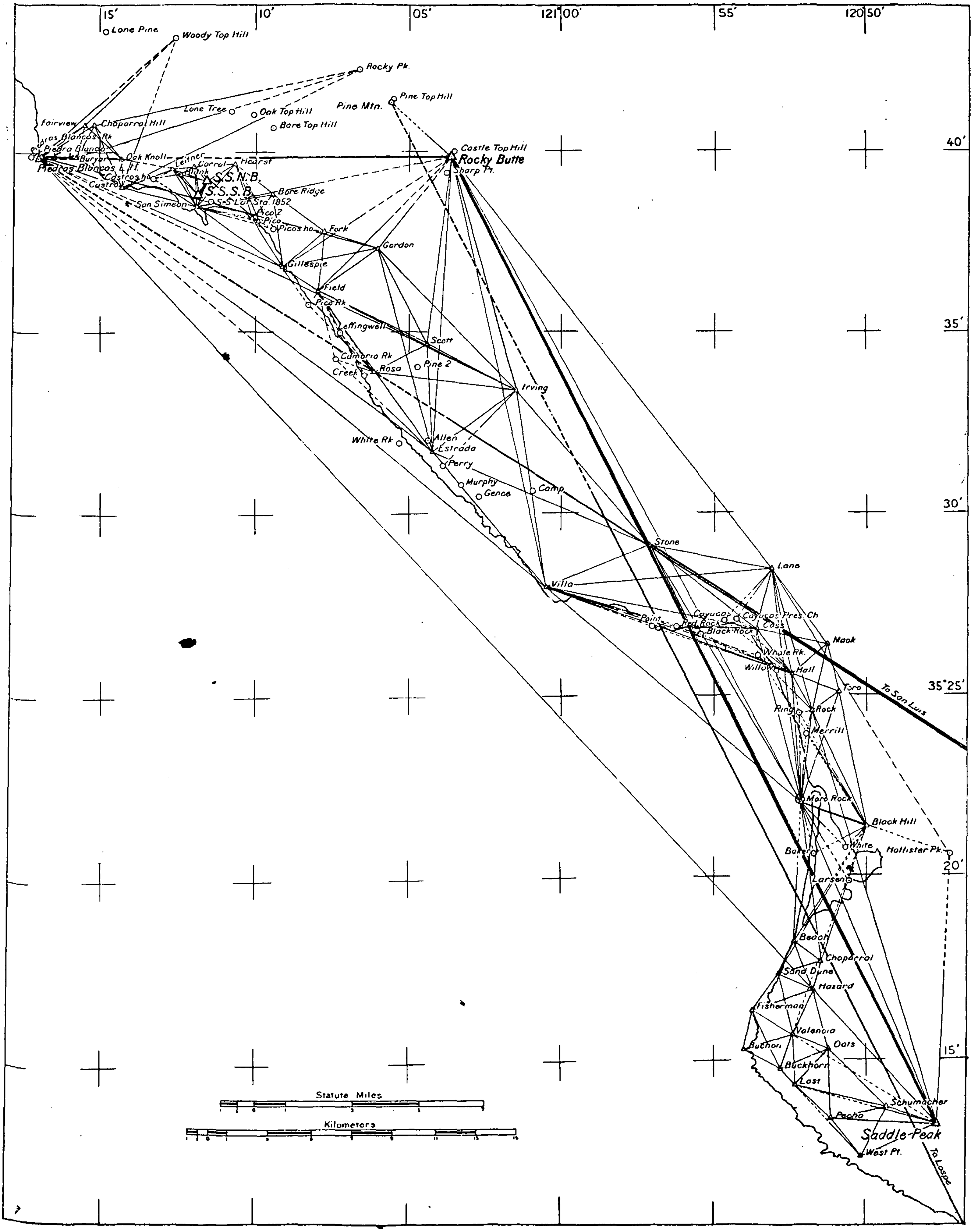
Santa Rosa and San Miguel islands.



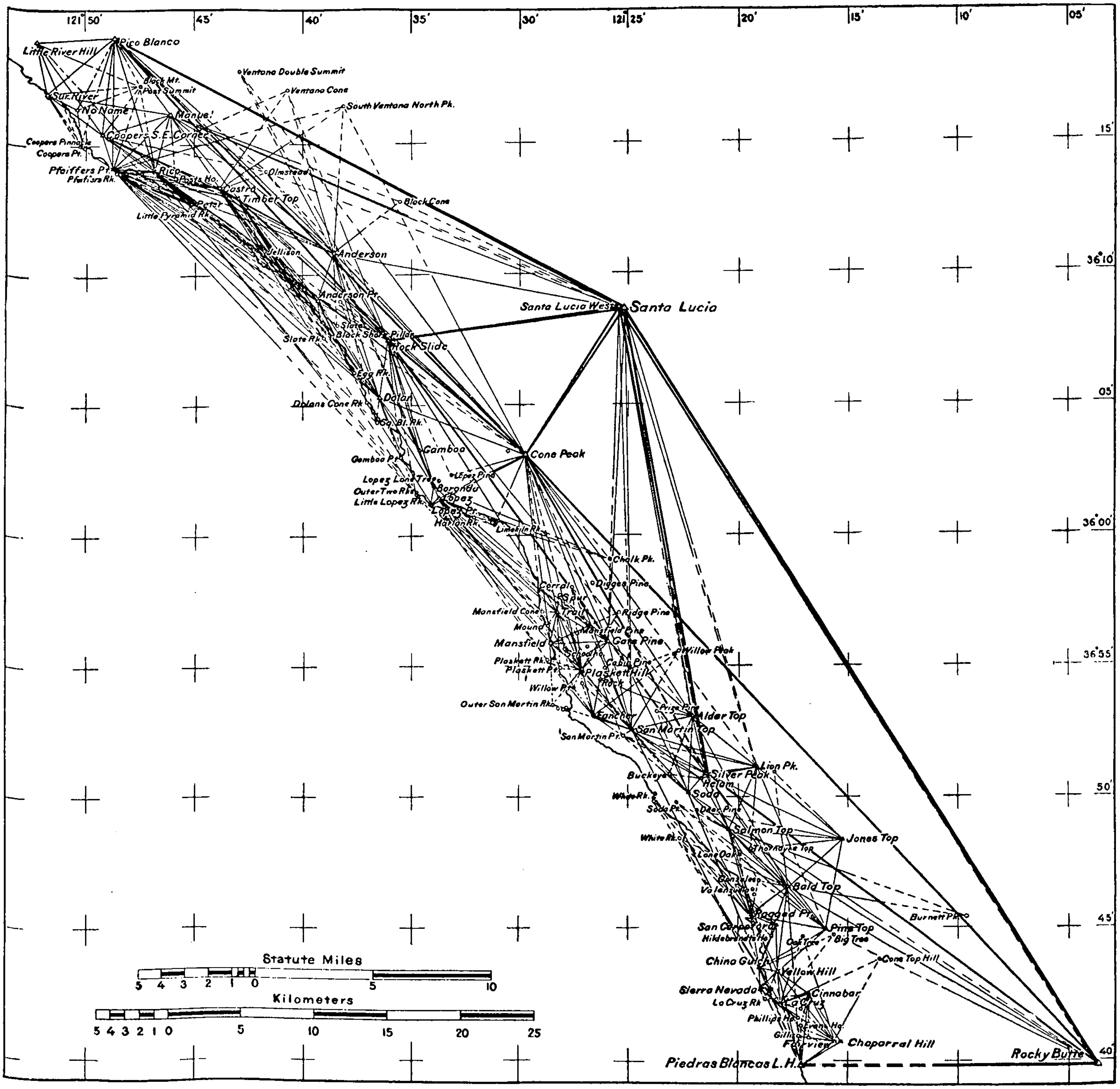
Point Arguello to Point Sal.



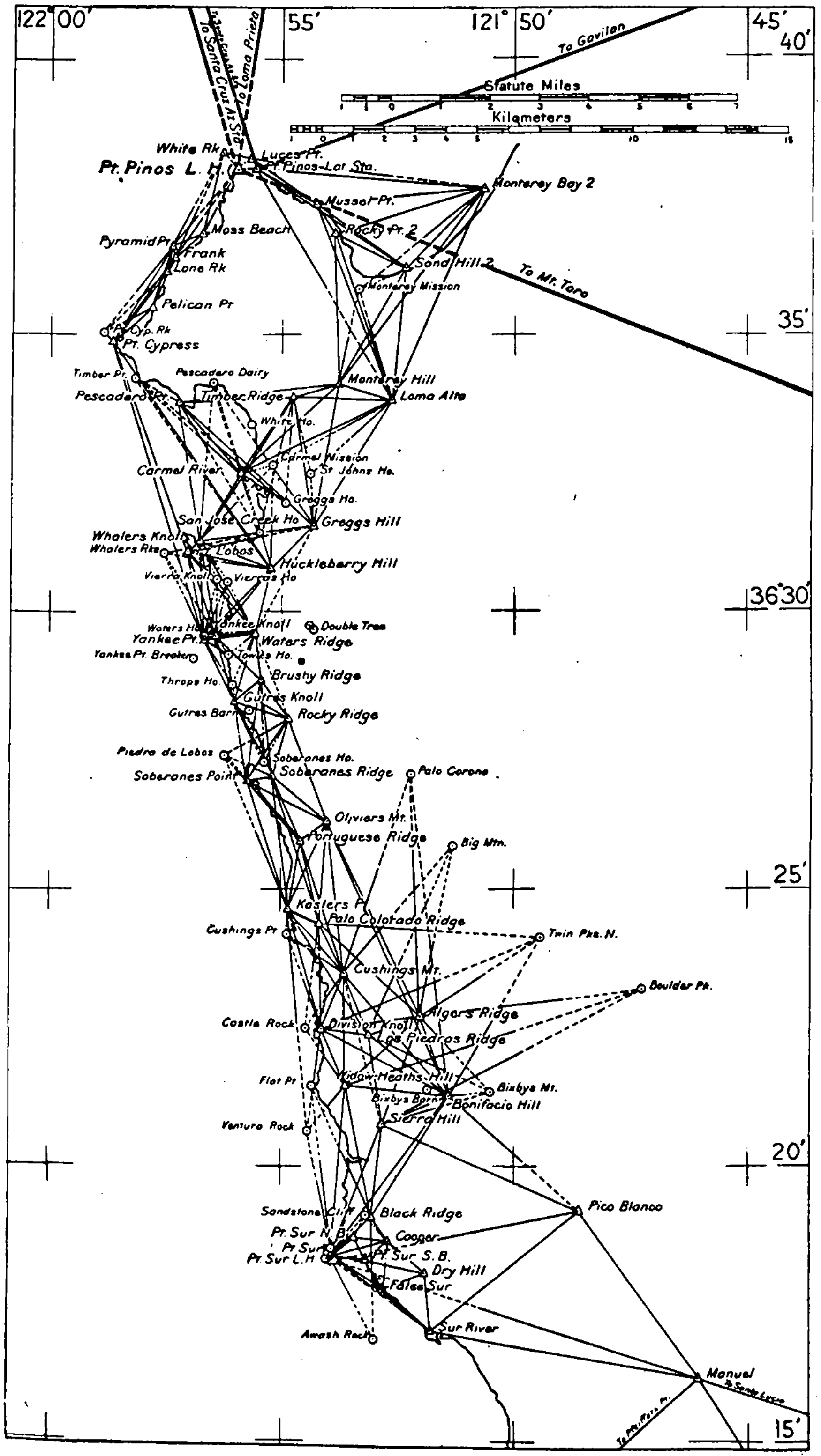
Point Sal to Saddle Peak.



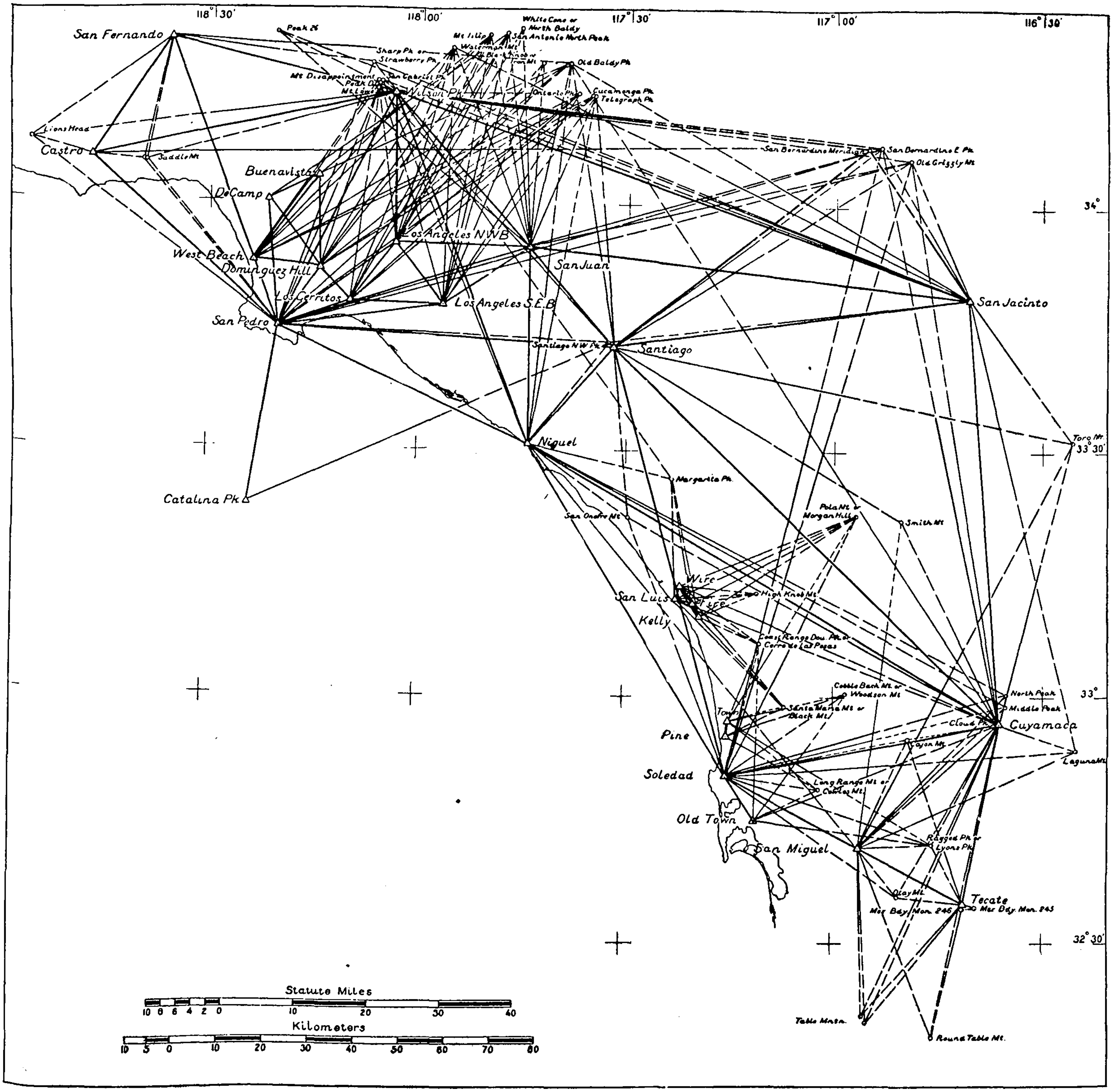
Saddle Peak to Piedras Blancas.



Piedras Blancas to Point Sur.



Point Sur to Monterey Bay.



Inland Peaks.

ALPHABETICAL INDEX.

(Exclusive of Appendices 3 to 9.)

(For table of contents see p. 7. Tabular index of field work on p. 33.)

○

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U. S. *Coast and geodetic survey.*

. . . Report of the superintendent of the Coast and geodetic survey, showing the progress of the work from July 1, 1903, to June 30, 1904 . . . Washington, Gov't print. off., 1904.

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O. H. Tittmann, superintendent.

9 appendices; nos. 3-9 also issued separately.

Contents of appendices: 1. Details of field operations. 2. Details of office operations. 3. Results of magnetic observations made by the Coast and geodetic survey between July 1, 1903, and June 30, 1904. By L. A. Bauer. 4. Telegraphic longitudes. The Pacific arcs from San Francisco to Manila, 1903-4. By Edwin Smith. 5. Manual of tides, part IV B. By Rollin A. Harris. 6. Precise leveling from Red Desert, Wyoming, to Owyhee, Idaho, 1903. By John F. Hayford. 7. Precise leveling from Holland to New Braunfels, Texas, 1903. By John F. Hayford. 8. A test of a transit micrometer. By John F. Hayford. 9. Triangulation in California, part I. By A. L. Baldwin.

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[For pasting in "List and Catalogue of publications," C. & G. S., 1902.]

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9 appendices; nos. 3-9 also issued separately.

APPENDICES.

1. Details of field operations. pp. 33–153.
56 maps and sketches.
2. Details of office operations. pp. 157–205.
3. Results of magnetic observations made by the Coast and geodetic survey between July 1, 1903, and June 30, 1904. By L. A. Bauer. pp. 207–255.
2 illus.
4. Telegraphic longitudes. The Pacific arcs from San Francisco to Manila, 1903–4, completing the circuit of the earth. By Edwin Smith. pp. 259–311.
13 illus.
5. Manual of tides, part IV B. Cotidal lines for the world. By Rollin A. Harris. pp. 315–400.
41 illus.
6. Precise leveling from Red Desert, Wyoming, to Owyhee, Idaho, 1903. By John F. Hayford. pp. 403–430.

7. Precise leveling from Holland to New Braunfels, Texas, 1903. By John F. Hayford. pp. 433-450.
8. A test of a transit micrometer. By John F. Hayford. pp. 453-487.

2 illus.

9. Triangulation in California, part I. By A. L. Baldwin. pp. 491-764.

21 illus.

CATALOGUE ENTRIES.

Baldwin, Albert Leseur.

Triangulation in California, part I. Rept. 1904, app. 9, pp. 491-764.

Bauer, Louis Agricola.

Results of magnetic observations made by the Coast and geodetic survey between July 1, 1903, and June 30, 1904. Rept. 1904, app. 3, pp. 207-255.

California.

TRIANGULATION. Baldwin, A. L. Triangulation in California, part I. Rept. 1904, app. 9, pp. 491-764.

Harris, Rollin Arthur.

Manual of tides, part IV B. Cotidal lines for the world. Rept. 1904, app. 5, pp. 315-400.

Hayford, John Fillmore.

Precise leveling from Holland to New Braunfels, Texas, 1903. Rept. 1904, app. 7, pp. 433-450.

Hayford, John Fillmore.

Precise leveling from Red Desert, Wyoming, to Owyhee, Idaho, 1903. Rept. 1904, app. 6, pp. 403-430.

Hayford, John Fillmore.

A test of a transit micrometer. Rept. 1904, app. 8, pp. 453-487.

Idaho.

LEVELING. Hayford, J. F. Precise leveling from Red Desert, Wyoming, to Owyhee, Idaho, 1903. Rept. 1904, app. 6, pp. 403-430.

Leveling.

IDAHO. Hayford, J. F. Precise leveling from Red Desert, Wyoming, to Owyhee, Idaho, 1903. Rept. 1904, app. 6, pp. 403-430.

Leveling.

TEXAS. Hayford, J. F. Precise leveling from Holland to New Braunfels, Texas, 1903. Rept. 1904, app. 7, pp. 433-450.

UNITED STATES
COAST AND GEODETIC SURVEY

SKETCH OF GENERAL PROGRESS

JUNE 30 1904

Western Sheet

Scale $\frac{1}{5.000000}$

THE NORRIS PETERS CO., LITHO., WASHINGTON, D. C.

UNITED STATES
COAST AND GEODETIC SURVEY

SKETCH OF GENERAL PROGRESS

JUNE 30 1904

Eastern Sheet

Scale $\frac{1}{5.000000}$

EXPLANATION OF SYMBOLS

Primary Triangulation	▲
Secondary / Tertiary Triangulation	▲
Reconnaissance	△
Surveyed Topography	▨
do. In-shore Hydrography	∴
do. Off-shore do.	·
Lines of Deep Sea Soundings	×
do. Geodetic Levelling	○

PLATE No. 1655

UNITED STATES
COAST AND GEODETIC SURVEY

SKETCH OF GENERAL PROGRESS

JUNE 30 1904

Eastern Sheet

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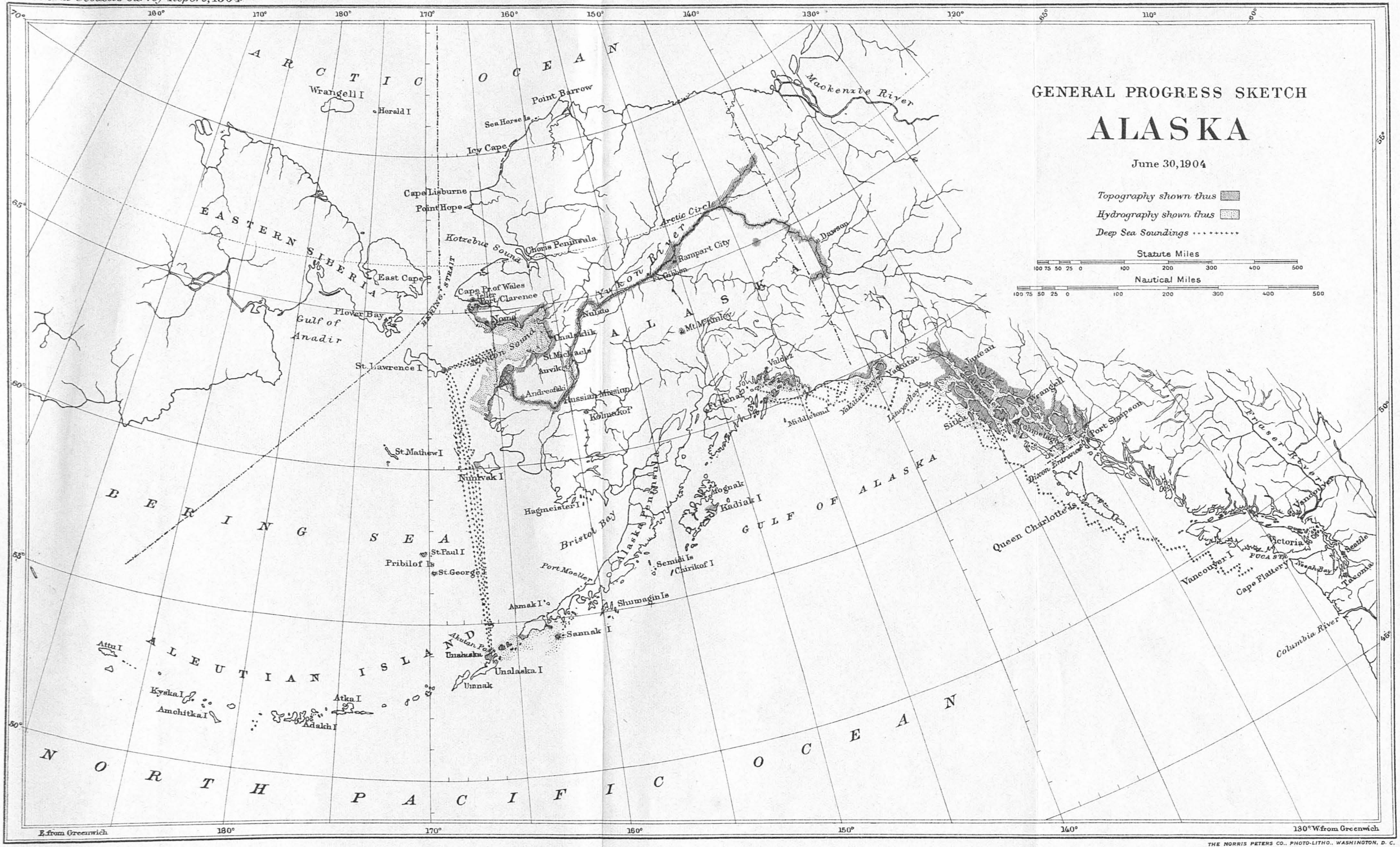

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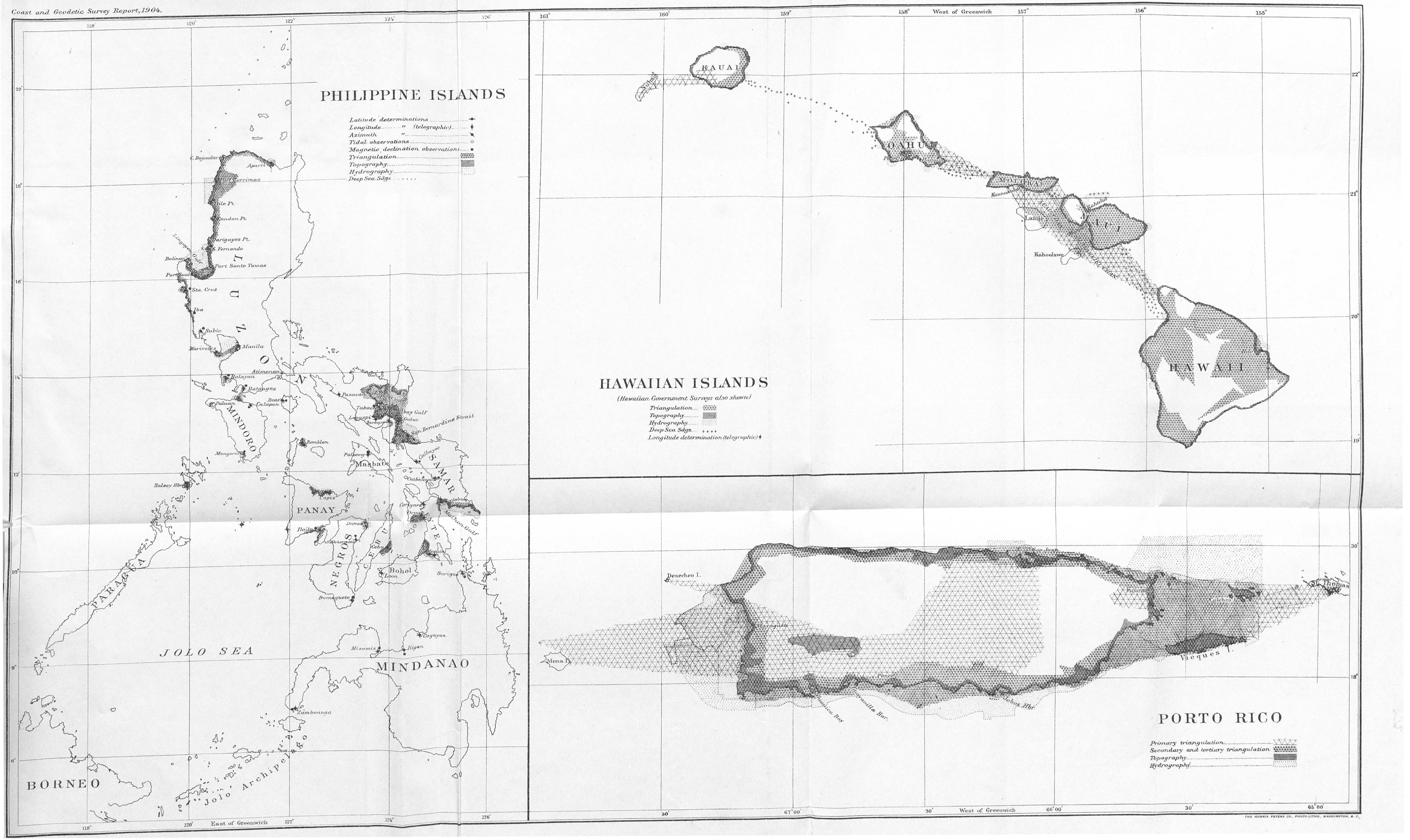
GENERAL PROGRESS SKETCH



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