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REPORT ON THE CONNECTION OF THE ARCS OF PRIMARY TRIANGULATION ALONG THE NINETY-EIGHTH MERIDIAN IN THE UNITED STATES AND IN MEXICO AND ON TRIANGULATION IN SOUTHERN TEXAS

BY

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REPORT ON THE CONNECTION OF THE ARCS OF PRIMARY TRIANGULATION ALONG THE NINETY-EIGHTH MERIDIAN IN THE UNITED STATES AND IN MEXICO AND ON TRIANGULATION IN SOUTHERN TEXAS.

By WILLIAM BOWIE, *Chief, Division of Geodesy, U. S. Coast and Geodetic Survey.*

INTRODUCTION.

An event of great importance in the history of geodesy was consummated in the spring of 1916 when observations were made at stations on the northern and southern banks of the Rio Grande, which connected the arcs of primary triangulation which had been established in the United States and in Mexico along the ninety-eighth meridian. The connection is interesting to the geodesist because it makes available a very long meridional arc of connected and completed triangulation.

This connection will make available data from which to compute with greater accuracy than heretofore the dimensions of the earth. This will in itself make the work a notable contribution to science. But of even greater moment is the fact that the connection of the triangulation of the United States and Mexico will enable the latter country to extend to new areas from the ninety-eighth meridian arc geodetic control for surveys and maps in the form of triangulation which can be based on the North American datum.

This datum had been called the United States standard datum previous to the year 1913, when it was also adopted by Mexico and by Canada for their geodetic coordinates. Its designation was changed to the North American datum when it had thus assumed an international character.

On June 2, 1913, Mr. Pedro C. Sánchez, subdirector of the Comisión Geodésica Mexicana, wrote as follows from Tacubaya, D. F., Mexico, to Dr. Otto Hilgard Tittmann, at that time Superintendent of the United States Coast and Geodetic Survey:

> I have the honor to inform you that the Mexican Geodetic Commission has accepted as the datum for the computation of geodetic positions of triangulation stations in all of the area of Mexico, what is known by the Coast and Geodetic Survey as the "United States standard datum."[2] As you have previously been advised, the computations which have been made in this office have been based on the Clarke spheroid of 1866.

On June 13, 1913, the Superintendent of the United States Coast and Geodetic Survey replied to Mr. Sánchez as follows:

Señor DON PEDRO C. SÁNCHEZ,

Subdirector de la Comisión Geodésica Mexicana, Tacubaya, D. F., México.

DEAR SIR: I have the honor to acknowledge receipt of your letter of June 2, 1913, announcing the adoption by the Comisión Geodésica Mexicana of the United States standard datum and the Clarke spheroid of 1866 as the basis for all triangulation stations established in Mexico.

A letter recently received from the office of the chief astronomer of Canada, who is in charge of the geodetic work of that country, announces that Canada will also use the same datum and spheroid that are used in the United States.

I take pleasure in announcing that hereafter this datum will be called the North American datum on account of its international character.

The adoption of the same datum for practically all of the continent of North America is an event of great importance in the history of geodesy.

Very respectfully yours,

O. H. TITTMANN, *Superintendent.*

An acknowledgment from Mr. Sánchez, dated July 8, 1913, read as follows:

I have the honor to acknowledge receipt of your letter of June 13, announcing that the United States standard datum will be called hereafter the North American datum on account of its international character, since Canada, the United States, and Mexico have adopted it and the Clarke spheroid of 1866 as a basis for their geodetic work.

During the conference of the International Geodetic Association held at Hamburg, Germany, in 1912, Prof. Aurelio Leyva, the delegate from Mexico, and Mr. William Bowie, one of the delegates from the United States, considered carefully the question of joining the triangulation and leveling systems of Mexico and the United States. It was their opinion that the sections of the ninety-eighth meridian primary triangulation in the two countries should be joined at the Rio Grande. Recommendations were made to their respective geodetic organizations, with the result that arrangements were made early in 1913 to complete this connection.

The triangulation along the ninety-eighth meridian in Mexico had been completed some time previous to the year 1913. The northern end of the Mexican arc was located at the town of Colombres, within a few miles of the Rio Grande, near the ninety-eighth meridian.

The arc of the ninety-eighth meridian in the United States had been completed in 1907 between Alice, Tex., and the Canadian border, with spurs running to Duluth, on Lake Superior, and to Corpus Christi, on the Gulf of Mexico.[1]

It had been planned originally that the old tertiary triangulation which had been carried along the coast between Corpus Christi and Point Isabel would serve as a link in the ninety-eighth meridian triangulation and connect the primary work of the United States

[1] See Appendix 6, Report for 1901; Appendix 3, Report for 1902; Appendix 4, Report for 1903; Appendix 5, Report for 1905; Appendices 4 and 5, Report for 1911.

and Mexico. But as it is probable that in the future there will be continuous primary triangulation from Alaska through Canada, the United States, Mexico, and other countries to the southward, there should be no section of the ninety-eighth meridian triangulation of a lower order than primary.

In the spring of 1913, parties of the United States Coast and Geodetic Survey took the field and started working southward from Alice, Tex. The reconnaissance and building were carried on by one party and the observing by another. Details of this work are given later in this report.

The reconnaissance was completed to Point Isabel where a connection was made with the coast triangulation. Several stations were established to the westward of Harlingen, Tex., in order that a direct connection could be made with the Colombres base line which was located to the southward of the Rio Grande and parallel to that river.

The observing on the triangulation was carried to the stations opposite the Mexican base early in April, 1913. Arrangements between the officials of the Mexican Geodetic Commission and the United States Coast and Geodetic Survey had been made for the necessary observing between the stations on the Mexican and United States sides of the river in order to complete the quadrilaterals joining the Mexican and the United States arcs. Just at the time when the observer of the United States was ready to cooperate with the Mexican representative, it was found that political conditions in Mexico made it desirable to postpone the observations necessary to join the arcs of the two countries. The observing party of the Coast and Geodetic Survey thereupon completed the connection with the Gulf coast triangulation at Point Isabel, and the connection with the Mexican arc was deferred.

In December, 1915, Mr. Pedro C. Sánchez, now the director of Geographical and Climatological Studies of Mexico, in a communication to the United States Coast and Geodetic Survey, suggested that the time was opportune to connect the arcs of the ninety-eighth meridian triangulation in Mexico and in the United States and that he was especially anxious that this should be done as soon as practicable, as he wished to base all the triangulation of Mexico on the ninety-eighth meridian arc, and to have the geodetic coordinates of the triangulation stations in that arc based on the North American datum.

The Superintendent of the United States Coast and Geodetic Survey informed the director of Geographical and Climatological Studies of Mexico that he would be glad to cooperate with him in joining the two arcs of the ninety-eighth meridian. Mr. C. V. Hodgson, of the Coast and Geodetic Survey, and Mr. Silverio Alemán, of the section of geodesy of Mexico (now under the Bureau of Geographical and Climatological Studies) proceeded to Brownsville, Tex., and made

arrangements to observe between the stations on the Mexican and the United States sides of the Rio Grande. Before the connection was made Mr. Hodgson was called away to his work in Idaho, on the Utah–Oregon arc of primary triangulation, and Mr. E. H. Pagenhart, of the Coast and Geodetic Survey, was directed to represent the United States in Mr. Hodgson's place.

The observations were completed successfully early in May, 1916. After the completion of the field work, the computation and adjustment of the triangulation from Alice southward were made at this Office. In the adjustment there were used the bases measured at Point Isabel, Tex., and Colombres, Mexico, and the Laplace azimuths at Point Isabel and Alice and at triangulation station Donna. The latter is one of the stations of the quadrilateral connecting the two sections of the arc. Details in regard to the adjustment are given later in this report. As soon as the computations had been completed and the geographic positions of the ends of the base line in Mexico had been placed on the North American datum, the information needed by the section of geodesy of the Bureau of Geographical and Climatolgical Studies of Mexico was sent to that office.

GENERAL STATEMENT.

This report gives the results of a primary triangulation which extends from the Alice base net, Texas, to Point Isabel, Tex., at the mouth of the Rio Grande, with a spur line running westward and southward from Harlingen, Tex., to the Colombres base on the Mexican side of the Rio Grande. It also contains the descriptions and geographic positions, with other data, for the triangulation along the Gulf coast between Point Isabel and Corpus Christi, Tex.

In Appendix 5 of the Report for 1911 are given the data for the primary triangulation in Texas at the lower end of the ninety-eighth meridian arc and for the tertiary triangulation established some years previously along the coast of Texas between Point Isabel and Corpus Christi. After that report had been printed it was learned that very few of the monuments marking the old coast stations had escaped destruction by the erosion of the shores of the Laguna Madre and of the Gulf of Mexico and that it was therefore desirable to have a new triangulation made between Corpus Christi and Point Isabel for use in chart revision operations and for other surveying and engineering work.

As a result of the extension of the primary triangulation from the Alice base net to Point Isabel, at the mouth of the Rio Grande, it became necessary to readjust the coast triangulation to make the coordinates of the latter agree with those of the primary triangulation. In consequence of this, it will be found that the positions given for the old coast triangulation stations in Appendix 5 of the

Report for 1911 do not agree with the positions as given in this report. Any one using the triangulation along the coast between the two points mentioned above should accept the positions as given herein, rather than as given in the Appendix referred to above.

In this report are given sufficient details of the triangulation to enable geodesists to follow the adjustment made between base lines and Laplace azimuth stations. There is also given a brief description of the field operations conducted by the surveying parties.

The engineer or surveyor who simply wishes to find the descriptions and geographic positions of the various triangulation stations should consult the sketches at the end of this volume, which will enable him to find the names of the triangulation stations located within any area in which he is interested. From the index he will be able to learn the numbers of the pages on which the descriptions and positions of the stations may be found.

Engineers and others using the data given in this report for the control of maps and surveys will find it of help to have the Special Publications Nos. 5 and 8 of the Coast and Geodetic Survey. They may be obtained at a nominal cost from the Superintendent of Documents, Washington, D. C.

Special Publication No. 5 is entitled "Tables for a Polyconic Projection of Maps Based on Clarke's Reference Spheroid of 1866." These tables give the necessary explanation of the method employed in constructing a polyconic projection, and they also give the values in meters of the degrees, minutes, and seconds of latitude and longitude for all latitudes.

Special Publication No. 8 is entitled "Formulæ and Tables for the Computation of Geodetic Positions." As the title of this publication implies, the data contained in it will enable one to compute the spherical coordinates for triangulation where the distances and angles are known.

RECONNAISSANCE.

On January 19, 1913, Signalman Jasper S. Bilby arrived at Alice, Tex., and began the organization and equipment of a party for the purpose of extending a reconnaissance from that place to Point Isabel and to a point north of the Rio Grande opposite the Colombres base, which is approximately on the ninety-eighth meridian, with its ends only about 2 miles south of the river.

The reconnaissance was done under instructions which specify the strength of the triangulation in so far as the number of bases and the character of the figures are concerned. The triangulation was designed to contain quadrilaterals with the two diagonals observed and central point figures. In no case was it permitted for the scheme to consist of only a single triangle nor for the quadrilaterals to overlap

each other, except in a base net. The strength of the quadrilaterals had to conform to the requirements of the general instructions for reconnaissance for primary triangulation which have been published frequently in reports of the Coast and Geodetic Survey, notably in Special Publication No. 19. It is not thought necessary to repeat those instructions here, for they may be referred to in the publication mentioned.

The chief of the party engaged on the reconnaissance was directed to use that length of line which would make the total cost of the triangulation a minimum. While the observing on triangulation increases in cost with the increase in the number of stations for any particular length of an arc, at the same time the building of high signals, incident to longer lines and fewer stations, will frequently more than offset the saving to the observing party by the decrease in the number of stations.

The reconnaissance was planned to have lines of such length that signals of only moderate height would be required. It was found that, in general, signals of about 45 feet as the average height of the tripod and scaffold, with superstructures on some of the scaffolds, elevated the lines sufficiently to overcome the curvature of the earth and to lift the line above the trees, which were on the average about 30 feet in height, for lines averaging about 12 miles (19 kilometers) in length.

The actual field work of the reconnaissance was begun on January 20, 1913, and was completed to the Rio Grande, opposite the Colombres base, and to Point Isabel, on March 16, 1913. Owing to the scarcity of teams in the country over which the work was carried, it was necessary for the team used on reconnaissance to haul most of the lumber used by the building party. This method of getting the lumber to the stations delayed the reconnaissance but it reduced the cost of the combined reconnaissance and building.

The reconnaissance started from the line connecting triangulation stations Wood and Alice west base which had been established some years previously. Alice east base, another old station, was used as a check to insure the exact recovery of the marks of the other two stations. From these stations the scheme of triangulation was carried a little to the eastward to the St. Louis, Brownsville & Mexico Railway, in order that the railroad could be used as a means of transportation by the reconnaissance, building, and observing parties. It has been found that primary triangulation can be made at a much smaller cost when a railroad runs through the scheme than over country where there is no railroad. Besides, when the primary triangulation stations are established near a railroad they are more readily available when they are needed in making extensions of the triangulation net of the country.

The arc was extended southward to Harlingen, from which place it was carried southeastward to Point Isabel, Tex., at the mouth of the Rio Grande. At that place a connection was made with three of the primary triangulation stations which had been established in 1906. A connection in length, position, and azimuth was made with the line joining the two existing stations Arista and Point Isabel west base. The station Point Isabel east base was used as the check point.

A quadrilateral was provided to the west of Harlingen by means of which a direct connection could be made with the ends of the Colombres base, which is located on the Mexican side of the river. Connections were also provided with four reference monuments of the topographic survey of the Rio Grande which had previously been made by the United States and Mexico International Boundary Commission,

The building operations were under the general direction of Signalman J. S. Bilby. The actual building was done by Mr. William C. Nohl, while the reconnaissance was being made by Mr. Bilby. On March 18, 1913, Mr. Bilby took direct charge of the building party and continued its operations until all of the signals had been erected. The last building was done on May 17, 1913.

In all, there were erected 34 scaffold signals, two poles, and one longitude observatory. The average height of the tripod and scaffold signals was 43 feet from the ground to the top of the tripod. On 24 of the signals superstructures were built, each of which was 24 feet in height. All of the stations were marked in a permanent manner by the building party, the marks being of concrete into which were set the standard metal disk station marks.

There are given below statements of the cost of the reconnaissance and the building. These indicate very efficient management of the work.

Cost of reconnaissance.

Number of months		1.9
Total progress	(282 kms.) miles	175
Total cost	dollars	480.00
Cost per mile of progress	dollars	2.80
Number of primary stations selected		30
Cost per station selected	dollars	16.00

Cost of building.

Number of double signals		34
Total height to tripod heads	feet	1463
Number of superstructures		24
Total height of superstructures	feet	576
Total cost of building	dollars	5600
Cost per vertical foot of double structure to tripod head	dollars	3.35
Cost per vertical foot of superstructure	dollars	1.25

The cost of the material for the monuments and the cost of setting them at the triangulation stations is included in the above amount for building. The cost of the travel to and from the field is also included in the above amounts. In fact, all expenditures incident to the work of the reconnaissance and building are taken into account.

TRIANGULATION SIGNALS.

The type of signal used on the triangulation in southern Texas was the same as has been used during a number of years by the Coast and Geodetic Survey triangulation parties, except that at many of the stations superstructures were erected on the scaffolds to make it possible to use tripods of only moderate height. It was concluded, after preliminary investigations had been made by Mr. Bilby, that it would make the unit cost of the work less to modify the usual type of signal by the frequent use of the superstructure. The results of the season's work confirmed his judgment in the matter.

Except for the superstructure and the absence of what was called the top platform in the older type of signal, the description of the signal given in Appendix 4 of the Report for 1903 of the Coast and Geodetic Survey, applies to the signal used in Texas. There was no need for a second platform, such as is shown on the signals described in that report. This was used in the past only when there were two observers working simultaneously along an arc.

In the report for 1903, mentioned above, there is shown a triangulation signal with a superstructure extending to a total height of 137 feet above the ground. That superstructure was somewhat different from the one used in the southern Texas work. The old superstructure was used to clear obstructed lines after the tripod and scaffold had been built, while the new type of superstructure is an integral part of the scaffold and as such is planned for by the reconnaissance party. The method of erecting the signal is shown in figs. 1 to 9.

The signal lamps and heliotropes used by the observing party were posted by the light keepers on the top of the tripod or on the superstructure, if there were one.

OBSERVING.

The observing party worked under the general instructions for primary triangulation which have been in use in the Coast and Geodetic Survey for a number of years. They were adopted by the Superintendent of the Survey on January 10, 1905, and have been changed only slightly since then. These instructions are designed to make the triangulation of sufficient accuracy for all purposes to which the results of the work can be applied. They are also designed to make the cost of work of the required accuracy a minimum.

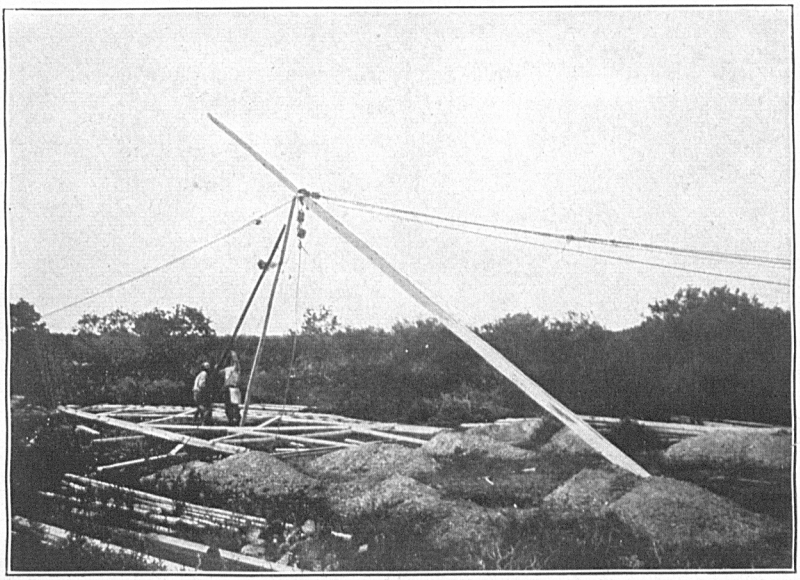

Fig. 1.—ERECTING DERRICK.

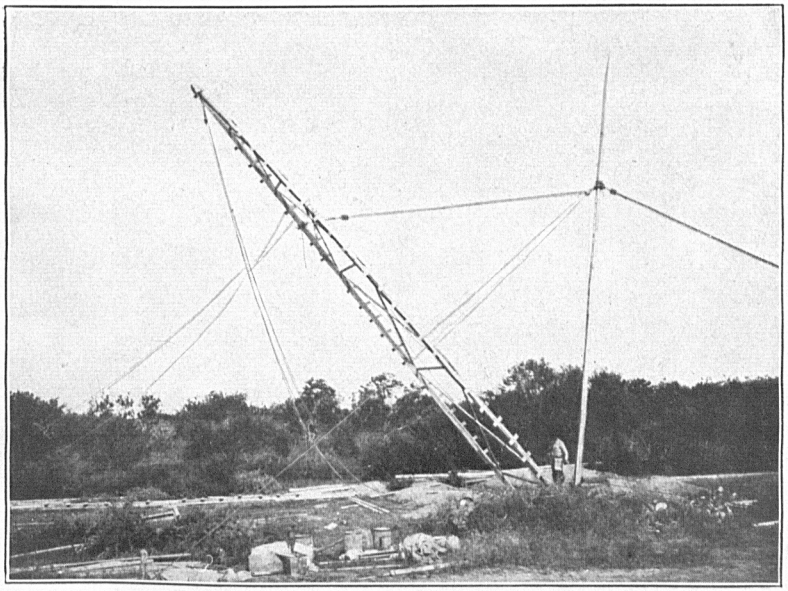

Fig. 2.—ERECTING ONE SIDE OF TRIPOD, WHICH HAS BEEN COMPLETELY FRAMED ON THE GROUND.

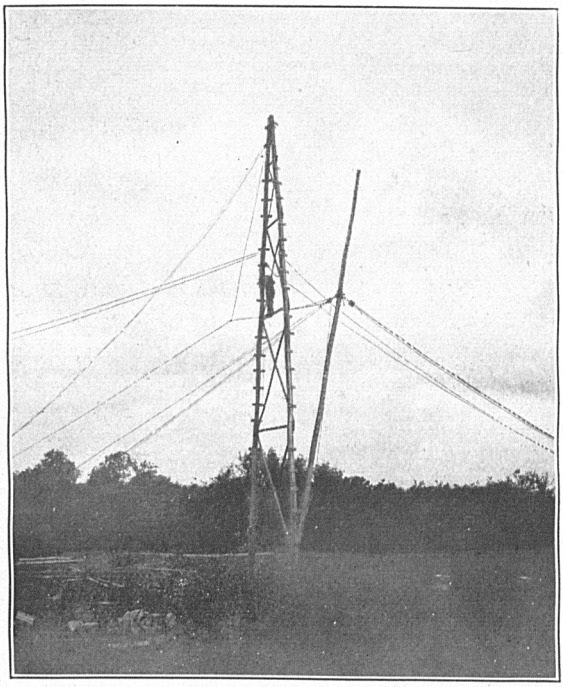

Fig. 3.—FIRST SIDE OF TRIPOD ERECTED TO ITS PROPER PLACE.

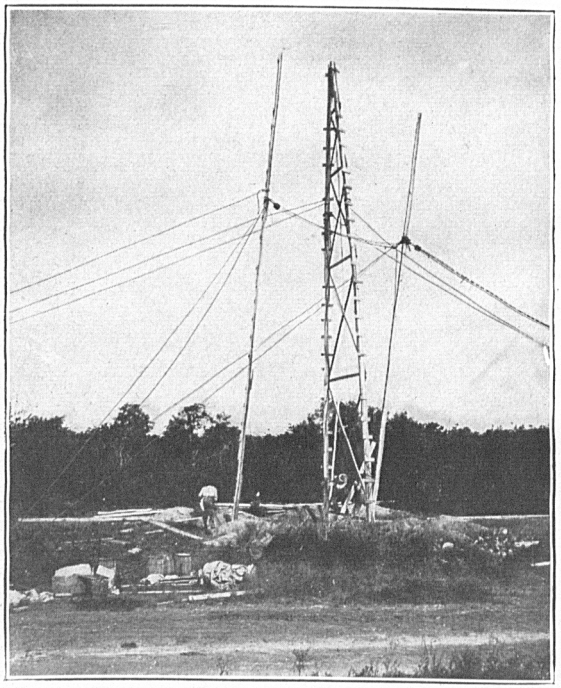

Fig. 4.—THIRD LEG OF TRIPOD BEING HOISTED INTO PLACE.

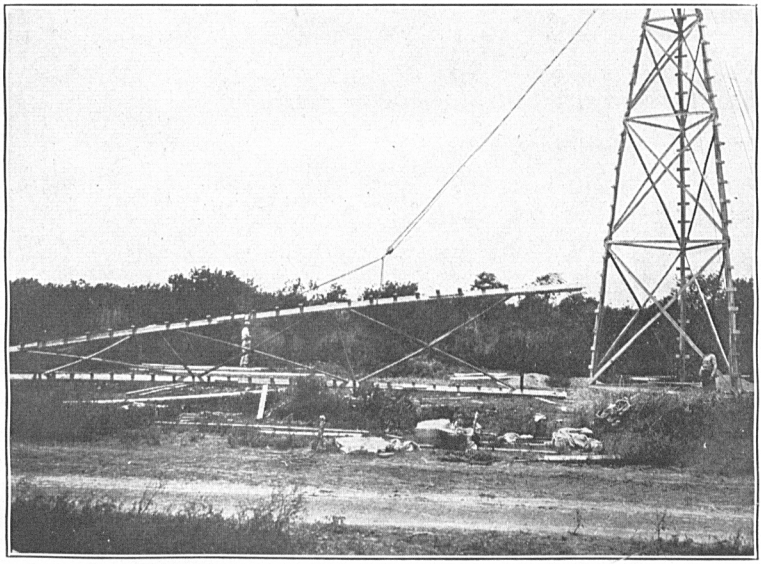

Fig. 5.—THE COMPLETED TRIPOD.

The ties and braces for the second and third sides of the tripod are duplicates of the similar members of the first side which was framed on the ground. In this illustration a side of the scaffold is being turned over preparatory to being hoisted into place.

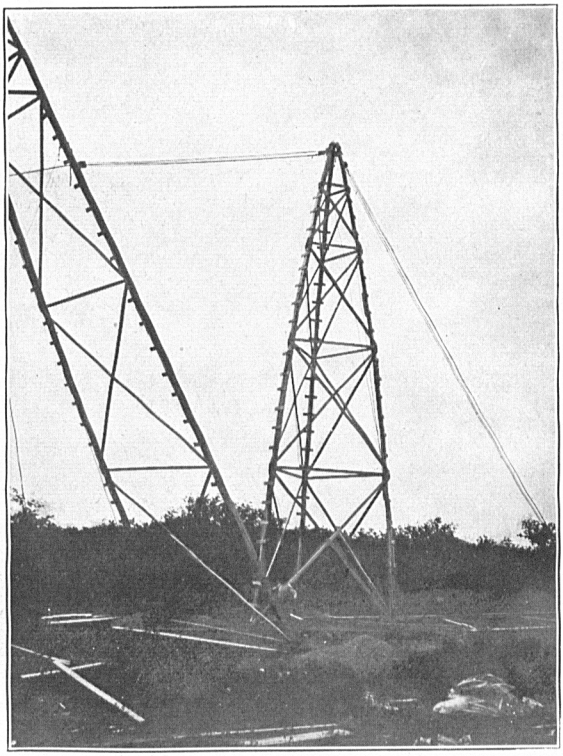

Fig. 6.—ONE SIDE OF SCAFFOLD BEING HOISTED INTO PLACE. THE TRIPOD IS USED AS THE DERRICK.

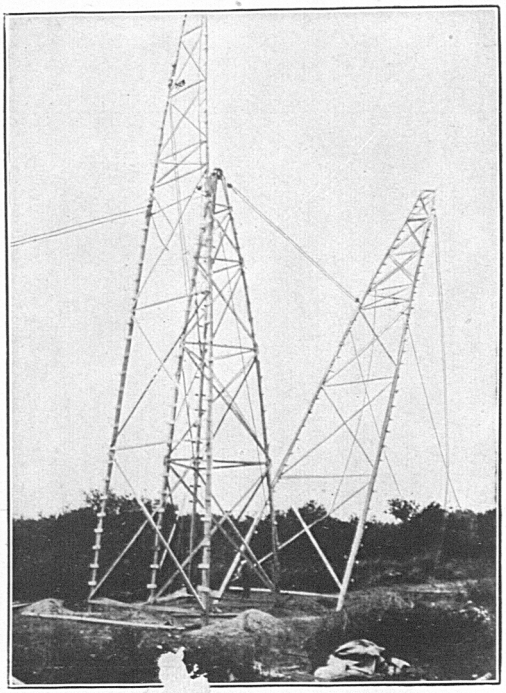

Fig. 7.—ONE SI[illegible] OF SCAFFOLD IN PLACE AND THE C[illegible] SIDE BEING HOISTED.

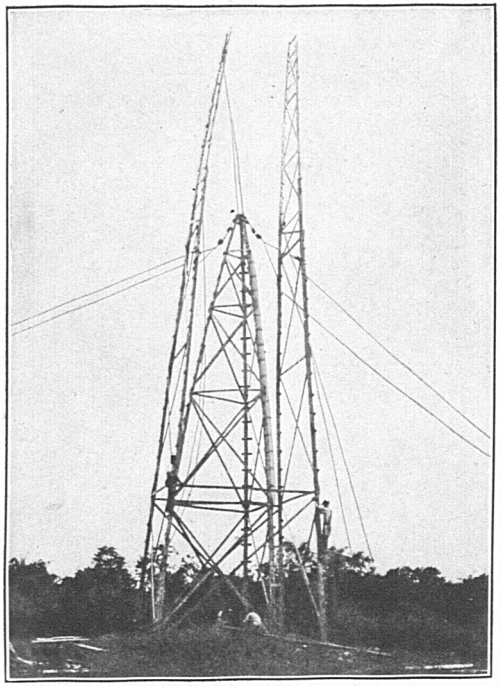

Fig. 8.—TWO OPPOSITE SIDES OF SCAFFOLD IN PLACE AND THE THIRD AND FOURTH SIDES BEING CONSTRUCTED.

The ties and braces of those sides are duplicates of the ties and braces of the first two sides and are cut on the ground.

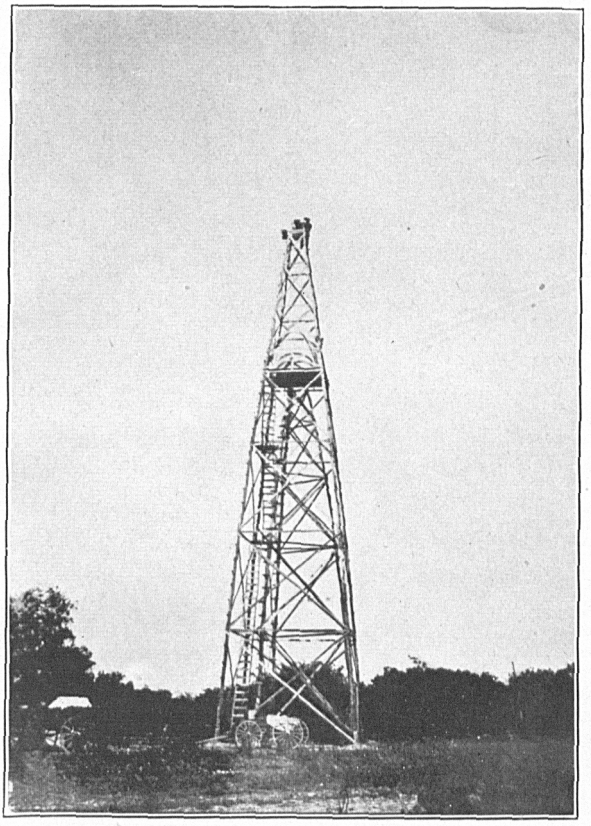

Fig. 9.—THE COMPLETED DOUBLE TOWER.

The observing tent is shown which protects the instrument from the wind and the direct rays of the sun. A signal lamp and a light keeper are shown at the top of the outer structure called the scaffold. The center of the tripod and of the stand at the top of the scaffold are in the same vertical line with the center of the tablet in the concrete marker or monument in the ground.

It was decided that an accuracy represented by an average closing error of a triangle of about one second, with a maximum closing error of a triangle of not more than three seconds, was what the observers should strive for. It has been found that this accuracy can be obtained when all of the observations at a station are made on a single day or even in a single observing period, afternoon or night, if the observations are made in 16 positions of the circle of the theodolite. Each position consists of two pointings on an object, one when the telescope of the theodolite is direct or upright and the second when it is in the reverse position. The difference in the initial settings of the instrument for any two consecutive positions is such that for the whole set of observations the readings of the micrometer microscopes will be nearly evenly spaced around the circle.

Investigations conducted at the office of the Coast and Geodetic Survey several years ago seemed to indicate that there is less deviation in the geodetic azimuths of the lines of the triangulation from the true geodetic or Laplace azimuth, for triangulation which has the observing done on lamps at night than for triangulation in which the observing is done on heliotropes or poles in daylight or where the observing is a combination of day and night work. The result of the investigations made it desirable to have the triangulation from Alice base net to the Rio Grande, in Texas, observed entirely at night, in so far as the primary horizontal directions were concerned.

The following table shows the number of days on which primary horizontal directions were observed at each of the stations contained in the scheme to the southward of the Alice base net:

No.	Station.	Days on which observations of primary hozizontal directions were made.	Number of days.	No.	Station.	Days on which observations of primary horizontal directions were made.	Number of days.
1	Wood	Feb. 25, 26	2	19	Brenner	Apr. 11	1
2	Alice west base	Feb. 28	1	20	Raymond	Apr. 14	1
3	King	Mar. 1, 3	2	21	Sebastian	Apr. 15, 16	2
4	Bishop	Mar. 4, 5	2	22	Hidalgo	Apr. 17	1
5	Kleberg *ecc*	Mar. 9, 10	2	23	Donna	Apr. 21	1
6	Ricardo	Mar. 12, 13	2	24	Rio	Apr. 23	1
7	Riviera	Mar. 14	1	25	Maria	Apr. 24, 25	2
8	Robbins	Mar. 17	1	26	Mercedes	Apr. 26	1
9	Sarita	Mar. 18, 19, 20	3	27	Harlingen	Apr. 28, 29	2
10	Roza	Mar. 21	1	28	Mitla	Apr. 30	1
11	Turcotte	Mar. 25, 27	2	29	Benito	May 6	1
12	Kenedy	Mar. 28	1	30	Cowgill	May 7	1
13	Armstrong	Mar. 29, 30, 31	3	31	Olmito	May 12	1
14	Katherine	Apr. 1	1	32	Resaca	May 13	1
15	Vinson	Apr. 2, 3	2	33	Point Isabel west base.	May 14	1
16	Nonas	Apr. 4	1				
17	Yturria	Apr. 7	1	34	Arista	May 16	1
18	Stillman	Apr. 9	1				

An observing party was organized by Mr. C. V. Hodgson, assistant (now hydrographic and geodetic engineer), in February, 1913. It consisted of the chief of party, one recorder, one teamster, and five

light keepers, for showing the lights from the stations on which observations were made.

Since the distances between the stations were comparatively short, it was arranged to have the light keepers retain their relative positions throughout the work; that is, two light keepers were kept ahead of the observer, two behind him, and one at the station opposite him. Whenever the observer moved east or west between two stations of that part of the scheme which extended north and south, it was necessary for only one light keeper to change to a new station. When, however, the observing party moved southward to a new station, then each one of the five light keepers moved ahead to a new station. The light keepers in some cases were able to move forward by the railroad, and at other times they moved by teams hired especially for the trip.

The personal equipment of the various members of the observing party was held to a minimum and the general property and instruments were only such as would barely meet the needs of the party. The instruments were moved from station to station in a light spring wagon, drawn by two horses, and the camp equipment and horse feed and sometimes water were hauled from station to station in a light freight wagon, also drawn by two horses.

In general, the roads were in fair condition, but along approximately 50 miles of the scheme deep sand was encountered, which made it necessary for the teams to go as light as possible, and even then not more than 20 miles could be traveled in a single day.

The light keepers, whenever necessary, secured teams from the neighboring ranches for moving from station to station, except when the work was being done in the region of the heavy sand mentioned above. While working through that sandy stretch a team was provided for the two light keepers who were working ahead of the observer and a second team for the two light keepers who were working to the rear of the observer. While operating over the sandy area the light keeper whose station was always directly opposite that of the observer, was moved by one of the teams of the observing party. At practically all stations the members of the observing party and the light keepers prepared their own meals.

The observing party reached its first station on February 24, and the last observations on the triangulation were made on May 16. The weather was, in general, very favorable to the work, as during the season only 11 days were lost on account of bad weather.

As was mentioned in the early part of this report, one of the objects of undertaking the triangulation to the south of Alice, Tex., was to furnish a connection between the two sections of the arc of primary triangulation along the ninety-eighth meridian, one in Mexico, and the other in the United States. Owing to the political con-

ditions which existed in Mexico in the early half of 1913, it was found to be impracticable at the time the observing party was in the field to make the observations necessary to connect the stations on the two sides of the river.

When the triangulation had been completed, except for the actual connection across the river, the chief of party, Mr. Hodgson, and Mr. G. D. Cowie, assistant, determined astronomically the difference in longitude between the old astronomic station at Austin, Tex., and the triangulation station previously established at Donna, Tex. The object of making this determination was to furnish a Laplace station at the latter place which would provide for a true geodetic azimuth that would be free from the effect of the local deflection of the vertical. Actual observations on this astronomic work were completed on June 1, 1913, shortly after which the party disbanded.

During the interval between the first and the last observations on the triangulation 34 primary stations were completed and four primary astronomic azimuths were observed. The total interval between the first and the last observations was 2.8 months; therefore the average number of stations completed per month was 12.1. During the month of April, 15 primary stations were occupied. So far as the author is aware these records for rapidity of operations of primary triangulation had previously never been equaled in this or in any other country. This rapidity of operations was accompanied by great accuracy, as is indicated by an unusually small average closing error for the triangles. The closing error is the difference between the sum of the observed angles of a triangle, less the spherical excess of the triangle, and 180°. The average closing error for the 68 triangles was 0″.63, and the maximum closing error was 1″.86.

During the whole season it was not necessary to reoccupy a single station on account of large closing errors. One station was reoccupied, but that was in order to obtain additional observations at that point on several reference monuments established during the topographical survey along the Rio Grande by the International Boundary Commission, United States and Mexico.

ECONOMY AND EFFICIENCY.

As is well known the object of the primary triangulation of the United States, done by the Coast and Geodetic Survey, is, first, the control of maps and surveys and engineering works of all descriptions where accurate positions, directions, and distances are needed; and second, the determination of the figure of the earth and data for investigations in the subject of isostasy or the distribution of densities in the outer portions of the earth. It has been decided that, in order to fulfill all the functions to which a primary triangulation may be put, an average closing error of the triangles of one second is all that

is to be desired, provided it is impossible to secure greater accuracy without an increase of time and money. It is of course advisable, if it is possible to do so, to secure the smallest possible error in the triangulation, but it does not seem to be desirable to add to the time and money spent on primary triangulation to secure an accuracy greater than that represented by a closing error of one second.

As the funds available are limited, the officials of the Coast and Geodetic Survey are forced to make a decision as to whether a reasonable limit of accuracy should be established and that no time and money should be spent to obtain a greater accuracy than that or to strive for extremely small closing errors and the greatest possible accuracy by spending as much time and money as might be necessary to secure them.

Much greater quantities of work can be done for the same expenditure of money if the triangulation of moderate accuracy is accepted. It was decided that, owing to the limited funds, the great demand for geodetic control, and the enormous areas now lacking such control, every effort should be made to extend the network of primary triangulation as rapidly as possible. The author does not wish to convey the idea that the limit of accuracy adopted is a low one. As a matter of fact, any triangulation that has an average closing error for the triangles of about 1 second is a very high grade of work, and according to all geodetic authorities the results are such as to satisfy the most exacting demands of the geodesist, engineer, and geographer.

The average closing error of a triangle on this southern Texas triangulation indicates that the accuracy of this work is greater than that of most of the triangulation already done in the United States. This is worthy of comment, for the observations were completed at most of the stations on a single day each. It no doubt would have increased the accuracy of the triangulation somewhat if more than one day had always been used to make the observations, but this would have added to the expense of the work and would not have been justified.

The past experience in the Coast and Geodetic Survey shows conclusively that the lamp is the most economical instrument for furnishing an object on which to make observations.

In the report of the chief of the triangulation party he states that an important element which entered into the rather remarkable progress of the observing party was the excellent reconnaissance or selection of stations by the chief of the reconnaissance party. He had located the stations to the best advantage as regards water supply for the party and in regard to roads on which to travel between stations. He also furnished the observing party with very complete

notes which showed the best route by which each station might be approached.

STATEMENT OF COSTS.

There is given below a statement which shows the cost of the triangulation in southern Texas. There are also given the costs of some triangulation previously done in the United States.

Name of arc.	Months of observation.	Primary stations occupied.	Stations occupied per month.	Total field expenses.	Cost per station occupied.	Total points determined.	Cost per point determined.	Miles of progress.	Cost per mile of progress.	Area in main scheme in square miles.	Cost per square mile.
Southern Texas, 1913.	2.8	34	12.1	$9 900	$291	72	$138	175	$57	1 300	$7.62
One hundred and fourth meridian..	13.7	82	6.0	28 850	352	167	173	720	40	17 000	1.70
Texas-California....	16.7	94	5.6	38 384	408	262	147	1 207	32	49 220	.78
Ninety-eighth meridian triangulation after 1901....	30.5	265	8.6	78 187	293	849	109	1 329	63	21 655	5.19

The cost of triangulation will vary with the topography to such an extent that comparisons of the cost of two arcs reveal very little of the relative efficiency of the two pieces of work, unless allowance is made for certain favorable or unfavorable factors in each. The reason why the southern Texas work cost more than either the Texas-California or the one hundred and fourth meridian arc is that on those there was comparatively little signal building necessary. Heavy signal building adds materially to the cost of primary triangulation. The short season of the southern Texas work had the tendency to somewhat increase the unit costs, as there are certain fixed charges in any season's work and necessarily the shorter the season the more the unit costs will be affected. The cost per station occupied for the southern Texas work is less than for any of the other three arcs considered in the above table, while the cost per mile of progress on the southern Texas arc is only less than that on the ninety-eighth meridian. The ninety-eighth meridian work between 1902 and 1907 is comparable, so far as topography and many other conditions are concerned, with the southern Texas work. That the southern Texas work was done with very great efficiency is evident when it is realized that the cost for lumber and supplies and the wages paid hands were from 25 to 40 per cent greater on this work than on the ninety-eighth meridian triangulation.

OBSERVATIONS MADE IN 1916 TO CONNECT TRIANGULATION OF THE UNITED STATES AND MEXICO.

After the preliminary plans had been perfected by the officials of the United States Coast and Geodetic Survey and the section of geodesy of the Bureau of Geographical and Climatological Studies

of Mexico, Mr. C. V. Hodgson, assistant, proceeded to southern Texas and had conferences with Mr. Silverio Alemán, chief of the section of geodesy of Mexico, and they arranged to have signals erected at the two stations Donna and Rio on the United States side, and at Colombres and Tenacitas, the two stations at the ends of the Colombres base line, on the Mexican side of the Rio Grande.

It was decided that Mr. Hodgson would make the observations at the two stations in the United States and that Mr. Alemán would make the observations at the two stations in Mexico and that each would have signal lamps posted and lights shown to the other.

Owing to the obstructions on several of the lines in the quadrilateral formed by the four stations which were to be occupied and the necessity for extending the height of the signals, it was not possible for the observations on the United States side to be completed by Mr. Hodgson before it became necessary for him to proceed to Utah and start observations on the Utah–Oregon arc of primary triangulation. In order that there might be no danger of a postponement of the work, Assistant E. H. Pagenhart was sent to Texas to relieve Mr. Hodgson.

Mr. Pagenhart completed the observations on the American side of the river on May 3, 1916, and on May 6 he was notified by Mr. Alemán that the observations at the Mexican stations had been completed. On May 8 Messrs. Pagenhart and Alemán had a conference at Brownsville, Tex., at which they combined their observations and found that they were in every way satisfactory.

STATEMENT OF ADJUSTMENTS.

No local adjustments were made, these having become unnecessary since the adoption of the present method of supplying missing observations in a broken series.

The primary triangulation considered in this publication starts from the line joining triangulation stations Alice west base and Wood of the Alice base net. The length and azimuths of this line and the geographic coordinates of the stations at its ends were fixed by the adjustment of the triangulation which extends from the Seguin base net to Corpus Christi, Tex.[1]

The length discrepancy developed in the triangulation between the Alice base net and the line joining the stations Point Isabel west base and Arista of the Point Isabel base net was 97 in the seventh decimal place of logarithms or one part in 44 800. The length of the line was longer, as carried from the Alice base than as carried from the Point Isabel base.

[1] See Appendix 5 of the Report of the Coast and Geodetic Survey for 1911.

The length discrepancy developed between the Alice base net and the Colombres base line was 149 in the seventh decimal place of logarithms or one part in 29 100. The measured length of the Colombres base is shorter than the length computed through the triangulation from the Alice base net.

The length discrepancy between the Point Isabel base net and the Colombres base net is 52 in the seventh decimal place of logarithms, or one part in 83 500. The Colombres base, as measured, is shorter than as computed through the triangulation from the Point Isabel base net.

A single adjustment was made for all of the triangulation joining the Alice and Point Isabel base nets and the Colombres base line. The geographic positions [1] already adopted for the line joining stations Wood and Alice west base of the Alice base net were held fixed. There were also held the previously adopted length of the line joining stations Arista and Point Isabel west base of the Point Isabel base net[1] and the measured length of the Colombres base line, as furnished by the Mexican Geodetic Commission.

There were also held in the adjustment the Laplace azimuth at Donna and the previously adopted azimuth of the line joining stations Arista and Point Isabel west base of the Point Isabel base net. This line is separated by only one line from Fronton station, at which there is a Laplace azimuth. There were 70 conditional or observation equations relating to the primary triangulation from Alice southward and two azimuth equations. The total number of normal equations solved was 72.

The azimuth discrepancy between the Alice base net and the Point Isabel base net was $+0''.82$, while between the Alice base net and Donna Laplace station it was $+2''.66$ and between Point Isabel base net and Donna Laplace station it was $+1''.84$. These discrepancies are of the size to be expected in the triangulation. The probable error in the determination of the astronomic longitude of Point Isabel or Donna is $\pm 0^s.02$ or $\pm 0''.30$. The probable error of the observed astronomic azimuth is $\pm 0''.30$, while the probable error of the Laplace azimuth is $\pm 0''.45$. The actual error may be as great as $1''.5$. The uncertainty of one Laplace azimuth as carried to another Laplace station is the combination of the probable error of the observed Laplace azimuth and the probable error of the azimuth as carried through the triangulation. The probable error of the geodetic azimuth carried from Alice base net to Point Isabel base net is $\pm 0''.81$, while from Point Isabel base net to Donna it is $\pm 0''.51$, and from Alice base net to Donna

[1] See Appendix 5 of the Report of the Coast and Geodetic Survey for 1911.

it is $\pm 0''.71$. When these are combined with the probable error of the Laplace azimuth before carrying it through the triangulation we have the following results:

Probable error Alice to Point Isabel	$\pm 0''.93$
Probable error Alice to Donna	$\pm 0''.84$
Probable error Point Isabel to Donna	$\pm 0''.68$

If, now, the probable error of the Laplace azimuths at the stations to which the other azimuths have been carried are considered, the values above become, respectively, $\pm 1''.03$, $\pm 0''.95$, $\pm 0''.82$. These are of the same order of magnitude as the actual discrepancies found. The actual discrepancy is in no case as large as three times the probable error.

ABSTRACT OF HORIZONTAL DIRECTIONS AND ELEVATIONS OF TELESCOPE ABOVE THE STATION MARKS.

All observed directions in the triangulation along the ninety-eighth meridian in the United States and Mexico have been given equal or unit weight. Those directions were reduced to center where either the instrument or the object observed was not coincident with the center of the station mark.

The horizontal directions were all reduced to sea level. The correction for this reduction expressed in seconds is given by

$$\frac{e^2 h \sin 2\alpha \cos^2 \phi}{2\rho \sin 1''}$$

where $e^2 = \frac{(a^2 - b^2)}{a^2}$, a = the earth's equatorial radius and b = the polar semidiameter, h = height of station observed, ρ = radius of curvature of the earth in a plane normal to the meridian, ϕ = the latitude, and α = the azimuth reckoned from the south to the westward.

In the following table are given the lists of observed and adjusted directions and also the elevations of the telescope of the theodolite above the station mark at each of the stations of the primary triangulation considered in this publication. The elevations enable the reader to judge of the amount of building done and they permit the engineer or surveyor who uses the stations in the future to form an estimate of the probable amount of building required by him to make any particular line clear. In the table is included a column showing the number assigned to each direction in the figure adjustment.

Following the table of horizontal directions and elevations of telescope above the station marks there is given a list of condition equations used in the adjustment of the primary triangulation considered in this publication.

Abstract of horizontal directions and elevations of telescope above the station marks.

Station occupied and elevation of instrument above station mark.	Number of direction.	Object observed.	Observed direction reduced to sea level.			Final seconds after figure adjustment.
			°	′	″	″
Wood, 15.65 meters	3	Alice west base	0	00	00.00	59.80
	1	Bishop	266	33	16.43	16.91
	2	King	310	22	17.04	16.76
	.....	Alice east base	333	44	40.05	.....
Alice west base, 15.91 meters	4	Wood	0	00	00.00	00.51
	.....	Alice east base	39	53	52.76	.....
	5	Bishop	56	37	18.23	18.05
	6	King	83	14	26.34	23.01
King, 6.57 meters	7	Alice west base	0	00	00.00	00.41
	8	Wood	47	07	55.39	55.41
	9	Bishop	129	52	55.52	55.35
	10	Kleberg *ecc*	187	24	35.29	35.48
	11	Ricardo	226	51	03.94	03.49
Bishop, 18.86 meters	12	Kleberg *ecc*	0	00	00.00	00.07
	13	Ricardo	30	37	58.71	58.88
	14	King	71	44	49.00	49.13
	15	Alice west base	95	14	50.08	49.72
	16	Wood	125	10	50.16	50.17
Kleberg *ecc.*, 10.83 meters	22	Robbins	0	00	00.00	00.08
	23	Riviera	62	36	46.92	46.89
	24	Ricardo	118	33	44.49	44.43
	25	King	171	49	45.51	45.55
	26	Bishop	222	33	17.13	17.11
Ricardo, 15.62 meters	17	King	0	00	00.00	00.15
	18	Bishop	41	55	02.38	02.46
	19	Kleberg *ecc*	87	17	31.56	31.57
	20	Robbins	118	03	49.52	49.45
	21	Riviera	155	33	32.88	32.70
Riviera, 10.91 meters	27	Ricardo	0	00	00.00	00.00
	28	Kleberg *ecc*	55	47	01.66	01.74
	29	Robbins	109	09	55.44	55.24
	30	Sarita	159	56	19.80	20.11
	31	Roza	194	41	56.96	56.77
Robbins, 6.44 meters	34	Riviera	0	00	00.00	00.09
	35	Ricardo	33	20	21.92	22.06
	36	Kleberg *ecc*	64	00	20.18	20.22
	32	Sarita	273	16	39.57	39.45
	33	Roza	314	47	59.31	59.15
Roza, 10.67 meters	37	Riviera	0	00	00.00	00.04
	38	Robbins	49	15	57.94	58.08
	39	Sarita	108	14	00.16	00.13
	40	Kenedy	157	59	44.30	44.40
	41	Turcotte	186	17	44.56	44.32
Sarita, 10.67 meters	46	Robbins	0	00	00.00	00.30
	42	Kenedy	190	07	21.90	21.96
	43	Turcotte	223	50	29.11	29.05
	44	Roza	280	29	21.54	21.51
	45	Riviera	317	29	45.46	45.19
Turcotte, 10.66 meters	47	Roza	0	00	00.00	59.98
	48	Sarita	45	17	23.71	23.82
	49	Kenedy	104	59	36.80	36.70
	50	Armstrong	150	11	31.63	31.59
	51	Katherine	187	33	35.08	35.14
Kenedy, 10.40 meters	56	Sarita	0	00	00.00	00.08
	52	Armstrong	170	46	08.86	08.79
	53	Katherine	211	12	32.25	31.94
	54	Turcotte	273	25	19.43	19.66
	55	Roza	320	07	43.33	43.39
Katherine, 10.71 meters	57	Turcotte	0	00	00.00	00.01
	58	Kenedy	35	13	14.31	14.23
	59	Armstrong	86	03	31.57	31.77
	60	Norias	147	15	55.18	55.08
	61	Vinson	181	44	13.47	13.43

Abstract of horizontal directions and elevations of telescope above the station marks—Continued.

Station occupied and elevation of instrument above station mark.	Number of direction.	Object observed.	Observed direction reduced to sea level.			Final seconds after figure adjustment.
			°	′	″	″
Armstrong, 10.78 meters	62	Norias	0	00	00.00	59.94
	63	Vinson	33	55	02.25	02.37
	64	Katherine	85	16	16.28	16.14
	65	Turcotte	141	50	41.72	41.26
	66	Kenedy	173	59	35.28	35.82
Vinson, 10.73 meters	71	Stillman	0	00	00.00	00.11
	67	Katherine	178	19	51.12	50.76
	68	Armstrong	211	17	55.61	55.77
	69	Norias	271	16	13.89	14.02
	70	Yturria	314	40	09.78	09.75
Norias, 10.77 meters	74	Vinson	0	00	00.00	59.92
	75	Katherine	52	35	18.41	18.76
	76	Armstrong	86	06	39.64	39.74
	72	Yturria	256	12	13.41	13.57
	73	Stillman	304	48	34.31	33.76
Stillman, 10.72 meters	78	Norias	0	00	00.00	00.31
	79	Yturria	47	55	06.44	06.38
	80	Raymond	89	12	15.78	15.52
	81	Brenner	123	49	16.12	16.25
	77	Vinson	323	55	12.24	12.11
Yturria, 10.69 meters	86	Norias	0	00	00.00	00.18
	82	Raymond	178	52	12.33	12.33
	83	Brenner	222	05	55.85	55.67
	84	Stillman	276	31	25.58	25.91
	85	Vinson	327	11	42.17	41.86
Brenner, 15.64 meters	89	Raymond	0	00	00.00	00.37
	90	Sebastian	60	36	15.66	15.60
	91	Hidalgo	89	36	58.39	58.28
	87	Stillman	258	28	17.46	17.31
	88	Yturria	308	08	37.81	37.75
Raymond, 15.55 meters	94	Brenner	0	00	00.00	59.81
	95	Stillman	43	51	16.55	16.51
	96	Yturria	84	54	54.01	54.32
	92	Sebastian	281	44	58.86	59.00
	93	Hidalgo	307	38	46.61	46.37
Hidalgo, 15.60 meters	99	Sebastian	0	00	00.00	00.34
	100	Harlingen	56	51	25.39	25.42
	101	Mercedes	92	09	19.26	18.95
	97	Brenner	268	43	37.34	37.46
	98	Raymond	306	45	26.84	26.64
Sebastian, 15.63 meters	102	Harlingen	0	00	00.00	00.46
	103	Mercedes	40	03	12.16	11.70
	104	Hidalgo	95	30	13.12	13.00
	105	Brenner	155	13	08.03	07.82
	106	Raymond	196	21	51.97	52.31
Mercedes, 15.63 meters	107	Hidalgo	0	00	00.00	00.32
	108	Sebastian	32	23	40.54	40.74
	109	Harlingen	99	47	08.55	08.36
	110	Mitla	135	58	30.37	30.97
	111	Maria	177	46	52.56	52.64
	112	Rio	206	19	48.85	48.52
	113	Donna	252	30	03.34	02.65
Harlingen, 15.62 meters	116	Mitla	0	00	00.00	59.72
	117	Maria	47	36	32.78	32.79
	118	Mercedes	103	59	03.96	04.03
	119	Hidalgo	148	54	03.30	02.87
	120	Sebastian	176	32	25.62	25.63
	114	Cowgill	274	37	52.16	52.43
	115	Benito	315	23	05.27	05.64
Maria, 15.45 meters	121	Rio	0	00	00.00	00.02
	122	Donna	34	25	28.62	28.57
	123	Mercedes	99	06	04.21	03.95
	124	Harlingen	144	43	48.57	48.81
	125	Mitla	187	05	16.79	16.86

Abstract of horizontal directions and elevations of telescope above the station marks—Continued.

Station occupied and elevation of instrument above station mark.	Number of direction.	Object observed.	Observed direction reduced to sea level.			Final seconds after figure adjustment.
			°	′	″	″
Mitla, 15.56 meters	126	Maria	0	00	00.00	59.99
	127	Mercedes	50	12	26.37	25.81
	128	Harlingen	90	01	59.03	59.19
	129	Cowgill	150	38	19.84	19.98
	130	Benito	188	39	53.32	53.58
Cowgill, 15.70 meters	137	Resaca	0	00	00.00	00.15
	138	Olmito	49	31	13.18	13.49
	139	Benito	91	24	59.78	59.70
	140	Mitla	131	34	54.93	55.11
	141	Harlingen	165	36	28.03	27.47
Benito, 15.61 meters	144	Cowgill	0	00	00.00	00.02
	145	Resaca	45	43	44.08	44.20
	146	Olmito	87	03	38.57	38.88
	142	Mitla	258	11	29.02	28.66
	143	Harlingen	294	56	40.62	40.52
Resaca, 15.53 meters	149	Olmito	0	00	00.00	59.70
	150	Benito	34	30	21.91	21.70
	151	Cowgill	77	21	38.54	38.35
	147	Point Isabel, west base	257	15	37.91	38.16
	148	Arista	295	12	04.90	05.35
Olmito, 15.64 meters	152	Benito	0	00	00.00	59.79
	153	Cowgill	51	02	35.41	35.03
	154	Resaca	104	09	43.16	43.41
	155	Point Isabel, west base	148	46	41.74	42.15
	156	Arista	182	14	26.22	26.13
Arista, 15.56 meters	159	Point Isabel, west base	0	00	00.00	00.20
	157	Olmito	269	27	59.93	59.95
	158	Resaca	306	35	23.63	23.41
Point Isabel, west base, 15.58 meters	160	Arista	0	00	00.00	00.65
	161	Olmito	56	00	17.09	16.96
	162	Resaca	88	38	57.66	57.14
	.....	Point Isabel, east base	275	09	21.24	.....
Donna, 18.50 meters	131	Mercedes	0	00	00.00	00.29
	132	Maria	40	36	15.28	15.51
	133	Rio	59	43	29.00	28.54
	163	Tenacitas	103	30	00.39	00.65
	164	Colombres	122	32	45.25	44.93
Rio, 18.53 meters	134	Donna	0	00	00.00	59.50
	135	Mercedes	74	06	17.20	17.69
	136	Maria	126	27	18.10	18.15
	165	Tenacitas	270	50	25.18	25.41
	166	Colombres	285	10	30.68	30.40
Colombres	167	Donna	0	00	00.00	59.96
	168	Rio	42	21	15.43	15.10
	169	Tenacitas	72	22	32.14	32.50
Tenacitas	170	Colombres	0	00	00.00	59.86
	171	Donna	88	34	43.60	43.35
	172	Rio	135	38	37.22	37.62

CONDITION EQUATIONS.

[Ninety-eighth meridian in United States and Mexico

No.

1. 0=+1.00−(1)+(3)−(4)+(5)−(15)+(16).
2. 0=+1.15−(2)+(3)−(4)+(6)−(7)+(8).
3. 0=+1.22−(5)+(6)−(7)+(9)−(14)+(15).
4. 0=−0.36−(9)+(10)−(12)+(14)−(25)+(26).
5. 0=+0.39−(9)+(11)−(13)+(14)−(17)+(18).
6. 0=+0.68−(10)+(11)−(17)+(19)−(24)+(25).
7. 0=+0.32−(19)+(20)−(22)+(24)−(35)+(36).
8. 0=+0.14−(19)+(21)−(23)+(24)−(27)+(28).
9. 0=+0.26−(20)+(21)−(27)+(29)−(34)+(35).
10. 0=−1.29−(29)+(30)−(32)+(34)−(45)+(46).
11. 0=−0.36−(29)+(31)−(33)+(34)−(37)+(38).
12. 0=+0.81−(30)+(31)−(37)+(39)−(44)+(45).
13. 0=−0.06−(39)+(40)−(42)+(44)−(55)+(56).
14. 0=+0.05−(39)+(41)−(43)+(44)−(47)+(48).
15. 0=+0.59−(40)+(41)−(47)+(49)−(54)+(55).
16. 0=−1.36−(49)+(50)−(52)+(54)−(65)+(66).
17. 0=−0.61−(49)+(51)−(53)+(54)−(57)+(58).
18. 0=+0.03−(50)+(51)−(57)+(59)−(64)+(65).
19. 0=+0.63−(59)+(60)−(62)+(64)−(75)+(76).
20. 0=−0.02−(59)+(61)−(63)+(64)−(67)+(68).
21. 0=−0.98−(60)+(61)−(67)+(69)−(74)+(75).
22. 0=−0.09−(69)+(70)−(72)+(74)−(85)+(86).
23. 0=−0.89−(69)+(71)−(73)+(74)−(77)+(78).
24. 0=+0.43−(70)+(71)−(77)+(79)−(84)+(85).
25. 0=−0.48−(79)+(80)−(82)+(84)−(95)+(96).
26. 0=−0.79−(79)+(81)−(83)+(84)−(87)+(88).
27. 0=−1.06−(80)+(81)−(87)+(89)−(94)+(95).
28. 0=+0.21−(89)+(90)−(92)+(94)−(105)+(106).
29. 0=+0.75−(89)+(91)−(93)+(94)−(97)+(98).
30. 0=−0.08−(90)+(91)−(97)+(99)−(104)+(105).
31. 0=+0.45−(99)+(100)−(102)+(104)−(119)+(120).
32. 0=+0.43−(99)+(101)−(103)+(104)−(107)+(108).
33. 0=+1.35−(100)+(101)−(107)+(109)−(118)+(119).
34. 0=−0.83−(109)+(111)−(117)+(118)−(123)+(124).
35. 0=+0.74−(110)+(111)−(123)+(125)−(126)+(127).
36. 0=−0.29−(116)+(117)−(124)+(125)−(126)+(128).
37. 0=+1.13−(111)+(112)−(121)+(123)−(135)+(136).
38. 0=+0.12−(112)+(113)−(131)+(133)−(134)+(135).
39. 0=+0.21−(121)+(122)−(132)+(133)−(134)+(136).
40. 0=+1.31−(114)+(116)−(128)+(129)−(140)+(141).
41. 0=+0.29−(115)+(116)−(128)+(130)−(142)+(143).
42. 0=−0.76−(129)+(130)−(139)+(140)−(142)+(144).
43. 0=+0.11−(137)+(139)−(144)+(145)−(150)+(151).
44. 0=+0.27−(138)+(139)−(144)+(146)−(152)+(153).
45. 0=−0.74−(145)+(146)−(149)+(150)−(152)+(154).
46. 0=+0.78−(147)+(149)−(154)+(155)−(161)+(162).
47. 0=+1.33−(148)+(149)−(154)+(156)−(157)+(158).
48. 0=+1.10−(155)+(156)−(157)+(159)−(160)+(161).
68. 0=+0.37−(133)+(134)+(164)−(166)−(167)+(168).
69. 0=−0.64−(133)+(134)+(163)−(165)−(171)+(172).
70. 0=+0.29−(163)+(164)−(167)+(169)−(170)+(171).
49. 0=−3.55+2.19(1)−3.98(2)+1.79(3)+0.25(4)−4.20(5)+3.95(6)+3.28(14)−4.84(15)
+1.56(16).
50. 0=+2.32−0.26(9)−2.56(10)+2.82(11)+3.56(12)−5.97(13)+2.41(14)+2.09(24)−1.57(25)
−0.52(26).
51. 0=+0.72+2.70(19)−3.54(20)+0.84(21)+1.43(27)−3.00(28)+1.57(29)+1.03(34)−3.55(35)
+2.52(36).
52. 0=+0.08+0.16(29)−3.03(30)+2.87(31)+2.38(32)−4.47(33)+2.09(34)+2.40(44)−2.79(45)
+0.39(46).
53. 0=+0.49+3.16(42)−4.55(43)+1.39(44)+0.45(39)−3.91(40)+3.46(41)+1.86(54)−1.99(55)
+0.13(56).
54. 0=−4.01+1.82(49)−2.09(50)+0.27(51)+2.98(57)−4.69(58)+1.71(59)+0.04(64)−3.35(65)
+3.31(66).
55. 0=+3.64+1.16(59)−4.23(60)+3.07(61)+3.13(62)−4.82(63)+1.69(64)+3.25(67)−4.47(68)
+1.22(69)+1.61(74)−4.79(75)+3.18(76).
56. 0= 0.00+2.18(69)−2.23(70)+0.05(71)+2.89(77)−4.79(78)+1.90(79)+0.24(84)−3.27(85)
+3.03(86).
57. 0=−3.94+2.40(79)−5.45(80)+3.05(81)+2.24(82)−3.75(83)+1.51(84)+1.79(87)−3.44(88)
+1.65(89)+2.19(94)−4.61(95)+2.42(96).
58. 0=−1.43+0.02(89)−3.80(90)+3.78(91)+4.34(92)−5.97(93)+1.63(94)+1.63(104)−1.23(105)
−0.40(106).
59. 0=−2.35+1.46(99)−1.38(100)−0.08(101)+3.32(107)−4.20(108)+0.88(109)+0.66(118)−4.02(119)
+3.36(120)
60. 0=+1.78+2.44(109)−2.88(110)+0.44(111)+2.06(123)−4.37(124)+2.31(125)−2.52(127)+2.52(128).
61. 0=+2.06+3.87(111)−5.89(112)+2.02(113)+3.42(121)−3.08(122)−0.34(123)+1.23(131)−6.07(132)
+4.84(133).
62. 0=+5.13+0.17(114)−2.13(115)+1.96(116)+2.50(139)−5.61(140)+3.11(141)+3.26(142)−2.82(143)
−0.44(144).
63. 0=+1.03+1.80(137)−4.15(138)+2.35(139)+0.11(144)−2.39(145)+2.28(146)+2.59(149)−3.06(150)
+0.47(151).
64. 0=+2.08+2.70(147)−3.69(148)+0.99(149)+2.14(154)−5.32(155)+3.18(156)+2.78(157)−4.34(158)
+1.56(159)+1.42(160)−4.70(161)+3.28(162).
71. 0=+1.30−2.20(133)−0.03(134)+8.30(163)−6.10(164)−8.21(165)+8.24(166)−0.67(167)+3.64(168)
−2.97(169)

No.

65. 0=+9.71−2.19(1)+2.19(2)−0.25(4)+0.25(6)+1.96(7)−1.96(8)−2.56(10)+2.56(11)
−0.70(12)+2.26(14)−1.56(16)+0.10(17)−0.94(19)+0.84(21)−1.09(22)+1.09(23)
+1.72(25)−1.72(26)+1.43(27)−1.43(28)−0.16(29)+0.16(31)−2.38(32)+2.38(33)
+1.03(34)−1.03(36)+1.81(37)−1.81(38)−0.45(39)+0.45(41)−3.16(42)+3.16(43)
+0.39(44)−0.39(46)+2.09(47)−2.09(48)−0.27(49)+0.27(51)−2.47(52)+2.47(53)
+0.13(54)−0.13(56)+2.98(57)−2.98(58)−3.07(60)+3.07(61)−0.17(62)+0.21(64)
−0.04(66)−0.11(67)+0.06(69)+0.05(71)−1.86(72)+1.86(73)+3.18(75)−3.18(76)
+2.89(77)−2.89(78)−0.53(79)+0.53(81)−2.24(82)+2.24(83)+0.24(84)−0.24(86)
+1.79(87)−1.79(88)−3.80(90)+3.80(91)−0.44(92)+0.63(94)−0.19(96)−0.05(97)
+0.13(99)−0.08(101)−2.51(102)+2.51(103)+2.41(105)−2.41(106)+3.32(107)−3.32(108)
−0.44(109)+0.44(111)−2.44(114)+2.44(115)+0.66(118)−0.66(120)+2.06(123)−4.37(124)
+2.31(125)+0.32(128)−0.32(130)−1.80(137)+1.80(138)+0.59(139)−0.59(141)+2.82(142)
−2.82(143)−0.11(144)+0.11(146)−2.70(147)+2.70(148)+0.47(149)−0.47(151)+1.70(152)
−1.70(153)−0.45(154)+0.45(156)+2.78(157)−2.78(158)+0.05(160)−0.05(162).

72. 0=−5.17−0.44(109)+0.44(111)−2.44(114)+2.44(115)+2.02(112)−2.02(113)+1.40(117)−1.40(118)
−0.34(121)+0.34(123)−2.31(124)+2.31(125)+0.32(128)−0.32(130)−1.23(131)+1.23(133)
−0.03(134)−1.63(135)+1.63(136)−1.80(137)+1.80(138)+0.59(139)−0.59(141)+2.82(142)
−2.82(143)−0.11(144)+0.11(146)−2.70(147)+2.70(148)+0.47(149)−0.47(151)+1.70(152)
−1.70(153)−0.45(154)+0.45(156)+2.78(157)−2.78(158)+0.05(160)−0.05(162)+6.10(163)
−6.10(164)+0.03(165)−0.67(167)+0.67(169)−1.96(171)+1.96(172).

66. 0=+0.82−(4)+(6)−(7)+(11)−(17)+(21)−(27)+(31)−(37)+(41)−(47)+(51)−(57)+(61)−(67)
+(71)−(77)+(81)−(87)+(91)−(97)+(101)−(107)+(111)−(123)+(125)−(126)+(130)−(142)
+(146)−(152)+(156)−(157)+(159).

67. 0=+1.84+(121)−(125)+(126)−(130)+(134)−(136)+(142)−(146)+(152)−(156)+(157)−(159).

COMPUTED CORRECTIONS TO OBSERVED DIRECTIONS.

The corrections to observed directions resulting from the figure adjustments indicated by the preceding condition equations are as follows:

Table of corrections to observed directions.

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	+0.478	44	−0.027	87	−0.148	130	+0.260
2	−0.278	45	−0.272	88	−0.058	131	+0.290
3	−0.200	46	+0.301	89	+0.373	132	+0.231
4	+0.510	47	−0.023	90	−0.054	133	−0.459
5	−0.181	48	+0.108	91	−0.113	134	−0.496
6	−0.330	49	−0.104	92	+0.144	135	+0.489
7	+0.412	50	−0.040	93	−0.235	136	+0.055
8	+0.024	51	+0.059	94	−0.185	137	+0.149
9	−0.173	52	−0.064	95	−0.037	138	+0.312
10	+0.189	53	−0.312	96	+0.313	139	−0.082
11	−0.452	54	+0.231	97	+0.122	140	+0.178
12	+0.067	55	+0.062	98	−0.192	141	−0.558
13	+0.162	56	+0.083	99	+0.343	142	−0.358
14	+0.124	57	+0.012	100	+0.034	143	−0.097
15	−0.361	58	−0.083	101	−0.306	144	+0.022
16	+0.008	59	+0.202	102	+0.460	145	+0.123
17	+0.153	60	−0.097	103	−0.461	146	+0.310
18	+0.080	61	−0.035	104	−0.127	147	+0.252
19	+0.016	62	−0.059	105	−0.209	148	+0.450
20	−0.068	63	+0.117	106	+0.337	149	−0.300
21	−0.180	64	−0.141	107	+0.321	150	−0.210
22	+0.078	65	−0.459	108	+0.206	151	−0.191
23	−0.031	66	+0.542	109	−0.184	152	−0.211
24	−0.062	67	−0.358	110	+0.603	153	−0.375
25	+0.037	68	+0.157	111	+0.081	154	+0.252
26	−0.022	69	+0.127	112	−0.335	155	+0.417
27	−0.002	70	−0.033	113	−0.691	156	−0.083
28	+0.085	71	+0.107	114	+0.267	157	+0.022
29	−0.195	72	+0.160	115	+0.364	158	−0.221
30	+0.304	73	−0.545	116	−0.285	159	+0.198
31	−0.192	74	−0.078	117	+0.009	160	+0.647
32	−0.123	75	+0.356	118	+0.070	161	−0.127
33	−0.158	76	+0.107	119	−0.435	162	−0.520
34	+0.096	77	−0.127	120	+0.010	163	+0.260
35	+0.141	78	+0.316	121	+0.014	164	−0.323
36	+0.044	79	−0.057	122	−0.056	165	+0.232
37	+0.039	80	−0.261	123	−0.264	166	−0.280
38	+0.142	81	+0.130	124	+0.239	167	−0.038
39	−0.031	82	−0.006	125	+0.066	168	−0.327
40	+0.095	83	−0.186	126	−0.007	169	+0.365
41	−0.246	84	+0.328	127	−0.552	170	−0.143
42	+0.059	85	−0.312	128	+0.163	171	−0.252
43	−0.061	86	+0.176	129	+0.140	172	+0.396

The maximum correction to a direction is 0″.69.

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 and c is the number of conditions.

The probable error of an observed direction resulting from the figure adjustment for this arc of primary triangulation is ± 0″.27.

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. There are shown the corrections to the angles resulting from the figure adjustment, the errors of closure of the triangles, the corrected spherical angles, and the spherical excess for each triangle. 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.

Table of triangles.

Station.	Correction to angles from figure adjustment.	Error of closure of triangle.	Corrected spherical angles.	Spherical excess.
	″	″	° ′ ″	″
King	−0.39	−1.15	47 07 55.00	0.54
Alice west base	−0.84		83 14 22.50	
Wood	+0.08		49 37 43.04	
Bishop	−0.49	−1.22	23 30 00.59	0.49
King	−0.55		129 52 54.94	
Alice west base	−0.15		26 37 04.96	
Bishop	−0.12	−1.07	53 26 01.04	0.83
King	−0.19		82 44 59.94	
Wood	−0.76		43 48 59.85	
Bishop	+0.37	−1.00	29 56 00.45	0.88
Alice west base	−0.69		56 37 17.54	
Wood	−0.68		93 26 42.89	
Ricardo	−0.07	−0.39	41 55 02.31	0.70
King	−0.28		96 58 08.14	
Bishop	−0.04		41 06 50.25	
Kleberg *ecc.*	+0.10	−0.68	53 16 01.12	0.55
Ricardo	−0.14		87 17 31.42	
King	−0.64		39 26 28.01	
Kleberg *ecc.*	+0.04	+0.07	103 59 32.68	0.60
Ricardo	−0.07		45 22 29.11	
Bishop	+0.10		30 37 58.81	
Kleberg *ecc.*	−0.06	+0.36	50 43 31.56	0.75
King	+0.36		57 31 40.13	
Bishop	+0.06		71 44 49.06	
Riviera	+0.08	−0.14	55 47 01.74	0.41
Ricardo	−0.19		68 16 01.13	
Kleberg *ecc.*	−0.03		55 56 57.54	
Robbins	+0.05	−0.26	33 20 21.97	0.46
Riviera	−0.20		109 09 55.24	
Ricardo	−0.11		37 29 43.25	
Robbins	−0.05	−0.44	64 00 20.13	0.44
Riviera	−0.28		53 22 53.50	
Kleberg *ecc.*	−0.11		62 36 46.81	
Robbins	−0.10	−0.32	30 39 58.16	0.39
Ricardo	−0.08		30 46 17.88	
Kleberg *ecc.*	−0.14		118 33 44.35	
Roza	+0.10	+0.36	49 15 58.04	0.51
Riviera	+0.01		85 32 01.53	
Robbins	+0.25		45 12 00.94	

Table of triangles—Continued.

Station.	Correction to angles from figure adjustment.	Error of closure of triangle.	Corrected spherical angles.	Spherical excess.
	″	″	° ′ ″	″
Sarita	−0.24	−0.81	37 00 23.68	0.43
Roza	−0.07		108 14 00.09	
Riviera	−0.50		34 45 36.66	
Sarita	+0.33	+0.12	79 30 38.79	0.54
Roza	−0.17		58 58 02.05	
Robbins	−0.04		41 31 19.70	
Sarita	+0.57	+1.29	42 30 15.11	0.62
Riviera	+0.51		50 46 24.87	
Robbins	+0.21		86 43 20.64	
Turcotte	+0.13	−0.05	45 17 23.84	0.49
Roza	−0.21		78 03 44.19	
Sarita	+0.03		56 38 52.46	
Kenedy	−0.17	−0.59	46 42 23.73	0.37
Turcotte	−0.08		104 59 36.72	
Roza	−0.34		28 17 59.92	
Kenedy	−0.15	−0.48	86 34 40.42	0.39
Turcotte	−0.21		59 42 12.88	
Sarita	−0.12		33 43 07.09	
Kenedy	+0.02	+0.06	39 52 16.69	0.51
Roza	+0.13		49 45 44.27	
Sarita	−0.09		90 21 59.55	
Katherine	−0.09	+0.61	35 13 14.22	0.38
Turcotte	+0.16		82 33 58.44	
Kenedy	+0.54		62 12 47.72	
Armstrong	−0.32	−0.03	56 34 25.12	0.43
Katherine	+0.19		86 03 31.76	
Turcotte	+0.10		37 22 03.55	
Armstrong	+0.68	+0.72	88 43 19.68	0.37
Katherine	+0.28		50 50 17.54	
Kenedy	−0.24		40 26 23.15	
Armstrong	+1.00	+1.36	32 08 54.56	0.32
Turcotte	+0.06		45 11 54.89	
Kenedy	+0.30		102 39 10.87	
Vinson	+0.52	+0.02	32 58 05.01	0.44
Katherine	−0.24		95 40 41.66	
Armstrong	−0.26		51 21 13.77	
Norias	+0.43	+0.98	52 35 18.84	0.45
Vinson	+0.49		92 56 23.26	
Katherine	+0.06		34 28 18.35	
Norias	+0.18	+0.33	86 06 39.82	0.50
Vinson	−0.03		59 58 18.25	
Armstrong	+0.18		33 55 02.43	
Norias	−0.25	−0.63	33 31 20.98	0.49
Katherine	−0.30		61 12 23.31	
Armstrong	−0.08		85 16 16.20	
Stillman	+0.44	+0.89	36 04 48.20	0.45
Vinson	−0.02		88 43 46.09	
Norias	+0.47		55 11 26.16	
Yturria	−0.64	−0.43	50 40 15.95	0.58
Stillman	+0.07		83 59 54.27	
Vinson	+0.14		45 19 50.36	
Yturria	−0.15	−1.23	83 28 34.27	0.53
Stillman	−0.37		47 55 06.07	
Norias	−0.71		48 36 20.19	
Yturria	+0.49	+0.09	32 48 18.32	0.40
Vinson	−0.16		43 23 55.73	
Norias	−0.24		103 47 46.35	
Brenner	+0.09	+0.79	49 40 20.44	0.55
Stillman	+0.19		75 54 09.87	
Yturria	+0.51		54 25 30.24	
Raymond	+0.15	+1.06	43 51 16.70	0.49
Brenner	+0.52		101 31 43.06	
Stillman	+0.39		34 37 00.73	
Raymond	+0.50	+0.75	84 54 54.51	0.47
Brenner	+0.43		51 51 22.62	
Yturria	−0.18		43 13 43.34	
Raymond	+0.35	+0.48	41 03 37.81	0.53
Stillman	−0.20		41 17 09.14	
Yturria	+0.33		97 39 13.58	
Hidalgo	−0.32	−0.75	38 01 49.18	0.53
Brenner	−0.48		89 36 57.91	
Raymond	+0.05		52 21 13.44	
Sebastian	−0.09	+0.08	59 42 54.82	0.38
Hidalgo	+0.22		91 16 22.88	
Brenner	−0.05		29 00 42.68	
Sebastian	+0.46	+0.62	100 51 39.31	0.38
Hidalgo	+0.54		53 14 33.70	
Raymond	−0.38		25 53 47.37	
Sebastian	+0.55	−0.21	41 08 44.49	0.53
Brenner	−0.43		60 36 15.23	
Raymond	−0.33		78 15 00.81	
Mercedes	−0.12	−0.43	32 23 40.42	0.33
Hidalgo	−0.65		92 09 18.61	
Sebastian	+0.34		55 27 01.30	
Harlingen	−0.50	−1.35	44 54 58.84	0.41
Mercedes	−0.51		99 47 08.04	
Hidalgo	−0.34		35 17 53.53	
Harlingen	−0.06	−1.37	72 33 21.60	0.46
Mercedes	−0.39		67 23 27.62	
Sebastian	−0.92		40 03 11.24	
Harlingen	+0.44	−0.45	27 38 22.76	0.38
Hidalgo	−0.31		56 51 25.08	
Sebastian	−0.58		95 30 12.54	
Maria	+0.50	+0.83	45 37 44.86	0.38
Mercedes	+0.27		77 59 44.28	
Harlingen	+0.06		56 22 31.24	
Mitla	−0.55	−0.74	50 12 25.82	0.40
Maria	+0.33		87 59 12.91	
Mercedes	−0.52		41 48 21.67	
Mitla	+0.17	+0.29	90 01 59.20	0.32
Maria	−0.17		42 21 28.05	
Harlingen	+0.29		47 36 33.07	
Mitla	+0.72	+1.86	39 49 33.38	0.30
Mercedes	+0.79		36 11 22.61	
Harlingen	+0.35		103 59 04.31	
Benito	+0.26	−0.29	36 45 11.86	0.33
Mitla	+0.10		98 37 54.39	
Harlingen	−0.65		44 36 54.08	

Table of triangles—Continued.

Station.	Correction to angles from figure adjustment.	Error of closure of triangle.	Corrected spherical angles.	Spherical excess.
	″	″	° ′ ″	″
Cowgill	+0.26	+0.76	40 09 55.41	0.37
Benito	+0.38		101 48 31.36	
Mitla	+0.12		38 01 33.60	
Cowgill	−0.48	−0.26	74 11 27.77	0.48
Benito	+0.12		65 03 19.50	
Harlingen	+0.10		40 45 13.21	
Cowgill	−0.74	−1.31	34 01 32.36	0.44
Mitla	−0.02		60 36 20.79	
Harlingen	−0.55		85 22 07.29	
Olmito	−0.17	−0.27	51 02 35.24	0.31
Benito	+0.29		87 03 38.86	
Cowgill	−0.39		41 53 46.21	
Resaca	+0.09	+0.74	34 30 22.00	0.30
Olmito	+0.46		104 09 43.62	
Benito	+0.19		41 19 54.68	
Resaca	+0.11	+0.90	77 21 38.65	0.37
Olmito	+0.63		53 07 08.38	
Cowgill	+0.16		49 31 13.34	
Resaca	+0.02	−0.11	42 51 16.65	0.38
Benito	+0.10		45 43 44.18	
Cowgill	−0.23		91 24 59.55	
Arista	−0.24	−1.53	37 07 23.46	0.53
Olmito	−0.34		78 04 42.72	
Resaca	−0.75		64 47 54.35	
Point Isabel west base	−0.78	−1.10	56 00 16.31	0.54
Arista	+0.18		90 32 00.25	
Olmito	−0.50		33 27 43.98	
Point Isabel west base	−1.17	−0.55	88 38 56.49	0.47
Arista	+0.42		53 24 36.79	
Resaca	+0.20		37 56 27.19	
Point Isabel west base	−0.39	−0.78	32 38 40.18	0.46
Olmito	+0.16		44 36 58.74	
Resaca	−0.55		102 44 21.54	
Donna	−0.06	−1.04	40 36 15.22	0.61
Mercedes	−0.77		74 43 10.01	
Maria	−0.21		64 40 35.38	
Rio	+0.99	−0.12	74 06 18.19	0.57
Donna	−0.75		59 43 28.25	
Mercedes	−0.36		46 10 14.13	
Rio	+0.55	−0.21	126 27 18.65	0.23
Donna	−0.69		19 07 13.03	
Maria	−0.07		34 25 28.55	
Rio	−0.44	−1.13	52 21 00.46	0.27
Mercedes	−0.41		28 32 55.88	
Maria	−0.28		99 06 03.93	
Tenacitas	+0.65	+0.64	47 03 54.27	0.17
Donna	+0.72		43 46 32.11	
Rio	−0.73		89 09 34.09	
Colombres	−0.29	−0.37	42 21 15.14	0.63
Donna	+0.14		62 49 16.30	
Rio	−0.22		74 49 29.10	
Colombres	+0.40	−0.29	72 22 32.[illegible]	0.31
Donna	−0.58		19 02 44.[illegible]	
Tenacitas	−0.11		88 34 43.[illegible]	
Colombres	+0.69	+0.72	30 01 17.[illegible]	0.15
Rio	−0.51		14 20 04.[illegible]	
Tenacitas	+0.54		135 38 37.[illegible]	

The maximum correction 1″.17 to any angle is to the one at Point Isabel west base, between the lines to Arista and Resaca.

The statistics as to closures of triangles and the mean error of an angle for the arc of primary triangulation along the ninety-eighth meridian in the United States and Mexico are given in the following table. 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 is the number of triangles in the season's work.

Statistics showing accuracy of triangulation.

Total number of triangles	68
Number of triangles with plus closures	28
Number of triangles with minus closures	40
Average closure of a triangle	0″.63
Maximum closure of a triangle	1″.86
Mean error of an angle	±0″.44
Probable error of an observed direction	±0″.27

The average closing error of a triangle for the 68 triangles of this arc of primary triangulation is 0″.63. This mean closing error indicates that the methods employed and the number of observations made will give the accuracy called for by the general instructions, viz, 1″.00 on the average. The instructions also state that the closing error shall seldom exceed 3″.00. The maximum closing error of any triangle of this arc of primary triangulation is 1″.86.

Of seven definite arcs of primary triangulation in the United States, the ninety-eighth meridian in the United States and Mexico stands first in accuracy, using the average closing error of a triangle as the standard.

The comparison of the average closing errors is given below:

	Average closing error.
Ninety-eighth meridian in United States and Mexico	0″.63
Texas–California	.90
Ninety-eighth meridian	.92
One hundred and fourth meridian	.99
Transcontinental triangulation	1.06
Eastern oblique arc	1.19
California–Washington	1.22

ACCURACY OF THE TRIANGULATION AS COMPARED WITH OTHER PRIMARY TRIANGULATION IN THE UNITED STATES.

The most severe, and therefore the best, test of accuracy is believed by the writer to be the quantity d, expressing the probable error of the observed direction as derived from the corrections to directions resulting from the figure adjustment before the introduction of equations necessary to hold fixed the positions of previously adjusted triangulation.

On pages 79–80, Special Publication No. 19, there appears a table in which 66 sections of triangulation in the United States have been arranged in order of accuracy—that is, in order of the values of d—the most accurate being placed first. The triangulation considered in this publication would appear between Nos. 8 and 9 in such a table.

ADJUSTMENT OF THE TERTIARY TRIANGULATION.

In adjusting the tertiary triangulation along the coast of Texas between Corpus Christi and Point Isabel, the length and azimuth of the line Mustang–Laguna Madre south base and the geographic coordinates at its ends were held fixed. These were determined by the adjustment made of the triangulation which extends from the Seguin base net to Corpus Christi, Tex.[1]

[1] See Appendix 5 of the Report of the Coast and Geodetic Survey, 1911.

Starting from the above-mentioned line, the triangulation as far south as the line Salt–Murdock was adjusted by figures of two or three quadrilaterals at a time. From the line Salt–Murdock to Point Isabel the work was adjusted as a whole. In this adjustment the azimuth and length of the line Salt–Murdock and the geographic coordinates of the stations at its ends, as determined from the quadrilateral adjustment, were held fixed. The length and azimuth of the line Fox–Cameron, as determined from the Point Isabel base and the Laplace station at Fronton, were also held fixed,[1] but the older geographic coordinates of Fox and Cameron were not held fixed, but were given the new values determined by the primary triangulation carried southward from the Alice base net.

So that while the length and azimuth of the line Fox–Cameron appearing in this report will be consistent with those in Appendix 5, Report of the Coast and Geodetic Survey for 1911, the geographic positions of the two stations will differ somewhat in the two publications, the values appearing in this report superseding those in the earlier report.

Some of the old stations in Laguna Madre from Corpus Christi to Point Isabel, the geographic positions of which appeared in the above-mentioned publication, were recovered during the surveys of 1912 and 1913. The geographic coordinates of these points and the lengths and azimuths connecting the points were redetermined and made consistent with the newer work.

For those old stations which were not recovered in 1912–13, the latitudes and longitudes only appear in this report. These positions were made to fit into the new work, and therefore differ from those appearing in Appendix 5, Report of the Coast and Geodetic Survey for 1911. The new positions were determined by applying to the old positions corrections which were determined by distributing according to length the discrepancy which occurred in the positions from Laguna Madre to Point Isabel on account of the new triangulation.

In all cases the positions appearing in this report should supersede those appearing in the earlier report.

THE NORTH AMERICAN DATUM.

Early in the year 1913 the Superintendent of the United States Coast and Geodetic Survey was notified by the director of the Comisión Geodésica Mexicana and by the chief astronomer of the Dominion of Canada Astronomical Observatory that the so-called United States standard datum had been adopted as the datum for the triangulation of those organizations. They also reported that the Clarke spheroid of 1866, now used in the United States, would be used by them.

[1] See Appendix 5, Report of the Coast and Geodetic Survey, 1911.

Owing to the international character of the datum now adopted by the three countries, the Superintendent of the United States Coast and Geodetic Survey has changed its designation from the "United States standard datum" to the "North American datum."

EXPLANATION OF THE NORTH AMERICAN DATUM.

The lengths, as already fully explained in connection with the adjustments, all depend upon the Alice, Colombres, and Point Isabel 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 accuracy ordinarily needed by adding to the sea level length as given a correction = (length of line as given) times

$$\left[\frac{\text{mean elevation of the two ends of the line in meters}}{6370000}\right].$$

The maximum value of this correction does not exceed $\frac{1}{138500}$ for the length of any portion of the triangulation here published. The maximim error made in the use of the above approximate formula for the correction does not exceed $\frac{1}{38000000}$ for the length of any portion of this triangulation.

The positions—that is, the latitudes, longitudes, and azimuths—need special explanation.

All of the positions and azimuths have been computed upon the Clarke spheroid of 1866, as expressed in meters, 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 expanded until they touched or overlapped.

The transcontinental triangulation, of which the office computation was completed in 1899, joined all of the detached portions mentioned and made them one continuous triangulation. As soon as this took place the logical necessity existed for discarding the old geodetic data used in these various pieces and substituting one for the whole country, or at least for as much of the country as is covered by continuous triangulation. To do this was 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 was known from that time until 1913 as the United States standard datum, but is now known as the North American datum (see above), 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.

As the adoption of such a standard datum was 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. 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 survey 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 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 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 (now the North American) 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 standard, of that datum which had been in use for many years in the northeastern group of States and along the Atlantic coast as far south 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.[1]

The North American 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

Points are then said to be upon the North American datum when they are connected with the station Meades Ranch by a continuous triangulation, through which the corresponding latitudes, longitudes, and azimuths have been computed on the Clarke spheroid of 1866, as expressed in meters, starting from the above data.

The principal lists of geographic positions published on the adopted datum throughout the whole United States are contained in the following publications of the Coast and Geodetic Survey and of other organizations:

Appendix 8 of the Report for 1885, positions in Massachusetts and Rhode Island.
Appendix 8 of the Report for 1888, positions in Connecticut.
Appendix 8 of the Report for 1893, positions in Pennsylvania, Delaware, and Maryland.
Appendix 10 of the Report for 1894, positions in Massachusetts.
Appendix 6 of the Report for 1901, positions in Kansas and Nebraska.
Appendix 3 of the Report for 1902, positions in Kansas, Missouri, Nebraska, and Colorado.
Appendix 4 of the Report for 1903, positions in Kansas, Oklahoma, and Texas.
Appendix 9 of the Report for 1904, positions in California.
Appendix 5 of the Report for 1905, positions in Texas.
Appendix 3 of the Report for 1907, positions in California.
Appendix 5 of the Report for 1910, positions in California.
Appendix 4 of the Report for 1911, positions in Nebraska, Minnesota, North Dakota, and South Dakota.
Appendix 5 of the Report for 1911, positions in Texas.
Appendix 6 of the Report for 1911, positions in Florida.
Special Publication No. 11, positions in Texas, New Mexico, Arizona, and California.
Special Publication No. 13, positions in California, Oregon, and Washington.
Special Publication No. 16, positions in Florida.
Special Publication No. 17, positions in Texas.
Special Publication No. 19, positions in Colorado, Utah, Nevada, Wyoming, Montana, South Dakota, and North Dakota.
Special Publication No. 24, positions in Alabama and Mississippi.
Special Publication No. 30, positions in West Virginia, Ohio, Kentucky, Indiana, Illinois, and Missouri.
Special Publication No. 31, positions in Oregon, Washington, and California.
Special Publication No. 43, positions in Georgia.
Special Publication No. 46, positions in Maine.

[1] This is further borne out in the reduction of 765 astronomic stations in connection with the "Supplementary investigation in 1909 of the figure of the earth and isostasy," by J. F. Hayford, published by the Coast and Geodetic Survey.

Special Publication No. 54, positions in Texas.
Appendix EEE, pages 2905–3031, Annual Report of the Chief of Engineers, 1902, positions of points on and near the Great Lakes.
Publications of the Massachusetts Harbor and Land Commission.
Report on the Triangulation of Greater New York.
Report on a Plan of Sewerage for the City of Cincinnati.
Various bulletins of the United States Geological Survey.

EXPLANATION OF TABLES OF POSITIONS.

In the tables of positions the latitude and longitude of each point are given on the North American datum (see p. 30), also the length and azimuth of each line observed over, whether in one or both ways. Along with the latitude and longitude of each point the lengths and azimuths are given of lines from that point to other points of the triangulation. No lengths or azimuths are repeated, and for a given line the length and azimuth will be found opposite the position of one or the other of the two stations involved.

For the convenience of the draftsman a column of "seconds in meters" is given, in which is placed the length (in meters) of each small arc of a meridian or parallel corresponding to the seconds of the given latitude or longitude. To facilitate further the use of the tables, a column is given of the logarithms of the lengths. It must be remembered that it is the logarithm which is derived first from the computation, the lengths given in this table being then derived from the corresponding logarithms.

The rule followed in recent publications of this office has been to give latitudes and longitudes to thousandths of seconds for all points the positions of which are fixed by fully adjusted triangulation. Points the positions of which are given to hundredths of seconds only are marked by footnotes as being without check (observed from only two stations) or checked by verticals only.

In the columns giving azimuths, distances, and logarithms of distances the accuracy is indicated to a certain extent by the number of decimal places given, it being understood that in each case two doubtful figures are given. In some cases there is very little doubt of the correctness of the second figure from the right, while in a few cases some doubt may be cast on the third figure from the right.

These tables may be conveniently consulted by using as finders the sketches and the index at the end of this publication. In the third column of the index will be found for each point a reference to the page on which its description is given, in the fourth column the page on which its elevation above sea level is shown, and in the fifth column the number of the sketch on which it appears.

The tables following are inserted for the convenience of those who may wish to convert the distances or elevations given in this publication from meters to feet or from feet to meters.

CONVERSION TABLES.

Lengths—Feet to meters (from 1 to 1000 units).

[Reduction factor: 1 foot=0.3048006096 meter.]

Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.
0	0.0	50	15.24003	100	30.48006	150	45.72009	200	60.96012
1	0.30480	1	15.54483	1	30.78486	1	46.02489	1	61.26492
2	0.60960	2	15.84963	2	31.08966	2	46.32969	2	61.56972
3	0.91440	3	16.15443	3	31.39446	3	46.63449	3	61.87452
4	1.21920	4	16.45923	4	31.69926	4	46.93929	4	62.17932
5	1.52400	5	16.76403	5	32.00406	5	47.24409	5	62.48412
6	1.82880	6	17.06883	6	32.30886	6	47.54890	6	62.78893
7	2.13360	7	17.37363	7	32.61367	7	47.85370	7	63.09373
8	2.43840	8	17.67844	8	32.91847	8	48.15850	8	63.39853
9	2.74321	9	17.98324	9	33.22327	9	48.46330	9	63.70333
10	3.04801	60	18.28804	110	33.52807	160	48.76810	210	64.00813
1	3.35281	1	18.59284	1	33.83287	1	49.07290	1	64.31293
2	3.65761	2	18.89764	2	34.13767	2	49.37770	2	64.61773
3	3.96241	3	19.20244	3	34.44247	3	49.68250	3	64.92253
4	4.26721	4	19.50724	4	34.74727	4	49.98730	4	65.22733
5	4.57201	5	19.81204	5	35.05207	5	50.29210	5	65.53213
6	4.87681	6	20.11684	6	35.35687	6	50.59690	6	65.83693
7	5.18161	7	20.42164	7	35.66167	7	50.90170	7	66.14173
8	5.48641	8	20.72644	8	35.96647	8	51.20650	8	66.44653
9	5.79121	9	21.03124	9	36.27127	9	51.51130	9	66.75133
20	6.09601	70	21.33604	120	36.57607	170	51.81610	220	67.05613
1	6.40081	1	21.64084	1	36.88087	1	52.12090	1	67.36093
2	6.70561	2	21.94564	2	37.18567	2	52.42570	2	67.66574
3	7.01041	3	22.25044	3	37.49047	3	52.73051	3	67.97054
4	7.31521	4	22.55525	4	37.79528	4	53.03531	4	68.27534
5	7.62002	5	22.86005	5	38.10008	5	53.34011	5	68.58014
6	7.92482	6	23.16485	6	38.40488	6	53.64491	6	68.88494
7	8.22962	7	23.46965	7	38.70968	7	53.94971	7	69.18974
8	8.53442	8	23.77445	8	39.01448	8	54.25451	8	69.49454
9	8.83922	9	24.07925	9	39.31928	9	54.55931	9	69.79934
30	9.14402	80	24.38405	130	39.62408	180	54.86411	230	70.10414
1	9.44882	1	24.68885	1	39.92888	1	55.16891	1	70.40894
2	9.75362	2	24.99365	2	40.23368	2	55.47371	2	70.71374
3	10.05842	3	25.29845	3	40.53848	3	55.77851	3	71.01854
4	10.36322	4	25.60325	4	40.84328	4	56.08331	4	71.32334
5	10.66802	5	25.90805	5	41.14808	5	56.38811	5	71.62814
6	10.97282	6	26.21285	6	41.45288	6	56.69291	6	71.93294
7	11.27762	7	26.51765	7	41.75768	7	56.99771	7	72.23774
8	11.58242	8	26.82245	8	42.06248	8	57.30251	8	72.54255
9	11.88722	9	27.12725	9	42.36728	9	57.60732	9	72.84735
40	12.19202	90	27.43205	140	42.67209	190	57.91212	240	73.15215
1	12.49682	1	27.73686	1	42.97689	1	58.21692	1	73.45695
2	12.80163	2	28.04166	2	43.28169	2	58.52172	2	73.76175
3	13.10643	3	28.34646	3	43.58649	3	58.82652	3	74.06655
4	13.41123	4	28.65126	4	43.89129	4	59.13132	4	74.37135
5	13.71603	5	28.95606	5	44.19609	5	59.43612	5	74.67615
6	14.02083	6	29.26086	6	44.50089	6	59.74092	6	74.98095
7	14.32563	7	29.56566	7	44.80569	7	60.04572	7	75.28575
8	14.63043	8	29.87046	8	45.11049	8	60.35052	8	75.59055
9	14.93523	9	30.17526	9	45.41529	9	60.65532	9	75.89535

Lengths—Feet to meters (from 1 to 1000 units)—Continued.

Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.
250	76.20015	300	91.44018	350	106.68021	400	121.92024	450	137.16027
1	76.50495	1	91.74498	1	106.98501	1	122.22504	1	137.46507
2	76.80975	2	92.04978	2	107.28981	2	122.52985	2	137.76988
3	77.11455	3	92.35458	3	107.59462	3	122.83465	3	138.07468
4	77.41935	4	92.65939	4	107.89942	4	123.13945	4	138.37948
5	77.72416	5	92.96419	5	108.20422	5	123.44425	5	138.68428
6	78.02896	6	93.26899	6	108.50902	6	123.74905	6	138.98908
7	78.33376	7	93.57379	7	108.81382	7	124.05385	7	139.29388
8	78.63856	8	93.87859	8	109.11862	8	124.35865	8	139.59868
9	78.94336	9	94.18339	9	109.42342	9	124.66345	9	139.90348
260	79.24816	310	94.48819	360	109.72822	410	124.96825	460	140.20828
1	79.55296	1	94.79299	1	110.03302	1	125.27305	1	140.51308
2	79.85776	2	95.09779	2	110.33782	2	125.57785	2	140.81788
3	80.16256	3	95.40259	3	110.64262	3	125.88265	3	141.12268
4	80.46736	4	95.70739	4	110.94742	4	126.18745	4	141.42748
5	80.77216	5	96.01219	5	111.25222	5	126.49225	5	141.73228
6	81.07696	6	96.31699	6	111.55702	6	126.79705	6	142.03708
7	81.38176	7	96.62179	7	111.86182	7	127.10185	7	142.34188
8	81.68656	8	96.92659	8	112.16662	8	127.40665	8	142.64669
9	81.99136	9	97.23139	9	112.47142	9	127.71146	9	142.95149
270	82.29616	320	97.53620	370	112.77623	420	128.01626	470	143.25629
1	82.60097	1	97.84100	1	113.08103	1	128.32106	1	143.56109
2	82.90577	2	98.14580	2	113.38583	2	128.62586	2	143.86589
3	83.21057	3	98.45060	3	113.69063	3	128.93066	3	144.17069
4	83.51537	4	98.75540	4	113.99543	4	129.23546	4	144.47549
5	83.82017	5	99.06020	5	114.30023	5	129.54026	5	144.78029
6	84.12497	6	99.36500	6	114.60503	6	129.84506	6	145.08509
7	84.42977	7	99.66980	7	114.90983	7	130.14986	7	145.38989
8	84.73457	8	99.97460	8	115.21463	8	130.45466	8	145.69469
9	85.03937	9	100.27940	9	115.51943	9	130.75946	9	145.99949
280	85.34417	330	100.58420	380	115.82423	430	131.06426	480	146.30429
1	85.64897	1	100.88900	1	116.12903	1	131.36906	1	146.60909
2	85.95377	2	101.19380	2	116.43383	2	131.67386	2	146.91389
3	86.25857	3	101.49860	3	116.73863	3	131.97866	3	147.21869
4	86.56337	4	101.80340	4	117.04343	4	132.28346	4	147.52350
5	86.86817	5	102.10820	5	117.34823	5	132.58827	5	147.82830
6	87.17297	6	102.41300	6	117.65304	6	132.89307	6	148.13310
7	87.47777	7	102.71781	7	117.95784	7	133.19787	7	148.43790
8	87.78258	8	103.02261	8	118.26264	8	133.50267	8	148.74270
9	88.08738	9	103.32741	9	118.56744	9	133.80747	9	149.04750
290	88.39218	340	103.63221	390	118.87224	440	134.11227	490	149.35230
1	88.69698	1	103.93701	1	119.17704	1	134.41707	1	149.65710
2	89.00178	2	104.24181	2	119.48184	2	134.72187	2	149.96190
3	89.30658	3	104.54661	3	119.78664	3	135.02667	3	150.26670
4	89.61138	4	104.85141	4	120.09144	4	135.33147	4	150.57150
5	89.91618	5	105.15621	5	120.39624	5	135.63627	5	150.87630
6	90.22098	6	105.46101	6	120.70104	6	135.94107	6	151.18110
7	90.52578	7	105.76581	7	121.00584	7	136.24587	7	151.48590
8	90.83058	8	106.07061	8	121.31064	8	136.55067	8	151.79070
9	91.13538	9	106.37541	9	121.61544	9	136.85547	9	152.09550

Lengths—Feet to meters (from 1 to 1000 units)—Continued.

Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.
500	152.40030	550	167.64034	600	182.88037	650	198.12040	700	213.36043
1	152.70511	1	167.94514	1	183.18517	1	198.42520	1	213.66523
2	153.00991	2	168.24994	2	183.48997	2	198.73000	2	213.97003
3	153.31471	3	168.55474	3	183.79477	3	199.03480	3	214.27483
4	153.61951	4	168.85954	4	184.09957	4	199.33960	4	214.57963
5	153.92431	5	169.16434	5	184.40437	5	199.64440	5	214.88443
6	154.22911	6	169.46914	6	184.70917	6	199.94920	6	215.18923
7	154.53391	7	169.77394	7	185.01397	7	200.25400	7	215.49403
8	154.83871	8	170.07874	8	185.31877	8	200.55880	8	215.79883
9	155.14351	9	170.38354	9	185.62357	9	200.86360	9	216.10363
510	155.44831	560	170.68834	610	185.92837	660	201.16840	710	216.40843
1	155.75311	1	170.99314	1	186.23317	1	201.47320	1	216.71323
2	156.05791	2	171.29794	2	186.53797	2	201.77800	2	217.01803
3	156.36271	3	171.60274	3	186.84277	3	202.08280	3	217.32283
4	156.66751	4	171.90754	4	187.14757	4	202.38760	4	217.62764
5	156.97231	5	172.21234	5	187.45237	5	202.69241	5	217.93244
6	157.27711	6	172.51715	6	187.75718	6	202.99721	6	218.23724
7	157.58192	7	172.82195	7	188.06198	7	203.30201	7	218.54204
8	157.88672	8	173.12675	8	188.36678	8	203.60681	8	218.84684
9	158.19152	9	173.43155	9	188.67158	9	203.91161	9	219.15164
520	158.49632	570	173.73635	620	188.97638	670	204.21641	720	219.45644
1	158.80112	1	174.04115	1	189.28118	1	204.52121	1	219.76124
2	159.10592	2	174.34595	2	189.58598	2	204.82601	2	220.06604
3	159.41072	3	174.65075	3	189.89078	3	205.13081	3	220.37084
4	159.71552	4	174.95555	4	190.19558	4	205.43561	4	220.67564
5	160.02032	5	175.26035	5	190.50038	5	205.74041	5	220.98044
6	160.32512	6	175.56515	6	190.80518	6	206.04521	6	221.28524
7	160.62992	7	175.86995	7	191.10998	7	206.35001	7	221.59004
8	160.93472	8	176.17475	8	191.41478	8	206.65481	8	221.89484
9	161.23952	9	176.47955	9	191.71958	9	206.95961	9	222.19964
530	161.54432	580	176.78435	630	192.02438	680	207.26441	730	222.50445
1	161.84912	1	177.08915	1	192.32918	1	207.56922	1	222.80925
2	162.15392	2	177.39395	2	192.63399	2	207.87402	2	223.11405
3	162.45872	3	177.69876	3	192.93879	3	208.17882	3	223.41885
4	162.76353	4	178.00356	4	193.24359	4	208.48362	4	223.72365
5	163.06833	5	178.30836	5	193.54839	5	208.78842	5	224.02845
6	163.37313	6	178.61316	6	193.85319	6	209.09322	6	224.33325
7	163.67793	7	178.91796	7	194.15799	7	209.39802	7	224.63805
8	163.98273	8	179.22276	8	194.46279	8	209.70282	8	224.94285
9	164.28753	9	179.52756	9	194.76759	9	210.00762	9	225.24765
540	164.59233	590	179.83236	640	195.07239	690	210.31242	740	225.55245
1	164.89713	1	180.13716	1	195.37719	1	210.61722	1	225.85725
2	165.20193	2	180.44196	2	195.68199	2	210.92202	2	226.16205
3	165.50673	3	180.74676	3	195.98679	3	211.22682	3	226.46685
4	165.81153	4	181.05156	4	196.29159	4	211.53162	4	226.77165
5	166.11633	5	181.35636	5	196.59639	5	211.83642	5	227.07645
6	166.42113	6	181.66116	6	196.90119	6	212.14122	6	227.38125
7	166.72593	7	181.96596	7	197.20599	7	212.44602	7	227.68606
8	167.03073	8	182.27076	8	197.51080	8	212.75083	8	227.99086
9	167.33553	9	182.57557	9	197.81560	9	213.05563	9	228.29566

Lengths—Feet to meters (from 1 to 1000 units)—Continued.

Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.
750	228.60046	800	243.84049	850	259.08052	900	274.32055	950	289.56058
1	228.90526	1	244.14529	1	259.38532	1	274.62535	1	289.86538
2	229.21006	2	244.45009	2	259.69012	2	274.93015	2	290.17018
3	229.51486	3	244.75489	3	259.99492	3	275.23495	3	290.47498
4	229.81966	4	245.05969	4	260.29972	4	275.53975	4	290.77978
5	230.12446	5	245.36449	5	260.60452	5	275.84455	5	291.08458
6	230.42926	6	245.66929	6	260.90932	6	276.14935	6	291.38938
7	230.73406	7	245.97409	7	261.21412	7	276.45415	7	291.69418
8	231.03886	8	246.27889	8	261.51892	8	276.75895	8	291.99898
9	231.34366	9	246.58369	9	261.82372	9	277.06375	9	292.30378
760	231.64846	810	246.88849	860	262.12852	910	277.36855	960	292.60859
1	231.95326	1	247.19329	1	262.43332	1	277.67336	1	292.91339
2	232.25806	2	247.49809	2	262.73813	2	277.97816	2	293.21819
3	232.56287	3	247.80290	3	263.04293	3	278.28296	3	293.52299
4	232.86767	4	248.10770	4	263.34773	4	278.58776	4	293.82779
5	233.17247	5	248.41250	5	263.65253	5	278.89256	5	294.13259
6	233.47727	6	248.71730	6	263.95733	6	279.19736	6	294.43739
7	233.78207	7	249.02210	7	264.26213	7	279.50216	7	294.74219
8	234.08687	8	249.32690	8	264.56693	8	279.80696	8	295.04699
9	234.39167	9	249.63170	9	264.87173	9	280.11176	9	295.35179
770	234.69647	820	249.93650	870	265.17653	920	280.41656	970	295.65659
1	235.00127	1	250.24130	1	265.48133	1	280.72136	1	295.96139
2	235.30607	2	250.54610	2	265.78613	2	281.02616	2	296.26619
3	235.61087	3	250.85090	3	266.09093	3	281.33096	3	296.57099
4	235.91567	4	251.15570	4	266.39573	4	281.63576	4	296.87579
5	236.22047	5	251.46050	5	266.70053	5	281.94056	5	297.18059
6	236.52527	6	251.76530	6	267.00533	6	282.24536	6	297.48539
7	236.83007	7	252.07010	7	267.31013	7	282.55017	7	297.79020
8	237.13487	8	252.37490	8	267.61494	8	282.85497	8	298.09500
9	237.43967	9	252.67971	9	267.91974	9	283.15977	9	298.39980
780	237.74448	830	252.98451	880	268.22454	930	283.46457	980	298.70460
1	238.04928	1	253.28931	1	268.52934	1	283.76937	1	299.00940
2	238.35408	2	253.59411	2	268.83414	2	284.07417	2	299.31420
3	238.65888	3	253.89891	3	269.13894	3	284.37897	3	299.61900
4	238.96368	4	254.20371	4	269.44374	4	284.68377	4	299.92380
5	239.26848	5	254.50851	5	269.74854	5	284.98857	5	300.22860
6	239.57328	6	254.81331	6	270.05334	6	285.29337	6	300.53340
7	239.87808	7	255.11811	7	270.35814	7	285.59817	7	300.83820
8	240.18288	8	255.42291	8	270.66294	8	285.90297	8	301.14300
9	240.48768	9	255.72771	9	270.96774	9	286.20777	9	301.44780
790	240.79248	840	256.03251	890	271.27254	940	286.51257	990	301.75260
1	241.09728	1	256.33731	1	271.57734	1	286.81737	1	302.05740
2	241.40208	2	256.64211	2	271.88214	2	287.12217	2	302.36220
3	241.70688	3	256.94691	3	272.18694	3	287.42697	3	302.66701
4	242.01168	4	257.25171	4	272.49174	4	287.73178	4	302.97181
5	242.31648	5	257.55652	5	272.79655	5	288.03658	5	303.27661
6	242.62129	6	257.86132	6	273.10135	6	288.34138	6	303.58141
7	242.92609	7	258.16612	7	273.40615	7	288.64618	7	303.88621
8	243.23089	8	258.47092	8	273.71095	8	288.95098	8	304.19101
9	243.53569	9	258.77572	9	274.01575	9	289.25578	9	304.49581

Lengths—Meters to feet (from 1 to 1000 units).

[Reduction factor: 1 meter=3.280833333 feet.]

Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.
0		50	164.04167	100	328.08333	150	492.12500	200	656.16667
1	3.28083	1	167.32250	1	331.36417	1	495.40583	1	659.44750
2	6.56167	2	170.60333	2	334.64500	2	498.68667	2	662.72833
3	9.84250	3	173.88417	3	337.92583	3	501.96750	3	666.00917
4	13.12333	4	177.16500	4	341.20667	4	505.24833	4	669.29000
5	16.40417	5	180.44583	5	344.48750	5	508.52917	5	672.57083
6	19.68500	6	183.72667	6	347.76833	6	511.81000	6	675.85167
7	22.96583	7	187.00750	7	351.04917	7	515.09083	7	679.13250
8	26.24667	8	190.28833	8	354.33000	8	518.37167	8	682.41333
9	29.52750	9	193.56917	9	357.61083	9	521.65250	9	685.69417
10	32.80833	60	196.85000	110	360.89167	160	524.93333	210	688.97500
1	36.08917	1	200.13083	1	364.17250	1	528.21417	1	692.25583
2	39.37000	2	203.41167	2	367.45333	2	531.49500	2	695.53667
3	42.65083	3	206.69250	3	370.73417	3	534.77583	3	698.81750
4	45.93167	4	209.97333	4	374.01500	4	538.05667	4	702.09833
5	49.21250	5	213.25417	5	377.29583	5	541.33750	5	705.37917
6	52.49333	6	216.53500	6	380.57667	6	544.61833	6	708.66000
7	55.77417	7	219.81583	7	383.85750	7	547.89917	7	711.94083
8	59.05500	8	223.09667	8	387.13833	8	551.18000	8	715.22167
9	62.33583	9	226.37750	9	390.41917	9	554.46083	9	718.50250
20	65.61667	70	229.65833	120	393.70000	170	557.74167	220	721.78333
1	68.89750	1	232.93917	1	396.98083	1	561.02250	1	725.06417
2	72.17833	2	236.22000	2	400.26167	2	564.30333	2	728.34500
3	75.45917	3	239.50083	3	403.54250	3	567.58417	3	731.62583
4	78.74000	4	242.78167	4	406.82333	4	570.86500	4	734.90667
5	82.02083	5	246.06250	5	410.10417	5	574.14583	5	738.18750
6	85.30167	6	249.34333	6	413.38500	6	577.42667	6	741.46833
7	88.58250	7	252.62417	7	416.66583	7	580.70750	7	744.74917
8	91.86333	8	255.90500	8	419.94667	8	583.98833	8	748.03000
9	95.14417	9	259.18583	9	423.22750	9	587.26917	9	751.31083
30	98.42500	80	262.46667	130	426.50833	180	590.55000	230	754.59167
1	101.70583	1	265.74750	1	429.78917	1	593.83083	1	757.87250
2	104.98667	2	269.02833	2	433.07000	2	597.11167	2	761.15333
3	108.26750	3	272.30917	3	436.35083	3	600.39250	3	764.43417
4	111.54833	4	275.59000	4	439.63167	4	603.67333	4	767.71500
5	114.82917	5	278.87083	5	442.91250	5	606.95417	5	770.99583
6	118.11000	6	282.15167	6	446.19333	6	610.23500	6	774.27667
7	121.39083	7	285.43250	7	449.47417	7	613.51583	7	777.55750
8	124.67167	8	288.71333	8	452.75500	8	616.79667	8	780.83833
9	127.95250	9	291.99417	9	456.03583	9	620.07750	9	784.11917
40	131.23333	90	295.27500	140	459.31667	190	623.35833	240	787.40000
1	134.51417	1	298.55583	1	462.59750	1	626.63917	1	790.68083
2	137.79500	2	301.83667	2	465.87833	2	629.92000	2	793.96167
3	141.07583	3	305.11750	3	469.15917	3	633.20083	3	797.24250
4	144.35667	4	308.39833	4	472.44000	4	636.48167	4	800.52333
5	147.63750	5	311.67917	5	475.72083	5	639.76250	5	803.80417
6	150.91833	6	314.96000	6	479.00167	6	643.04333	6	807.08500
7	154.19917	7	318.24083	7	482.28250	7	646.32417	7	810.36583
8	157.48000	8	321.52167	8	485.56333	8	649.60500	8	813.64667
9	160.76083	9	324.80250	9	488.84417	9	652.88583	9	816.92750

Lengths—Meters to feet (from 1 to 1000 units)—Continued.

Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.
250	820.20833	300	984.25000	350	1,148.29167	400	1,312.33333	450	1,476.37500
1	823.48917	1	987.53083	1	1,151.57250	1	1,315.61417	1	1,479.65583
2	826.77000	2	990.81167	2	1,154.85333	2	1,318.89500	2	1,482.93667
3	830.05083	3	994.09250	3	1,158.13417	3	1,322.17583	3	1,486.21750
4	833.33167	4	997.37333	4	1,161.41500	4	1,325.45667	4	1,489.49833
5	836.61250	5	1,000.65417	5	1,164.69583	5	1,328.73750	5	1,492.77917
6	839.89333	6	1,003.93500	6	1,167.97667	6	1,332.01833	6	1,496.06000
7	843.17417	7	1,007.21583	7	1,171.25750	7	1,335.29917	7	1,499.34083
8	846.45500	8	1,010.49667	8	1,174.53833	8	1,338.58000	8	1,502.62167
9	849.73583	9	1,013.77750	9	1,177.81917	9	1,341.86083	9	1,505.90250
260	853.01667	310	1,017.05833	360	1,181.10000	410	1,345.14167	460	1,509.18333
1	856.29750	1	1,020.33917	1	1,184.38083	1	1,348.42250	1	1,512.46417
2	859.57833	2	1,023.62000	2	1,187.66167	2	1,351.70333	2	1,515.74500
3	862.85917	3	1,026.90083	3	1,190.94250	3	1,354.98417	3	1,519.02583
4	866.14000	4	1,030.18167	4	1,194.22333	4	1,358.26500	4	1,522.30667
5	869.42083	5	1,033.46250	5	1,197.50417	5	1,361.54583	5	1,525.58750
6	872.70167	6	1,036.74333	6	1,200.78500	6	1,364.82667	6	1,528.86833
7	875.98250	7	1,040.02417	7	1,204.06583	7	1,368.10750	7	1,532.14917
8	879.26333	8	1,043.30500	8	1,207.34667	8	1,371.38833	8	1,535.43000
9	882.54417	9	1,046.58583	9	1,210.62750	9	1,374.66917	9	1,538.71083
270	885.82500	320	1,049.86667	370	1,213.90833	420	1,377.95000	470	1,541.99167
1	889.10583	1	1,053.14750	1	1,217.18917	1	1,381.23083	1	1,545.27250
2	892.38667	2	1,056.42833	2	1,220.47000	2	1,384.51167	2	1,548.55333
3	895.66750	3	1,059.70917	3	1,223.75083	3	1,387.79250	3	1,551.83417
4	898.94833	4	1,062.99000	4	1,227.03167	4	1,391.07333	4	1,555.11500
5	902.22917	5	1,066.27083	5	1,230.31250	5	1,394.35417	5	1,558.39583
6	905.51000	6	1,069.55167	6	1,233.59333	6	1,397.63500	6	1,561.67667
7	908.79083	7	1,072.83250	7	1,236.87417	7	1,400.91583	7	1,564.95750
8	912.07167	8	1,076.11333	8	1,240.15500	8	1,404.19667	8	1,568.23833
9	915.35250	9	1,079.39417	9	1,243.43583	9	1,407.47750	9	1,571.51917
280	918.63333	330	1,082.67500	380	1,246.71667	430	1,410.75833	480	1,574.80000
1	921.91417	1	1,085.95583	1	1,249.99750	1	1,414.03917	1	1,578.08083
2	925.19500	2	1,089.23667	2	1,253.27833	2	1,417.32000	2	1,581.36167
3	928.47583	3	1,092.51750	3	1,256.55917	3	1,420.60083	3	1,584.64250
4	931.75667	4	1,095.79833	4	1,259.84000	4	1,423.88167	4	1,587.92333
5	935.03750	5	1,099.07917	5	1,263.12083	5	1,427.16250	5	1,591.20417
6	938.31833	6	1,102.36000	6	1,266,40167	6	1,430.44333	6	1,594.48500
7	941.59917	7	1,105.64083	7	1,269.68250	7	1,433.72417	7	1,597.76583
8	944.88000	8	1,108.92167	8	1,272.96333	8	1,437.00500	8	1,601.04667
9	948.16083	9	1,112.20250	9	1,276.24417	9	1,440.28583	9	1,604.32750
290	951.44167	340	1,115.48333	390	1,279.52500	440	1,443.56667	490	1,607.60833
1	954.72250	1	1,118.76417	1	1,282.80583	1	1,446.84750	1	1,610.88917
2	958.00333	2	1,122.04500	2	1,286.08667	2	1,450.12833	2	1,614.17000
3	961.28417	3	1,125.32583	3	1,289.36750	3	1,453.40917	3	1,617.45083
4	964.56500	4	1,128.60667	4	1,292.64833	4	1,456.69000	4	1,620.73167
5	967.84583	5	1,131.88750	5	1,295.92917	5	1,459.97083	5	1,624.01250
6	971.12667	6	1,135.16833	6	1,299.21000	6	1,463.25167	6	1,627.29333
7	974.40750	7	1,138.44917	7	1,302.49083	7	1,466.53250	7	1,630.57417
8	977.68833	8	1,141.73000	8	1,305.77167	8	1,469.81333	8	1,633.85500
9	980.96917	9	1,145.01083	9	1,309.05250	9	1,473.09417	9	1,637.13583

Lengths—Meters to feet (from 1 to 1000 units)—Continued.

Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.
500	1,640.41667	550	1,804.45833	600	1,968.50000	650	2,132.54167	700	2,296.58333
1	1,643.69750	1	1,807.73917	1	1,971.78083	1	2,135.82250	1	2,299.86417
2	1,646.97833	2	1,811.02000	2	1,975.06167	2	2,139.10333	2	2,303.14500
3	1,650.25917	3	1,814.30083	3	1,978.34250	3	2,142.38417	3	2,306.42583
4	1,653.54000	4	1,817.58167	4	1,981.62333	4	2,145.66500	4	2,309.70667
5	1,656.82083	5	1,820.86250	5	1,984.90417	5	2,148.94583	5	2,312.98750
6	1,660.10167	6	1,824.14333	6	1,988.18500	6	2,152.22667	6	2,316.26833
7	1,663.38250	7	1,827.42417	7	1,991.46583	7	2,155.50750	7	2,319.54917
8	1,666.66333	8	1,830.70500	8	1,994.74667	8	2,158.78833	8	2,322.83000
9	1,669.94417	9	1,833.98583	9	1,998.02750	9	2,162.06917	9	2,326.11083
510	1,673.22500	560	1,837.26667	610	2,001.30833	660	2,165.35000	710	2,329.39167
1	1,676.50583	1	1,840.54750	1	2,004.58917	1	2,168.63083	1	2,332.67250
2	1,679.78667	2	1,843.82833	2	2,007.87000	2	2,171.91167	2	2,335.95333
3	1,683.06750	3	1,847.10917	3	2,011.15083	3	2,175.19250	3	2,339.23417
4	1,686.34833	4	1,850.39000	4	2,014.43167	4	2,178.47333	4	2,342.51500
5	1,689.62917	5	1,853.67083	5	2,017.71250	5	2,181.75417	5	2,345.79583
6	1,692.91000	6	1,856.95167	6	2,020.99333	6	2,185.03500	6	2,349.07667
7	1,696.19083	7	1,860.23250	7	2,024.27417	7	2,188.31583	7	2,352.35750
8	1,699.47167	8	1,863.51333	8	2,027.55500	8	2,191.59667	8	2,355.63833
9	1,702.75250	9	1,866.79417	9	2,030.83583	9	2,194.87750	9	2,358.91917
520	1,706.03333	570	1,870.07500	620	2,034.11667	670	2,198.15833	720	2,362.20000
1	1,709.31417	1	1,873.35583	1	2,037.39750	1	2,201.43917	1	2,365.48083
2	1,712.59500	2	1,876.63667	2	2,040.67833	2	2,204.72000	2	2,368.76167
3	1,715.87583	3	1,879.91750	3	2,043.95917	3	2,208.00083	3	2,372.04250
4	1,719.15667	4	1,883.19833	4	2,047.24000	4	2,211.28167	4	2,375.32333
5	1,722.43750	5	1,886.47917	5	2,050.52083	5	2,214.56250	5	2,378.60417
6	1,725.71833	6	1,889.76000	6	2,053.80167	6	2,217.84333	6	2,381.88500
7	1,728.99917	7	1,893.04083	7	2,057.08250	7	2,221.12417	7	2,385.16583
8	1,732.28000	8	1,896.32167	8	2,060.36333	8	2,224.40500	8	2,388.44667
9	1,735.56083	9	1,899.60250	9	2,063.64417	9	2,227.68583	9	2,391.72750
530	1,738.84167	580	1,902.88333	630	2,066.92500	680	2,230.96667	730	2,395.00833
1	1,742.12250	1	1,906.16417	1	2,070.20583	1	2,234.24750	1	2,398.28917
2	1,745.40333	2	1,909.44500	3	2,073.48667	2	2,237.52833	2	2,401.57000
3	1,748.68417	3	1,912.72583	3	2,076.76750	3	2,240.80917	3	2,404.85083
4	1,751.96500	4	1,916.00667	4	2,080.04833	4	2,244.09000	4	2,408.13167
5	1,755.24583	5	1,919.28750	5	2,083.32917	5	2,247.37083	5	2,411.41250
6	1,758.52667	6	1,922.56833	6	2,086.61000	6	2,250.65167	6	2,414.69333
7	1,761.80750	7	1,925.84917	7	2,089.89083	7	2,253.93250	7	2,417.97417
8	1,765.08833	8	1,929.13000	8	2,093.17167	8	2,257.21333	8	2,421.25500
9	1,768.36917	9	1,932.41083	9	2,096.45250	9	2,260.49417	9	2,424.53583
540	1,771.65000	590	1,935.69167	640	2,099.73333	690	2,263.77500	740	2,427.81667
1	1,774.93083	1	1,938.97250	1	2,103 01417	1	2,267.05583	1	2,431.09750
2	1,778.21167	2	1,942.25333	2	2,106.29500	2	2,270.33667	2	2,434.37833
3	1,781.49250	3	1,945.53417	3	2,109.57583	3	2,273.61750	3	2,437.65917
4	1,784.77333	4	1,948.81500	4	2,112.85667	4	2,276.89833	4	2,440.94000
5	1,788.05417	5	1,952.09583	5	2,116.13750	5	2,280.17917	5	2,444.22083
6	1,791.33500	6	1,955.37667	6	2,119.41833	6	2,283.46000	6	2,447.50167
7	1,794.61583	7	1,958.65750	7	2,122.69917	7	2,286.74083	7	2,450.78250
8	1,797.89667	8	1,961.93833	8	2,125.98000	8	2,290.02167	8	2,454.06333
9	1,801.17750	9	1,965.21917	9	2,129.26083	9	2,293.30250	9	2,457.34417

Lengths—Meters to feet (from 1 to 1000 units)—Continued.

Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.
750	2,460.62500	800	2,624.66667	850	2,788.70833	900	2,952.75000	950	3,116.79167
1	2,463.90583	1	2,627.94750	1	2,791.98917	1	2,956.03083	1	3,120.07250
2	2,467.18667	2	2,631.22833	2	2,795.27000	2	2,959.31167	2	3,123.35333
3	2,470.46750	3	2,634.50917	3	2,798.55083	3	2,962.59250	3	3,126.63417
4	2,473.74833	4	2,637.79000	4	2,801.83167	4	2,965.87333	4	3,129.91500
5	2,477.02917	5	2,641.07083	5	2,805.11250	5	2,969.15417	5	3,133.19583
6	2,480.31000	6	2,644.35167	6	2,808.39333	6	2,972.43500	6	3,136.47667
7	2,483.59083	7	2,647.63250	7	2,811.67417	7	2,975.71583	7	3,139.75750
8	2,486.87167	8	2,650.91333	8	2,814.95500	8	2,978.99667	8	3,143.03833
9	2,490.15250	9	2,654.19417	9	2,818.23583	9	2,982.27750	9	3,146.31917
760	2,493.43333	810	2,657.47500	860	2,821.51667	910	2,985.55833	960	3,149.60000
1	2,496.71417	1	2,660.75583	1	2,824.79750	1	2,988.83917	1	3,152.88083
2	2,499.99500	2	2,664.03667	2	2,828.07833	2	2,992.12000	2	2,156.16167
3	2,503.27583	3	2,667.31750	3	2,831.35917	3	2,995.40083	3	3,159.44250
4	2,506.55667	4	2,670.59833	4	2,834.64000	4	2,998.68167	4	3,162.72333
5	2,509.83750	5	2,673.87917	5	2,837.92083	5	3,001.96250	5	3,166.00417
6	2,513.11833	6	2,677.16000	6	2,841.20167	6	3,005.24333	6	3,169.28500
7	2,516.39917	7	2,680.44083	7	2,844.48250	7	3,008.52417	7	3,172.56583
8	2,519.68000	8	2,683.72167	8	2,847.76333	8	3,011.80500	8	3,175.84667
9	2,522.96083	9	2,687.00250	9	2,851.04417	9	3,015.08583	9	3,179.12750
770	2,526.24167	820	2,690.28333	870	2,854.32500	920	3,018.36667	970	3,182.40833
1	2,529.52250	1	2,693.56417	1	2,857.60583	1	3,021.64750	1	3,185.68917
2	2,532.80333	2	2,696.84500	2	2,860.88667	2	3,024.92833	2	2,188.97000
3	2,536.08417	3	2,700.12583	3	2,864.16750	3	3,028.20917	3	3,192.25083
4	2,539.36500	4	2,703.40667	4	2,867.44833	4	3,031.49000	4	3,195.53167
5	2,542.64583	5	2,706.68750	5	2,870.72917	5	3,034.77083	5	3,198.81250
6	2,545.92667	6	2,709.96833	6	2,874.01000	6	3,038.05167	6	3,202.09333
7	2,549.20750	7	2,713.24917	7	2,877.29083	7	3,041.33250	7	3,205.37417
8	2,552.48833	8	2,716.53000	8	2,880.57167	8	3,044.61333	8	3,208.65500
9	2,555.76917	9	2,719.81083	9	2,883.85250	9	3,047.89417	9	3,211.93583
780	2,559.05000	830	2,723.09167	880	2,887.13333	930	3,051.17500	980	3,215.21667
1	2,562.33083	1	2,726.37250	1	2,890.41417	1	3,054.45583	1	3,218.49750
2	2,565.61167	2	2,729.65333	2	2,893.69500	2	3,057.73667	2	3,221.77833
3	2,568.89250	3	2,732.93417	3	2,896.97583	3	3,061.01750	3	3,225.05917
4	2,572.17333	4	2,736.21500	4	2,900.25667	4	3,064.29833	4	3,228.34000
5	2,575.45417	5	2,739.49583	5	2,903.53750	5	3,067.57917	5	3,231.62083
6	2,578.73500	6	2,742.77667	6	2,906,81833	6	3,070.86000	6	3,234.90167
7	2,582.01583	7	2,746.05750	7	2,910.09917	7	3,074.14083	7	3,238.18250
8	2,585.29667	8	2,749.33833	8	2,913.38000	8	3,077.42167	8	3,241.46333
9	2,588.57750	9	2,752.61917	9	2,916.66083	9	3,080.70250	9	3,244.74417
790	2,591.85833	840	2,755.90000	890	2,919.94167	940	3,083.98333	990	3,248.02500
1	2,595.13917	1	2,759.18083	1	2,923.22250	1	2,087.26417	1	3,251.30583
2	2,598.42000	2	2,762.46167	2	2,926.50333	2	3,090.54500	2	3,254.58667
3	2,601.70083	3	2,765.74250	3	2,929.78417	3	3,093.82583	3	3,257.86750
4	2,604.98167	4	2,769.02333	4	2,933.06500	4	3,097.10667	4	3,261.14833
5	2,608.26250	5	2,772.30417	5	2,936.34583	5	3,100.38750	5	3,264.42917
6	2,611.54333	6	2,775.58500	6	2,939.62667	6	3,103.66833	6	3,267.71000
7	2,614.82417	7	2,778.86583	7	2,942.90750	7	3,106.94917	7	3,270.99083
8	2,618.10500	8	2,782.14667	8	2,946.18833	8	3,110.23000	8	3,274.27167
9	2,621.38583	9	2,785.42750	9	2,949.46917	9	3,113.51083	9	3,277.55250

GEOGRAPHIC POSITIONS.

Ninety-eighth meridian, Alice to Rio Grande and Point Isabel.

Station.	Latitude and longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.	Logarithm of distance.
Principal points.	° ′ ″		° ′ ″	° ′ ″		*Meters.*	
Wood, 1904	27 43 41.237	1269.3					
	97 56 24.473	670.4					
Alice, west base, 1900	27 38 38.960	1199.2	229 46 18.74	49 49 25.42	Wood	14414.33	4.1587944
	98 03 06.241	171.1					
King, 1913	27 33 06.739	207.4	133 03 46.25	313 00 41.24	Alice, west base	14983.48	4.1756128
	97 56 26.897	737.9	180 11 41.25	0 11 42.38	Wood	19530.20	4.2907066
Bishop, 1913	27 34 13.549	417.0	83 01 23.02	262 56 41.19	King	16835.57	4.2262278
	97 46 17.798	488.2	106 31 23.61	286 23 36.28	Alice, west base	28834.64	4.4599146
			136 27 24.06	316 22 42.53	Wood	24122.08	4.3824148
Ricardo, 1913	27 24 08.364	257.4	179 54 49.75	359 54 49.33	King	16571.00	4.2193486
	97 56 25.988	714.0	221 49 52.06	41 54 32.77	Bishop	25014.64	4.3981942
Kleberg, *ecc*, 1913	27 24 28.941	890.8	87 16 01.00	267 12 21.17	Ricardo	13135.62	4.1184507
	97 48 28.395	780.1	140 32 02.12	320 28 21.32	King	20653.68	4.3149975
			191 15 33.68	11 16 33.96	Bishop	18347.73	4.2635823
Riviera, 1913	27 17 39.302	1209.7	155 29 53.57	335 28 22.30	Ricardo	13161.37	4.1193011
	97 53 07.306	200.9	211 16 55.31	31 19 03.46	Kleberg, *ecc*	14755.86	4.1689644
Robbins, 1913	27 18 23.071	710.1	84 43 50.91	264 39 48.81	Riviera	14576.63	4.1636573
	97 44 19.471	535.4	118 04 12.88	297 58 39.05	Ricardo	22620.03	4.3544931
			148 44 11.04	328 42 16.65	Kleberg, *ecc*	13176.39	4.1197963
Roza, 1913	27 10 22.282	685.8	170 12 28.97	350 11 50.34	Riviera	13649.91	4.1351297
	97 51 42.887	1180.6	219 28 27.01	39 31 49.97	Robbins	19178.37	4.2828116
Sarita, 1913	27 09 20.400	627.9	98 30 01.13	278 26 29.06	Roza	12929.57	4.1115841
	97 43 58.376	1607.3	135 30 24.81	315 26 13.68	Riviera	21539.16	4.3332287
			178 00 39.92	358 00 30.27	Robbins	16712.70	4.2230465
Turcotte, 1913	27 02 09.436	290.4	176 30 28.57	356 30 13.25	Roza	15197.04	4.1817590
	97 51 09.263	255.3	221 47 52.41	41 51 08.67	Sarita	17799.88	4.2501171
Kenedy, 1913	27 01 05.185	159.6	101 32 45.18	281 30 05.29	Turcotte	9898.62	3.9955748
	97 45 17.397	479.6	148 15 08.91	328 12 13.33	Roza	20168.49	4.3046734
			188 07 25.60	8 08 01.58	Sarita	15396.35	4.1874177
Katherine, 1913	26 53 57.316	1764.0	184 03 46.03	4 04 03.73	Turcotte	15184.34	4.1813958
	97 51 48.294	1332.7	219 17 00.25	39 19 57.46	Kenedy	17019.22	4.2309397
Armstrong, 1913	26 53 56.397	1735.7	90 10 18.82	270 07 17.79	Katherine	11042.23	4.0430567
	97 45 08.155	225.0	146 44 43.94	326 42 00.18	Turcotte	18150.65	4.2588922
			178 53 38.50	358 53 34.31	Kenedy	13199.40	4.1205542
Vinson, 1913	26 45 25.006	769.6	185 47 33.29	5 47 59.45	Katherine	15848.27	4.1999819
	97 52 46.257	1278.1	218 45 38.30	38 49 05.05	Armstrong	20192.27	4.3051852
Norias, 1913	26 44 29.137	896.7	98 46 58.36	278 43 56.55	Vinson	11293.21	4.0528172
	97 46 02.325	64.2	151 22 17.20	331 19 41.10	Katherine	19926.42	4.2994293
			184 53 38.18	4 54 02.62	Armstrong	17522.38	4.2435931
Stillman, 1913	26 36 57.741	1777.0	187 27 09.45	7 27 42.64	Vinson	15744.80	4.1971373
	97 54 00.168	4.6	223 31 57.65	43 35 32.20	Norias	19171.59	4.2826582
Yturria, 1913	26 36 45.563	1402.2	91 30 58.05	271 27 03.72	Stillman	14475.79	4.1606422
	97 45 17.086	472.7	142 11 14.00	322 07 52.28	Vinson	20243.18	4.3062788
			174 59 32.32	354 59 12.01	Norias	14321.70	4.1559947
Brenner, 1913	26 28 48.067	1479.3	167 22 08.15	347 21 13.59	Stillman	15444.18	4.1887648
	97 51 58.090	1608.9	217 02 28.59	37 05 27.81	Yturria	18416.38	4.2652043
Raymond, 1913	26 28 55.781	1716.7	88 57 15.05	268 53 51.21	Brenner	12663.43	4.1025514
	97 44 20.953	580.3	132 48 31.75	312 44 12.86	Stillman	21841.69	4.3392863
			173 52 09.56	353 51 44.47	Yturria	14541.04	4.1625954
Hidalgo, 1913	26 19 59.395	1827.9	178 30 55.89	358 30 49.12	Brenner	16275.31	4.2115292
	97 51 42.867	1188.8	216 32 45.07	36 36 01.61	Raymond	20554.45	4.3129060
Sebastian, 1913	26 20 00.386	11.9	89 49 44.98	269 47 18.77	Hidalgo	9140.81	3.9609849
	97 46 13.257	367.6	149 32 39.80	329 30 06.44	Brenner	18842.78	4.2751449
			190 41 24.29	10 42 14.24	Raymond	16768.12	4.2244844

Ninety-eighth meridian, Alice to Rio Grande and Point Isabel—Continued.

Station.	Latitude and longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.	Logarithm of distance.
Principal points—Continued.	° ′ ″		° ′ ″	° ′ ″		*Meters.*	
Mercedes, 1913	26 12 23.019	708.4	181 56 29.77	1 56 37.38	Hidalgo	14052.72	4.1477605
	97 52 00.036	1.0	214 20 10.19	34 22 43.68	Sebastian	17049.77	4.2317185
Harlingen, 1913	26 11 06.904	212.5	101 46 36.83	281 43 37.81	Mercedes	11500.38	4.0607120
	97 45 14.510	402.9	146 41 35.67	326 38 43.85	Hidalgo	19613.08	4.2925458
			174 19 58.43	354 19 32.44	Sebastian	16498.24	4.2174376
Maria, 1913	26 05 07.703	237.0	179 43 23.12	359 43 22.09	Mercedes	13396.46	4.1269901
	97 51 57.704	1603.7	225 21 07.98	45 24 05.59	Harlingen	15736.49	4.1969078
Mitla, 1913	26 05 22.626	696.3	87 45 39.80	267 42 36.03	Maria	11622.39	4.0652955
	97 44 59.813	1662.2	137 58 05.62	317 55 00.42	Mercedes	17424.30	4.2411554
			177 47 39.00	357 47 32.52	Harlingen	10602.58	4.0254117
Donna, 1913	26 09 40.459	1245.1	254 21 47.32	74 26 32.10	Mercedes	18605.72	4.2696465
	98 02 45.414	1261.3	294 58 02.54	115 02 47.74	Maria	19855.97	4.2978912
Rio, 1913	26 04 24.807	763.4	134 07 54.34	314 05 15.57	Donna	13955.84	4.1447561
	97 56 44.751	1243.8	208 14 12.53	28 16 17.97	Mercedes	16706.89	4.2228956
			260 35 12.99	80 37 19.19	Maria	8086.15	3.9077416
Tenacitas (Mexico), 1911.	25 59 21.524	662.4	177 51 58.91	357 51 47.68	Donna	19060.00	4.2801228
	98 02 19.864	552.5	224 55 53.18	44 58 20.25	Rio	13187.79	4.1201721
Colombres (Mexico), 1911.	25 59 18.835	579.6	196 53 00.07	16 54 31.96	Donna	19992.54	4.3008679
	98 06 14.478	402.7	239 14 15.21	59 18 25.24	Rio	18427.64	4.2654698
			269 15 32.61	89 17 15.42	Tenacitas	6525.99	3.8146461
Benito, 1913	26 04 37.175	1144.0	96 28 49.03	276 25 33.39	Mitla	12444.82	4.0949887
	97 37 34.855	968.7	133 14 00.89	313 10 38.44	Harlingen	17518.40	4.2434945
Cowgill, 1913	26 10 43.878	1350.3	18 18 19.54	198 17 20.39	Benito	11885.72	4.0750256
	97 35 20.537	570.3	58 28 14.95	238 23 59.79	Mitla	18886.08	4.2761419
			92 29 47.31	272 25 25.23	Harlingen	16508.65	4.2177115
Olmito, 1913	26 03 09.256	284.8	105 23 34.83	285 20 59.25	Benito	10206.90	4.0088937
	97 31 40.780	1133.6	156 26 10.07	336 24 33.33	Cowgill	15264.65	4.1836870
Resaca, 1913	26 08 45.570	1402.4	29 34 51.41	209 33 18.45	Olmito	11899.21	4.0755181
	97 28 09.472	263.1	64 05 13.41	244 01 04.57	Benito	17470.06	4.2422945
			106 56 30.06	286 53 19.99	Cowgill	12513.18	4.0973675
Arista, 1885	26 00 13.287	408.9	107 42 29.43	287 38 01.17	Olmito	17839.35	4.2513791
	97 21 29.451	819.0	144 49 52.89	324 46 57.06	Resaca	19290.78	4.2853497
Point Isabel west base, 1906.	26 06 19.429	597.9	18 15 28.38	198 14 29.68	Arista	11864.19	4.0742379
	97 19 15.795	438.9	74 15 44.69	254 10 17.19	Olmito	21516.08	4.3327632
			106 54 24.87	286 50 29.87	Resaca	15493.32	4.1901445
Supplementary points.							
Alice Catholic Church spire,[1] 1913.	27 45 03.39	104.3	280 49 32	100 53 16	Wood	13425.3	4.127925
	98 04 25.88	708.7	349 32 49	169 33 26	Alice west base	12032.4	4.080354
Alice standpipe, center,[1] 1913.	27 44 58.95	1814.5	280 28 39	100 32 18	Wood	13117.0	4.117833
	98 04 15.36	420.7	350 47 55	170 48 27	Alice west base	11848.7	4.073672
Bishop standpipe, 1913.	27 34 54.542	1678.8	4 14 18.7	184 13 54.7	Kleberg, *ecc.*	19308.6	4.285750
	97 47 36.448	999.8	36 11 43.1	216 07 38.7	Ricardo	24634.9	4.391550
			77 11 17.9	257 07 12.4	King	14924.7	4.173905
			138 16 38.6	318 12 33.5	Wood	21732.4	4.337107
			300 19 01.3	120 19 37.7	Bishop	2499.2	3.397801
Kingsville standpipe, 1913.	27 31 08.037	247.4	29 05 17.0	209 03 16.4	Ricardo	14779.3	4.169655
	97 52 04.454	122.2	116 55 04.3	296 53 03.0	King	8075.2	3.907151
			238 59 58.3	59 02 38.6	Bishop	11093.6	4.045074
			334 12 31.1	154 14 10.7	Kleberg, *ecc.*	13641.5	4.134863
Kingsville Presbyterian Church steeple, 1913.	27 30 59.168	1821.2	28 50 20.2	208 48 23.3	Ricardo	14432.3	4.159337
	97 52 12.593	345.7	119 22 58.6	299 21 01.0	King	8007.0	3.903469
			238 24 07.5	58 26 51.5	Bishop	11426.3	4.057906
			332 50 58.2	152 52 41.5	Kleberg, *ecc.*	13496.7	4.130228
Kingsville, Henrietta M. King School, cupola, 1913.	27 30 58.660	1805.5	28 00 40.5	207 58 47.8	Ricardo	14302.4	4.155408
	97 52 21.489	589.8	120 21 41.9	300 19 48.5	King	7803.1	3.892265
			238 57 53.2	59 00 41.4	Bishop	11643.0	4.066066
			331 54 09.7	151 55 57.2	Kleberg, *ecc.*	13596.1	4.133413

[1] No check on this position.

Ninety-eighth meridian, Alice to Rio Grande and Point Isabel—Continued.

Station.	Latitude and longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.	Logarithm of distance.
Supplementary points—Contd.	° ′ ″		° ′ ″	° ′ ″		*Meters.*	
Kingsville Methodist Church steeple,[1] 1913.	27 30 59.04 97 52 16.82	1817.2 461.7	119 49 12 238 41 13	299 47 17 58 43 59	King..... Bishop.....	7908.0 11527.4	3.898067 4.061732
Kingsville, Frisco Railroad shops (taller of two metal stacks),[1] 1913.	27 30 40.53 97 52 16.53	1247.5 453.7	123 14 36 236 18 27	303 12 40 56 21 13	King..... Bishop.....	8213.0 11826.9	3.914503 4.072870
Ricardo schoolhouse, center of cupola,[1] 1913.	27 25 27.33 97 51 15.50	841.2 425.8	74 06 50 291 22 20	254 04 27 111 23 37	Ricardo..... Kleberg, *ecc*...	8868.8 4929.4	3.947863 3.692793
Riviera schoolhouse cupola, 1913.	27 17 48.674 97 48 35.275	1498.1 970.0	132 07 15.3 180 52 44.0 261 25 27.3	312 03 39.1 0 52 47.2 81 27 24.6	Ricardo..... Kleberg, *ecc*... Robbins.....	17434.5 12321.3 7113.2	4.241409 4.090656 3.852063
Sarita standpipe, 1913	27 13 25.413 97 47 34.936	782.2 961.2	143 36 46.7 210 23 40.2 321 39 43.1	323 32 43.0 30 25 09.8 141 41 22.1	Ricardo..... Robbins..... Sarita.....	24592.9 10622.6 9612.4	4.390809 4.026232 3.982833
Kenedy ranch oil well derrick,[1] 1913.	27 14 44.51 97 42 50.89	1370.0 1400.0	10 33 02 160 05 53	190 32 31 340 05 13	Sarita..... Robbins.....	10147.0 7154.6	4.006338 3.854584
Turcotte section house (largest) north chimney,[1] 1913.	27 00 13.26 97 47 44.56	408.1 1228.5	122 22 23 248 29 20	302 20 50 68 30 27	Turcotte..... Kenedy.....	6680.6 4360.4	3.824814 3.639526
Katherine, railroad water tank,[1] 1913.	26 55 24.30 97 47 32.31	747.8 891.5	69 15 30 304 12 49	249 13 34 124 13 54	Katherine..... Armstrong....	7553.8 4810.5	3.878163 3.682190
Windmill (¼ mi. NNE. of Norias's house),[1] 1913.	26 47 34.12 97 46 29.81	1050.1 823.4	69 06 45 352 24 06	249 03 55 172 24 18	Vinson..... Norias.....	11133.1 5743.5	4.046615 3.759174
Norias's house, south gable,[1] 1913.	26 47 08.60 97 46 32.71	264.7 903.6	72 51 19 350 17 29	252 48 31 170 17 43	Vinson..... Norias.....	10801.2 4979.0	4.033473 3.697143
Rudolph water tank,[1] 1913.	26 41 10.83 97 46 08.64	333.3 238.9	181 38 16 350 05 26	1 38 19 170 05 49	Norias..... Yturria.....	6105.5 8287.5	3.785722 3.918425
Raymondville cotton gin smokestack, 1913.	26 28 43.174 97 47 02.822	1328.7 78.2	91 04 23.7 265 02 37.8 355 07 00.3	271 02 12.1 85 03 50.0 175 07 22.4	Brenner..... Raymond..... Sebastian.....	8179.5 4500.0 16147.3	3.912725 3.653215 4.208099
Raymondville water tank,[1] 1913.	26 29 00.18 97 46 58.22	5.5 1612.5	87 26 57 271 46 10	267 24 43 91 47 20	Brenner..... Raymond.....	8313.7 4357.8	3.919794 3.639272
Harlingen standpipe, 1913.	26 11 40.638 97 41 55.439	1250.6 1539.3	23 46 23.2 79 22 30.9 155 04 09.4	203 45 02.0 259 21 03.0 335 02 15.3	Mitla..... Harlingen..... Sebastian.....	12710.3 5624.1 16961.9	4.104156 3.750051 4.229475
Harlingen sugar mill, latticed steel derrick,[1] 1913.	26 12 03.11 97 42 27.59	95.7 765.9	18 56 41 69 32 34	198 55 34 249 31 20	Mitla..... Harlingen.....	13029.6 4946.8	4.114931 3.694320
Harlingen pumping station, tall brick stack, 1913.	26 02 36.623 97 45 21.535	1127.0 598.7	112 54 49.9 148 29 42.8 180 42 42.1 186 44 21.1	292 51 55.8 328 26 47.4 0 42 45.3 6 44 30.7	Maria..... Mercedes..... Harlingen..... Mitla.....	11953.1 21170.9 15704.4 5144.0	4.077479 4.325740 4.196022 3.711303
Heidelberg church steeple, 1913.	26 11 51.362 97 52 53.548	1580.6 1486.7	236 44 30.9 276 05 55.1 352 52 42.9	56 44 54.6 96 09 17.7 172 53 07.5	Mercedes..... Harlingen..... Maria.....	1776.6 12818.8 12518.6	3.249591 4.107846 4.097555
La Feria pumping station, first lift brick stack, 1913.	26 03 09.563 97 49 50.777	294.3 1411.5	135 52 08.7 207 34 15.0 243 07 38.7	315 51 12.9 27 36 16.7 63 09 46.6	Maria..... Harlingen..... Mitla.....	5065.9 16574.0 9064.7	3.704658 4.219426 3.957354
La Feria pumping station, second lift tall stack, 1913.	26 08 17.225 97 49 26.320	530.1 731.1	35 48 27.7 150 34 16.7 233 14 16.4	215 47 21.0 330 33 08.9 53 16 07.3	Maria..... Mercedes..... Harlingen.....	7190.8 8685.4 8727.8	3.856775 3.938790 3.940904
Santa Maria Catholic Church steeple, 1913	26 04 27.785 97 50 17.026	855.0 473.2	113 42 31.7 214 21 45.6 259 08 36.3	293 41 47.4 34 23 58.8 79 10 55.8	Maria..... Harlingen..... Mitla.....	3055.8 14882.3 8975.9	3.485131 4.172671 3.953080

[1] No check on this position.

Ninety-eighth meridian, Alice to Rio Grande and Point Isabel—Continued.

Station.	Latitude and longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.	Logarithm of distance.
Supplementary points—Contd.	° ′ ″		° ′ ″	° ′ ″		*Meters.*	
Mercedes west church steeple, 1913.	26 09 09.101 97 55 09.200	280.1 255.5	16 53 10.7 221 20 35.9 324 22 43.5	196 52 28.7 41 21 59.4 144 24 07.8	Rio Mercedes Maria	9142.7 7950.1 9137.4	3.961075 3.900374 3.960821
Mercedes east church steeple, 1913.	26 08 55.216 97 54 40.312	1699.2 1119.7	22 34 12.5 214 49 37.8 327 09 25.2	202 33 17.7 34 50 48.5 147 10 36.7	Rio Mercedes Maria	9011.1 7791.3 8332.5	3.954780 3.891608 3.920774
Mercedes standpipe, 1913.	26 08 54.903 97 54 36.870	1689.6 1024.1	23 09 12.9 95 55 43.1 214 12 22.8 327 40 40.0	203 08 16.6 275 52 07.8 34 13 32.0 147 41 50.1	Rio Donna Mercedes Maria	9039.5 13641.2 7745.0 8272.9	3.956142 4.134854 3.889021 3.917656
Mercedes Canal pumping station, iron stack, 1913.	26 03 50.121 97 53 36.102	1542.4 1003.5	101 31 05.2 125 16 14.2 189 35 26.0 228 52 23.4 258 44 50.5	281 29 42.3 305 12 12.5 9 36 08.3 48 53 06.7 78 48 37.4	Rio Donna Mercedes Maria Mitla	5351.0 18686.2 16007.8 3630.3 14628.8	3.728435 4.271520 4.204331 3.559945 4.165208
Donna standpipe, 1913.	26 10 05.250 98 03 01.360	161.6 37.8	256 57 30.8 296 22 13.1 315 00 50.5 329 51 58.1	77 02 22.7 116 27 05.4 135 03 36.3 149 52 05.2	Mercedes Maria Rio Donna	18845.9 20585.6 14806.7 882.1	4.275216 4.313564 4.170458 2.945531
Progresso church steeple,[1] 1913.	26 04 12.47 97 56 44.37	383.7 1233.2	178 24 52 257 56 22	358 24 52 77 58 28	Rio Maria	379.9 8146.6	2.579631 3.910977
United States and Mexico Boundary Monument, R. P. No. 28,[1] 1913.	26 04 13.23 97 56 43.16	407.1 1199.6	172 55 31	352 55 30	Rio	358.92	2.554998
United States and Mexico Boundary Monument, R. P. No. 31,[1] 1913.	26 05 08.82 97 51 56.90	271.4 1581.3	32 54 27	212 54 26	Maria	41.12	1.614053
Rio Hondo standpipe, 1913.	26 14 16.236 97 34 39.041	499.6 1083.6	9 59 59.2 15 20 05.5 313 13 40.2	189 59 40.9 195 18 48.1 133 16 32.2	Cowgill Benito Resaca	6635.9 18476.8 14850.9	3.821897 4.266626 4.171752
Cowgill water tank [1], 1913.	26 09 51.66 97 36 11.92	1589.8 331.0	13 23 49 221 36 04	193 23 12 41 36 26	Benito Cowgill	9948.3 2149.1	3.997748 3.332263
San Benito sugar mill, tall brick stack 1913.	26 08 28.708 97 38 29.593	883.5 822.0	62 10 53.9 113 25 58.8 231 36 05.9 310 50 48.8 347 56 50.6	242 08 02.1 293 23 00.2 51 37 29.2 130 53 48.6 167 57 14.7	Mitla Harlingen Cowgill Olmito Benito	12261.2 12254.1 6608.7 15023.1 7285.6	4.088532 4.088281 3.825991 4.176761 3.862467
San Benito standpipe, 1913.	26 08 01.381 97 37 58.674	42.5 1629.9	115 16 41.0 221 16 59.5 310 32 32.7 353 59 12.2	295 13 28.8 41 18 09.2 130 35 19.0 173 59 22.7	Harlingen Cowgill Olmito Benito	13383.5 6655.6 13823.6 6318.9	4.126569 3.823187 4.140621 3.800640
San Benito Bank & Trust Co. building, cupola on southwest corner,[1] 1913.	26 07 49.93 97 37 58.22	1536.5 1617.4	219 16 39 309 26 50	39 17 49 129 29 36	Cowgill Olmito	6916.5 13587.4	3.839884 4.133135
San Benito pumping station, low brick stack, 1913.	26 02 50.529 97 45 42.721	1554.9 1187.6	112 04 16.5 182 56 08.4 194 17 32.5	292 01 31.7 2 56 20.8 14 17 51.4	Maria Harlingen Mitla	11245.2 15295.3 4830.1	4.050966 4.184559 3.683956
Olmito factory, north stack,[1] 1913.	25 56 52.11 97 33 54.73	1603.6 1522.8	197 47 17 253 19 41	17 48 16 73 25 08	Olmito Arista	12189.1 21635.9	4.085972 4.335175
Olmito factory, south stack,[1] 1913.	25 56 51.26 97 33 55.16	1577.4 1534.7	197 48 13 253 16 14	17 49 12 73 21 41	Olmito Arista	12217.7 21654.9	4.086991 4.335556
Ohio-Texas sugar factory, tall brick stack, 1913.	25 58 06.721 97 29 04.821	206.8 134.1	155 01 52.5 184 28 17.4 252 52 45.3	335 00 44.1 4 28 41.7 72 56 04.8	Olmito Resaca Arista	10270.6 19719.6 13251.1	4.011595 4.294899 4.122252
United States and Mexico Boundary Monument, R. P. No. 53,[1] 1913.	25 57 28.87 97 15 16.23	888.4 451.5	116 00 21 157 49 16	295 57 37 337 47 31	Arista Point Isabel, west base.	11548.6 17633.4	4.062530 4.246335
United States and Mexico Boundary Monument, R. P. No. 54,[1] 1913.	25 57 54.23 97 12 01.91	1668.8 53.1	105 12 05 142 13 02	285 07 57 322 09 51	Arista Point Isabel, west base.	16355.7 19677.9	4.213670 4.293978

[1] No check on this position.

Point Isabel to Corpus Christi.

Station.	Latitude and longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.	Logarithm of distance.
Principal points.	° ′ ″		° ′ ″	° ′ ″		*Meters.*	
Point Isabel, south base, 1886.	26 03 41.344	1272.3	54 15 24.95	234 13 04.62	Arista	10955.33	4.0396254
	97 16 09.717	270.1	133 15 43.21	313 14 21.39	Point Isabel, west base.	7099.96	3.8512557
Point Isabel, east base, 1886.	26 04 44.012	1354.4	39 46 45.70	219 46 20.32	Point Isabel, south base.	2509.29	3.3995509
	97 15 11.957	332.3	51 34 45.54	231 31 59.81	Arista	13399.56	4.1270907
			113 26 37.03	293 24 49.78	Point Isabel, west base.	7384.92	3.8683459
Fronton, 1867	26 04 41.082	1264.2	61 26 40.31	241 22 41.51	Arista	17221.80	4.2360786
	97 12 25.517	709.2	73 34 38.04	253 32 59.51	Point Isabel, south base.	6497.03	3.8127151
			91 07 37.07	271 06 23.90	Point Isabel, east base.	4626.65	3.6652667
			104 53 28.81	284 50 28.36	Point Isabel, west base.	11796.20	4.0717421
Cameron, 1867	26 09 20.138	619.7	314 08 13.41	134 10 33.54	Fronton	12327.43	4.0908726
	97 17 43.843	1217.7	333 34 51.98	153 35 58.84	Point Isabel, east base.	9487.52	3.9771525
			345 54 43.83	165 55 25.25	Point Isabel, south base.	10748.92	4.0313648
			20 26 55.21	200 25 16.02	Arista	17958.63	4.2542732
			24 40 36.96	204 39 56.46	Point Isabel, west base.	6119.69	3.7867294
Pool, 1867	26 07 56.021	1724.0	35 47 33.21	215 46 24.74	Fronton	7394.82	3.8689277
	97 09 49.904	1386.3	101 09 11.94	281 05 43.11	Cameron	13416.69	4.1276454
Fox, 1867	26 11 42.160	1297.4	297 42 18.39	117 45 48.53	Pool	14953.97	4.1747573
	97 17 46.494	1290.9	325 26 56.17	145 29 17.55	Fronton	15729.40	4.1967122
			359 02 05.60	179 02 06.77	Cameron	4371.20	3.6406005
Singer, 1867	26 12 49.264	1516.1	349 46 20.30	169 46 46.15	Pool	9169.83	3.9623615
	97 10 48.515	1346.8	60 51 43.85	240 48 40.58	Cameron	13206.71	4.1207947
			79 56 06.25	259 53 01.68	Fox	11786.53	4.0713858
Black Hill, 1879	26 16 09.273	285.4	351 26 59.76	171 27 14.50	Singer	6224.26	3.7940878
	97 11 21.850	606.3	52 25 44.73	232 22 54.71	Fox	13474.16	4.1295017
Armadillo, 1879	26 16 47.798	1470.9	277 20 27.23	97 22 53.64	Black Hill	9253.31	3.9662970
	97 16 52.602	1459.4	305 58 32.21	126 01 13.22	Singer	12489.34	4.0965395
			9 02 21.33	189 01 57.50	Fox	9523.95	3.9788169
Mesena 2, 1885	26 05 07.434	228.8	171 31 52.98	351 31 34.62	Cameron	7862.4	3.895555
	97 17 02.154	59.9	276 00 15.42	96 02 17.05	Fronton	7730.9	3.888228
			283 14 11.69	103 15 00.13	Point Isabel, east base.	3146.2	3.497792
			331 10 50.06	151 11 13.11	Point Isabel, south base.	3023.7	3.480540
			39 23 59.71	219 22 02.35	Arista	11711.4	4.068607
Point Isabel L. H., 1867.	26 04 38.543	1186.1	61 36 15.89	241 32 17.77	Arista	17146.41	4.2341731
	97 12 27.078	752.6	96 39 01.50	276 37 00.54	Mesena 2	7696.39	3.8862871
			134 34 33.78	314 32 14.34	Cameron	12351.08	4.0917048
			145 46 43.63	325 44 22.92	Fox	15769.42	4.1978157
			184 52 00.34	4 52 29.08	Black Hill	21333.50	4.3290620
			190 16 10.53	10 16 53.94	Singer	15347.49	4.1860373
			209 02 16.09	29 02 16.75	Fronton	89.38	1.95126
Armadillo 2, 1913	26 16 47.693	1467.7	341 46 42.0	161 48 39.3	Point Isabel L. H.	23621.2	4.373302
	97 16 52.838	1466.0					
			5 52 21.1	185 51 58.6	Cameron	13845.7	4.141315
			9 00 11.8	188 59 48.1	Fox	9519.7	3.978625
Bank, 1913	26 13 30.798	947.8	220 19 05.9	40 20 27.9	Armadillo 2	7948.4	3.900277
	97 19 58.201	1615.5	312 25 50.3	132 26 48.5	Fox	4954.4	3.694992
			334 10 56.4	154 11 55.7	Cameron	8568.6	3.932908
Hike, 1913	26 16 47.481	1461.2	269 55 34.1	89 57 13.4	Armadillo 2	6220.0	3.793787
	97 20 37.023	1027.2	333 15 14.6	153 16 30.0	Fox	10520.8	4.022047
			349 54 18.1	169 54 35.3	Bank	6147.9	3.788727
Cat 2, 1913	26 19 44.168	1359.3	320 56 23.7	140 57 34.1	Armadillo 2	6993.3	3.844680
	97 19 31.669	878.3	18 26 33.1	198 26 04.1	Hike	5731.7	3.758283

Point Isabel to Corpus Christi—Continued.

Station.	Latitude and longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.	Logarithm of distance.
Principal points—Con.	° ′ ″		° ′ ″	° ′ ″		*Meters.*	
Green, 1913	26 23 33.607	1034.3	341 13 28.1	161 14 36.0	Armadillo 2	13193.2	4.120350
	97 19 25.890	717.6	1 18 00.8	181 17 58.2	Cat 2	7062.7	3.848973
			8 58 24.2	188 57 52.6	Hike	12653.1	4.102196
Water, 1913	26 21 34.877	1073.3	241 54 22.2	61 56 12.0	Green	7763.0	3.890028
	97 23 32.962	913.9	296 58 13.4	117 00 00.5	Cat 2	7508.4	3.875548
			331 06 09.2	151 07 27.2	Hike	10101.3	4.004378
Colorado, 1879	26 21 58.011	1785.3	81 58 57.9	261 57 37.0	Water	5097.4	3.707347
	97 20 30.909	856.9	211 29 22.6	31 29 51.5	Green	3450.2	3.537842
			338 15 15.0	158 15 41.3	Cat 2	4434.4	3.646837
Pelican 2, 1913	26 24 33.083	1018.1	288 06 00.3	108 07 30.1	Green	5887.6	3.769941
	97 22 47.792	1324.5	12 51 48.7	192 51 28.6	Water	5625.4	3.750152
Skin, 1913	26 26 43.921	1351.7	303 50 50.9	123 53 11.1	Green	10510.1	4.021606
	97 24 40.808	1130.6	322 07 08.6	142 07 59.0	Pelican 2	5101.0	3.707655
			348 48 43.3	168 49 13.5	Water	9694.9	3.986544
Storm, 1913	26 29 05.621	173.0	345 30 54.1	165 31 36.5	Green	10552.9	4.023373
	97 21 01.120	31.0	54 23 18.1	234 21 40.1	Skin	7486.7	3.874288
Rifle, 1879	26 29 31.509	969.7	277 53 17.3	97 54 49.8	Storm	5795.8	3.763110
	97 24 28.404	786.6	322 42 43.0	142 44 57.7	Green	13840.8	4.141160
			3 48 43.8	183 48 38.2	Skin	5169.0	3.713404
Sauz, 1913	26 32 16.012	492.8	309 57 34.2	129 59 26.9	Storm	9120.2	3.960005
	97 25 13.527	374.5	346 08 03.6	166 08 23.7	Rifle	5214.5	3.717215
Windy, 1913	26 34 55.632	1712.1	349 48 19.2	169 48 50.5	Storm	10944.4	4.039190
	97 22 11.061	306.1	20 52 24.8	200 51 23.4	Rifle	10675.1	4.028371
			45 48 15.4	225 46 53.8	Sauz	7045.3	3.847902
Lomalto, 1879	26 35 16.443	506.0	275 43 15.3	95 44 58.5	Windy	6409.1	3.806795
	97 26 01.512	41.8	346 20 48.5	166 21 30.1	Rifle	10923.9	4.038379
			346 32 46.7	166 33 08.2	Sauz	5709.5	3.756596
Back, 1913	26 39 54.221	1668.7	338 21 17.4	158 22 16.5	Windy	9885.9	3.995016
	97 24 22.834	631.4	17 42 51.1	197 42 06.9	Lomalto	8974.1	3.952989
Portalis 2, 1913	26 38 34.578	1064.2	239 36 37.6	59 37 45.5	Back	4846.6	3.685437
	97 26 54.021	1494.1	310 42 12.0	130 44 18.9	Windy	10328.8	4.014048
			346 35 50.1	166 36 13.7	Lomalto	6268.4	3.797157
Last Resort, 1913	26 42 22.128	681.0	307 34 41.8	127 36 23.9	Back	7461.7	3.872836
	97 27 56.680	1566.8	346 06 01.0	166 06 29.1	Portalis 2	7214.2	3.858190
Topo, 1878	26 45 17.918	551.4	326 42 45.6	146 44 32.0	Back	11915.5	4.076111
	97 28 19.328	534.1	349 14 16.4	169 14 54.7	Portalis 2	12635.3	4.101585
			353 23 57.7	173 24 07.9	Last Resort	5446.2	3.736097
Sea, 1913	26 45 05.558	171.1	6 02 59.0	186 02 38.3	Portalis 2	12100.2	4.082792
	97 26 07.913	218.7	30 52 16.9	210 51 28.0	Last Resort	5859.6	3.767867
			95 59 18.7	275 58 19.6	Topo	3651.0	3.562416
Mosquito 2, 1913	26 48 12.733	391.9	315 43 29.3	135 45 00.9	Sea	8043.8	3.905461
	97 29 31.137	860.0	339 45 21.9	159 45 54.3	Topo	5734.2	3.758476
Norwest, 1913	26 51 55.479	1707.5	24 04 13.8	204 02 41.9	Sea	13816.1	4.140385
	97 22 43.979	1214.0	58 39 04.5	238 36 00.7	Mosquito 2	13167.6	4.119506
Southeast, 1913	26 50 58.284	1793.8	258 56 14.5	78 58 42.1	Norwest	9190.6	3.963345
	97 28 10.737	296.4	342 38 18.3	162 39 13.7	Sea	11373.4	4.055889
			23 32 58.7	203 32 22.4	Mosquito 2	5557.8	3.744902
Avoca 2, 1913	26 52 45.842	1410.9	279 33 39.6	99 36 10.0	Norwest	9311.9	3.969036
	97 28 16.629	459.0	357 11 11.8	177 11 14.5	Southeast	3314.3	3.520393
			0 18 35.6	180 18 34.5	Topo	13785.8	4.139433
			13 45 25.1	193 44 51.5	Mosquito 2	8653.5	3.937192
Plank, 1913	26 54 39.507	1215.9	8 30 29.4	188 30 17.0	Norwest	5104.5	3.707949
	97 22 16.620	458.6	70 37 29.4	250 34 46.5	Avoca 2	10533.0	4.022552
Beat, 1913	26 56 37.758	1162.1	353 45 05.5	173 45 12.1	Plank	3661.2	3.563619
	97 22 31.061	856.8	2 21 00.8	182 20 55.0	Norwest	8695.0	3.939271
			53 12 16.4	233 09 40.0	Avoca 2	11910.8	4.075940

Point Isabel to Corpus Christi—Continued.

Station.	Latitude and longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.	Logarithm of distance.
Principal points—Con.	° ′ ″		° ′ ″	° ′ ″		*Meters.*	
Lopeña, 1913	26 59 00.443	13.6	294 59 27.4	115 02 02.2	Beat	10386.3	4.016459
	97 28 12.327	339.9	309 16 38.5	129 19 19.8	Plank	12679.4	4.103100
			0 35 23.9	180 35 22.0	Avoca 2	11529.8	4.061821
Buoy, 1913	27 01 28.052	863.4	357 05 25.0	177 05 32.5	Beat	8946.0	3.951629
	97 22 47.523	1310.0	63 07 15.5	243 04 48.0	Lopeña	10041.4	4.001795
Indian 2, 1912	27 01 57.038	1755.5	276 26 35.9	96 28 45.8	Buoy	7927.6	3.899140
	97 27 33.298	917.8	319 40 46.4	139 43 03.6	Beat	12884.8	4.110076
			11 12 01.9	191 11 44.2	Lopeña	5540.6	3.743558
Gum, 1913	27 04 46.437	1429.2	0 51 55.1	180 51 53.6	Buoy	6106.5	3.785794
	97 22 44.177	1217.2	40 21 53.5	220 19 24.4	Lopeña	13971.8	4.145251
			56 49 07.0	236 46 55.5	Indian 2	9521.8	3.978717
Con, 1913	27 05 32.693	1006.2	280 21 16.2	100 23 24.7	Gum	7907.2	3.898024
	97 27 26.497	730.0	314 23 11.7	134 25 18.6	Buoy	10760.8	4.031843
			1 37 03.6	181 37 00.5	Indian 2	6640.0	3.822169
Gap, 1913	27 07 57.586	1772.4	145 11 51.0	325 10 14.5	Salt	10189.8	4.008168
	97 22 31.280	861.4	186 04 34.4	6 04 42.3	Murdock	4539.6	3.657022
			3 27 21.9	183 27 16.0	Gum	5893.9	3.770401
			36 52 59.7	216 50 42.2	Indian 2	13870.1	4.142079
			61 16 36.6	241 14 22.1	Con	9274.0	3.967266
Coyote 2, 1913	27 08 33.252	1023.4	191 34 18.4	11 34 43.1	Salt	7418.9	3.870341
	97 26 56.686	1561.0	246 17 45.6	66 19 54.7	Murdock	8504.3	3.929639
			278 31 29.9	98 33 31.0	Gap	7390.6	3.868681
			315 05 23.4	135 07 18.5	Gum	9854.3	3.993626
			4 43 50.0	184 43 33.4	Indian 2	12236.3	4.087649
			8 24 22.6	188 24 09.1	Con	5617.6	3.749550
McGloins Bluff, 1860	27 49 36.229	1115.1					
	97 13 18.803	514.6					
Mustang, 1905	27 41 50.533	1555.4	164 14 05.98	344 12 57.10	McGloins Bluff	14895.51	4.1730554
	97 10 50.923	1395.2					
Laguna Madre north base, 1882.	27 40 10.565	325.2	195 56 24.20	15 57 48.81	McGloins Bluff	18108.92	4.2578927
	97 16 20.529	562.6	251 09 56.15	71 12 29.28	Mustang	9541.85	3.9796327
Laguna Madre south base, 1882.	27 37 25.926	798.0	202 32 12.50	22 32 48.11	Laguna Madre north base.	5486.86	3.7393234
	97 17 37.263	1021.6					
			233 47 42.86	53 50 51.50	Mustang	13797.55	4.1398019
Oso, 1912	27 42 40.650	1251.2	214 45 06.2	34 47 37.3	McGloins Bluff	15572.9	4.192369
	97 18 43.169	1182.7	276 46 07.2	96 49 46.8	Mustang	13030.0	4.114943
Shamrock, 1912	27 45 34.816	1071.7	7 27 41.8	187 27 26.5	Mustang	6962.5	3.842765
	97 10 17.924	490.8	68 51 23.7	248 47 28.6	Oso	14840.6	4.171452
			146 20 03.2	326 18 38.9	McGloins Bluff	8929.6	3.950831
Grants 2, 1912	27 37 33.861	1042.2	88 32 58.9	268 30 18.3	Laguna Madre south base.	9504.5	3.977929
	97 11 50.716	1390.5					
			123 07 42.1	303 05 36.9	Laguna Madre north base.	8829.8	3.945952
			191 42 53.8	11 43 21.6	Mustang	8068.7	3.906802
Island, 1912	27 36 08.151	250.9	161 14 06.1	341 13 52.4	Laguna Madre south base.	2528.3	3.402835
	97 17 07.598	208.4					
			253 05 23.8	73 07 50.6	Grants 2	9080.6	3.958113
Pass, 1912	27 34 41.333	1272.2	112 39 08.3	292 37 20.1	Island	6942.9	3.841539
	97 13 13.951	382.7	203 15 13.1	23 15 51.6	Grants 2	5780.2	3.761944
Sandhill, 1912	27 31 37.520	1154.9	158 18 10.4	338 17 14.5	Island	8965.7	3.952584
	97 15 06.728	184.6	208 39 57.0	28 40 49.2	Pass	6448.5	3.809460
Hardpan, 1912	27 33 44.114	1357.8	204 07 46.6	24 08 38.3	Laguna Madre south base.	7481.6	3.873997
	97 19 28.814	790.5					
			221 07 57.0	41 09 02.4	Island	5887.1	3.769901
			298 26 06.5	118 28 07.7	Sandhill	8178.8	3.912688
Landing, 1912	27 28 38.978	1199.7	195 32 02.7	15 32 46.7	Hardpan	9748.4	3.988933
	97 21 03.981	109.3	240 42 34.2	60 45 19.2	Sandhill	11240.7	4.050795
Richards 2, 1912	27 26 20.512	631.3	126 31 31.5	306 29 54.8	Landing	7163.0	3.855094
	97 17 34.315	942.4	167 02 43.2	347 01 50.3	Hardpan	14010.9	4.146467
			202 32 27.2	22 33 35.3	Sandhill	10565.2	4.023876

Point Isabel to Corpus Christi—Continued.

Station.	Latitude and longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.	Logarithm of distance.
Principal points—Con.	° ′ ″		° ′ ″	° ′ ″		*Meters.*	
Spit, 1912	27 25 53.833	1656.9	153 28 43.3	333 28 00.7	Landing	5681.2	3.754438
	97 19 31.578	867.3	255 41 17.0	75 42 11.0	Richards 2	3323.6	3.521605
Lonehill, 1912	27 23 06.738	207.4	197 04 10.7	17 05 03.4	Landing	10697.8	4.029295
	97 22 58.360	1603.6	227 49 45.8	47 51 21.1	Spit	7662.9	3.884391
			236 09 22.3	56 11 51.5	Richards 2	10714.9	4.029989
Mid, 1912	27 23 23.058	709.7	85 51 39.0	265 49 43.2	Lonehill	6932.3	3.840880
	97 18 46.720	1283.7	158 49 05.1	338 48 01.8	Landing	10429.0	4.018244
			200 00 14.4	20 00 47.7	Richards 2	5812.8	3.764384
Transient, 1912	27 20 21.245	653.9	134 23 21.5	314 21 54.4	Lonehill	7283.2	3.862324
	97 19 48.941	1345.3	172 20 28.7	352 19 54.0	Landing	15458.0	4.189152
			196 59 14.2	16 59 42.8	Mid	5851.5	3.767265
			198 29 12.1	18 30 13.9	Richards 2	11660.3	4.066708
Rox, 1912	27 21 06.675	205.4	220 30 27.9	40 31 20.7	Lonehill	4860.9	3.686717
	97 24 53.272	1464.2	279 28 13.8	99 30 33.6	Transient	8481.1	3.928451
Shells 2, 1912	27 13 54.671	1682.7	157 47 37.3	337 46 06.8	Rox	14363.1	4.157248
	97 21 35.767	984.1	172 23 34.4	352 22 56.4	Lonehill	17143.1	4.234089
			193 51 46.7	13 52 35.7	Transient	12255.6	4.088334
Griffins Point 2, 1912	27 15 44.429	1367.5	193 11 19.6	13 11 58.4	Rox	10187.3	4.008059
	97 26 17.840	490.7	201 55 42.4	21 57 13.8	Lonehill	14676.9	4.166634
			293 30 25.7	113 32 34.8	Shells 2	8463.5	3.927549
Salt, 1912	27 12 29.394	904.7	176 00 27.5	356 00 20.5	Griffins Point 2	6017.5	3.779417
	97 26 02.609	71.8	250 18 48.8	70 20 50.8	Shells 2	7797.8	3.891972
Murdock, 1912	27 10 24.253	746.5	121 27 58.5	301 26 14.0	Salt	7381.7	3.868158
	97 22 13.825	380.6	145 44 42.8	325 42 51.2	Griffins Point 2	11924.8	4.076451
			189 11 03.6	9 11 21.0	Shells 2	6560.5	3.816936
Rabbit 2, 1912	27 18 05.785	178.1	239 22 08.8	59 24 45.9	Rox	10934.5	4.038798
	97 30 35.596	978.8	301 31 23.1	121 33 21.2	Griffins Point 2	8317.5	3.919994
Penescal 2, 1912	27 14 45.492	1400.2	166 31 06.6	346 30 42.0	Rabbit 2	6339.5	3.802058
	97 29 41.847	1151.3	214 03 15.4	34 05 27.7	Rox	14163.9	4.151183
			252 04 28.6	72 06 02.0	Griffins Point 2	5897.9	3.770700
Frank 2, 1912	27 22 45.621	1404.2	296 26 14.5	116 27 57.0	Rox	6837.0	3.834865
	97 28 36.012	989.5	20 53 47.6	200 52 52.7	Rabbit 2	9218.8	3.964683
Agua, 1912	27 19 35.985	1107.6	236 22 41.4	56 25 08.2	Frank 2	10546.9	4.023126
	97 33 55.631	1529.4	296 46 17.3	116 47 49.1	Rabbit 2	6160.8	3.789637
Crawford 2, 1912	27 14 28.354	872.7	195 23 27.7	15 24 11.2	Agua	9821.0	3.992154
	97 35 30.443	837.5	230 27 05.1	50 29 20.2	Rabbit 2	10514.5	4.021787
			266 49 47.2	86 52 26.7	Penescal 2	9604.9	3.982495
Pasadiso, 1912	27 15 37.760	1162.2	226 04 10.8	46 06 17.8	Agua	10571.9	4.024154
	97 38 32.582	896.3	250 49 02.1	70 52 40.7	Rabbit 2	13886.9	4.142606
			293 04 43.4	113 06 06.8	Crawford 2	5447.0	3.736154
Supplementary points.							
Ranch, 1917	26 03 46.904	1443.4	87 59 36.0	267 58 19.9	Point Isabel, south base.	4819.4	3.682989
	97 13 16.279	452.5	118 43 20.8	298 42 30.1	Point Isabel, east base.	3660.8	3.563580
			220 46 45.4	40 47 07.1	Point Isabel L. H.	2100.6	3.322339
Brazos Santiago L. H., 1904, 1917.	26 04 18.244	561.4	80 01 26.9	260 00 00.3	Ranch	5560.7	3.745132
	97 09 59.250	1646.8	83 44 05.5	263 41 22.8	Point Isabel, south base.	10355.0	4.015150
			98 40 58.1	278 39 53.2	Point Isabel L. H.	4151.6	3.618215
Point Isabel northeast radio tower, 1917.	26 04 12.749	392.3	58 28 46.7	238 28 26.2	Ranch	1521.2	3.182188
	97 12 29.626	823.4	81 02 33.7	261 00 57.1	Point Isabel, south base.	6188.7	3.791596
			102 04 36.6	282 03 25.4	Point Isabel, east base.	4609.0	3.663606
			185 24 56.2	5 24 57.4	Point Isabel L. H.	798.8	2.902419

Point Isabel to Corpus Christi—Continued.

Station.	Latitude and longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.	Logarithm of distance.
Supplementary points—Contd.	° ′ ″		° ′ ″	° ′ ″		*Meters.*	
Point Isabel southwest radio tower, 1917.	26 04 08.196 97 12 36.810	252.2 1023.1	59 09 14.8 82 04 18.4	239 08 57.4 262 02 44.9	Ranch Point Isabel, south base.	1277.8 5970.6	3.106477 3.776016
			104 22 49.0	284 21 40.9	Point Isabel, east base.	4446.7	3.648034
			196 23 08.8	16 23 13.1	Point Isabel L. H.	974.9	2.988967
Windmill, 1913	26 59 15.060 97 27 36.849	463.5 1016.1	299 50 21.0 5 14 12.9 65 18 23.1	119 52 39.7 185 13 54.9 245 18 07.0	Beat Avoca 2 Lopeña	9724.4 12029.2 1076.8	3.987861 4.080237 3.032138
Fox reference mark, 1913.	26 11 43.517 97 17 48.175	1339.2 1337.6	311 49 21	131 49 22	Fox	62.64	1.79688
Bank reference mark, 1913.	26 13 30.960 97 19 58.522	952.8 1624.5	349 53 01	169 53 01	Bank	50.76	1.70545
Armadillo 2 reference mark, 1913.	26 16 47.500 97 16 53.648	1461.8 1488.5	255 11 44	75 11 44	Armadillo 2	23.24	1.36624
Hike reference mark, 1913.	26 16 48.295 97 20 38.855	1486.2 1078.0	296 14 37	116 14 38	Hike	56.65	1.75322
Cat 2 reference mark, 1913.	26 19 43.840 97 19 31.991	1349.2 887.2	221 31 44	41 31 44	Cat 2	13.50	1.13033
Green reference mark, 1913.	26 23 33.621 97 19 26.192	1034.7 726.0	272 56 46	92 56 46	Green	8.37	0.92273
Colorado reference mark, 1913.	26 21 57.810 97 20 31.387	1779.1 870.2	245 01 44	65 01 44	Colorado	14.62	1.16495
Water reference mark, 1913.	26 21 34.808 97 23 33.483	1071.2 928.3	261 38 04	81 38 04	Water	14.60	1.16435
Pelican 2 reference mark, 1913.	26 24 33.116 97 22 48.126	1019.1 1333.8	276 12 29	96 12 29	Pelican 2	9.32	0.96942
Skin reference mark, 1913.	26 26 43.576 97 24 41.345	1341.1 1145.5	234 30	54 30	Skin	18.27	1.26174
Rifle reference mark, 1913.	26 29 31.826 97 24 29.047	979.4 804.4	298 40 23	118 40 23	Rifle	20.30	1.30750
Sauz reference mark. 1913.	26 32 15.873 97 25 13.007	488.5 360.1	106 35	286 35	Sauz	15.02	1.17667
Lomalto reference mark, 1913.	26 35 16.877 97 26 02.374	519.4 65.7	299 16	119 16	Lomalto	27.34	1.43672
Portalis 2 reference mark, 1913.	26 38 34.309 97 26 54.665	1055.9 1511.9	245 06 20	65 06 20	Portalis 2	19.64	1.29314
Last Resort reference mark, 1913.	26 42 21.631 97 27 57.078	665.7 1577.8	215 44	35 44	Last Resort	18.84	1.27508
Topo reference mark, 1913.	26 45 18.374 97 28 17.192	565.5 475.0	76 37	256 37	Topo	60.68	1.78305
Mosquito 2 reference mark, 1912.	26 48 14.333 97 29 28.808	441.1 795.6	52 34	232 34	Mosquito 2	81.0	1.90848
Avoca 2 reference mark, 1912.	26 52 47.079 97 28 13.267	1449.0 366.2	67 41	247 41	Avoca 2	100.30	2.00130
Lopeña reference mark, 1913.	26 58 57.815 97 28 11.929	1779.4 328.9	172 16 09	352 16 09	Lopeña	81.62	1.91180
Indian 2 reference mark, 1912.	27 01 55.876 97 27 31.551	1719.8 869.6	126 36 57	306 36 56	Indian 2	59.98	1.77801
Con reference mark, 1913.	27 05 31.340 97 27 25.324	964.6 697.7	142 11 09	322 11 09	Con	52.70	1.72181

Point Isabel to Corpus Christi—Continued.

Station.	Latitude and longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.	Logarithm of distance.
Supplementary points—Contd.	° ′ ″		° ′ ″	° ′ ″		*Meters.*	
Coyote 2 reference mark, 1912.	27 08 32.739 97 27 01.869	1007.6 51.5	263 41 34	83 41 32	Coyote 2.....	143.6	2.15715
Salt reference mark, 1912.	27 12 29.544 97 26 03.226	909.3 88.8	285 11	105 11	Salt.....	17.59	1.24527
Murdock reference mark, 1912.	27 10 22.857 97 22 14.779	703.5 406.9	211 26	31 26	Murdock.....	50.36	1.70209
Carnestoliendos windmill, 1913.[1]	27 08 25.58 97 28 02.84	787.3 78.2	262 36 35 349 20 39	82 37 05 169 20 56	Coyote 2..... Con.....	1836.9 5414.5	3.264077 3.733555
McGloin's Bluff, Windmill, 1912.	27 49 33.422 97 13 09.757	1028.8 267.0	327 21 01.4 345 03 05.0 35 43 12.1	147 22 21.5 165 04 09.7 215 40 36.9	Shamrock..... Mustang..... Oso.....	8721.8 14746.6 15645.2	3.940606 4.168691 4.194382
Demit, 1912.....	27 41 36.057 97 15 02.786	1109.9 76.3	266 17 22.0 38 59 51.9	86 19 19.1 218 59 15.8	Mustang..... Laguna Madre north base.	6915.3 3385.8	3.839814 3.529658
Windmill A, 1912....	27 41 42.613 97 15 39.555	1311.7 1083.8	268 12 56.5 281 19 24.7 21 37 14.6	88 15 10.6 101 19 41.8 201 36 55.6	Mustang..... Demit..... Laguna Madre north base.	7912.1 1027.5 3047.7	3.898293 3.011770 3.483968
Welburn'shouse, 1912	27 41 38.327 97 15 25.115	1179.7 688.2	229 07 03.5 267 07 09.8 29 20 42.5	49 09 26.2 87 09 17.2 209 20 16.8	Shamrock..... Mustang..... Laguna Madre north base.	11126.2 7522.1 3098.9	4.046347 3.876341 3.491211
Shed on end of wharf, northeast gable,[1] 1912.	27 41 22.42 97 15 25.44	690.1 697.1	235 55 36 34 19 08	55 55 46 214 18 42	Demit..... Laguna Madre north base.	749.5 2677.7	2.874781 3.427755
Channel stake with cross, Laguna Madre,[1] 1912.	27 39 32.18 97 16 10.48	990.5 287.2	166 52 40 205 56 25	346 52 35 25 56 56	Laguna Madre north base. Demit.....	1213.1 4240.3	3.083888 3.627392
Channelstake in Laguna,[1] 1912.	27 41 00.19 97 15 18.31	5.8 501.7	48 08 54 201 04 19	228 08 25 21 04 26	Laguna Madre north base. Demit.....	2289.2 1183.2	3.359677 3.073052
Channelstake in Laguna,[1] 1912.	27 40 21.36 97 15 43.33	657.5 1187.4	71 57 23 205 47 08	251 57 05 25 47 26	Laguna Madre north base. Demit.....	1072.3 2553.7	3.030308 3.407162
Windmill D, 1912....	27 40 31.573 97 16 11.683	971.8 320.2	223 33 43.0 307 23 16.0 20 33 04.6	43 34 15.0 127 25 17.1 200 33 00.5	Demit..... Grants 2..... Laguna Madre north base.	2739.4 9005.1 690.6	3.437650 3.954487 2.839216
Windmillnear barn,[1] 1912.	27 38 52.55 97 17 22.95	1617.5 629.1	318 32 26 344 24 05	138 34 21 164 25 08	Pass..... Sandhill.....	10315.4 13901.7	4.013488 4.143069
Mexican house (center),[1] 1912.	27 38 50.07 97 17 05.71	1541.2 156.5	0 35 39 18 28 05	180 35 38 198 27 50	Island..... Laguna Madre south base.	4984.3 2730.7	3.697601 3.436270
Windmillnear green-roofed house,[1] 1912.	27 38 53.90 97 17 02.06	1659.0 56.5	1 42 16 19 36 59	181 42 13 199 36 43	Island..... Laguna Madre south base.	5104.1 2874.7	3.707918 3.458595
Brighton Schoolhouse, east gable,[1] 1912.	27 38 38.45 97 17 16.10	1183.5 441.3	357 06 49 14 34 03	177 06 53 194 33 53	Island..... Laguna Madre south base.	4632.1 2306.5	3.665782 3.362951
Windmill, near Duncan's house, 1912.	27 38 17.207 97 17 32.364	529.6 887.2	313 08 31.3 350 17 52.1 4 51 47.8	133 10 31.1 170 18 03.6 184 51 45.6	Pass..... Island..... Laguna Madre south base.	9714.1 4030.0 1584.2	3.987403 3.605305 3.199799
Motte 1912.[1].....	27 35 16.45 97 19 19.03	506.3 521.9	246 10 12 276 08 16	66 11 13 96 11 05	Island..... Pass.....	3940.0 10071.4	3.595501 4.003088

[1] No check on this position.

Point Isabel to Corpus Christi—Continued.

Station.	Latitude and longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.	Logarithm of distance.
Supplementary points—Contd.	° ′ ″		° ′ ″	° ′ ″		*Meters.*	
House, red roof, center,[1] 1912.	27 39 26.89	827.7	320 16 32	140 18 35	Pass	11425.2	4.057865
	97 17 40.16	1100.8	351 41 43	171 41 58	Island	6182.1	3.791139
Barnes's house, south gable, 1912.	27 34 37.759	1162.2	234 45 44.3	54 46 50.8	Island	4823.3	3.683348
	97 19 31.257	857.4	257 19 47.8	77 20 14.1	Puzzle	1598.3	3.203657
			357 40 32.7	177 40 33.8	Hardpan	1652.6	3.218157
Puzzle, 1912	27 34 49.145	1512.7	224 23 09.5	44 23 49.7	Island	3403.2	3.531885
	97 18 34.405	943.7	315 58 39.8	136 00 15.9	Sandhill	8200.7	3.913852
Windmill at Barnes's house, 1912.	27 34 38.672	1190.3	235 03 25.8	55 04 32.4	Island	4809.7	3.682118
	97 19 31.369	860.4	269 31 21.1	89 34 15.8	Pass	10352.5	4.015046
			307 30 22.5	127 32 24.9	Sandhill	9154.5	3.961636
			357 36 36.2	177 36 37.4	Hardpan	1680.8	3.225515
Windmill,[1] 1912	27 33 07.34	225.9	281 38 33	101 42 18	Sandhill	13664.0	4.135577
	97 23 14.41	395.4	309 11 29	129 13 44	South Bird	10344.5	4.014708
Twin Windmills, south twin,[1] 1912.	27 30 53.11	1634.7	263 48 49	83 52 22	Sandhill	12744.2	4.105312
	97 22 48.43	1329.2	288 13 46	108 15 49	South Bird	7690.2	3.885938
Twin Windmills, north twin,[1] 1912.	27 30 53.34	1641.8	263 50 09	83 53 42	Sandhill	12726.7	4.104716
	97 22 47.82	1312.4	288 19 01	108 21 04	South Bird	7676.4	3.885155
South Bird, 1912	27 29 34.886	1073.8	166 37 43.2	346 37 12.5	Hardpan	7885.1	3.896807
	97 18 22.342	613.3	243 52 38.3	54 54 08.7	Sandhill	6562.9	3.817097
North Bird, 1912	27 31 07.170	220.7	27 44 27.7	207 44 02.6	South Bird	3209.2	3.506402
	97 17 27.922	766.3	145 31 55.7	325 30 59.8	Hardpan	5860.0	3.767894
			256 26 08.0	76 27 13.2	Sandhill	3985.8	3.600513
Lone Spanish dagger, 1912.	27 29 35.593	1095.6	89 08 01.2	269 07 37.1	South Bird	1433.5	3.156396
	97 17 30.126	827.0	156 56 39.7	336 55 44.9	Hardpan	8314.0	3.919808
			226 21 09.2	46 22 15.4	Sandhill	5438.2	3.735453
Stake on flat off South Bird Island,[1] 1912.	27 29 30.51	939.1	59 51 14	239 50 28	Landing	3157.9	3.499392
	97 19 24.52	673.1	179 08 04	359 08 02	Hardpan	7806.7	3.892468
Wind,[1] 1912	27 27 27.97	860.9	229 06 35	49 07 17	Landing	3339.1	3.523631
	97 22 35.93	986.6	238 03 05	58 06 32	Sandhill	14527.3	4.162184
Large Motte, approximate center,[1] 1912.	27 19 58.98	1815.3	215 00 38	35 01 02	Rox	2544.0	3.405518
	97 25 46.38	1275.0	6 18 13	186 17 59	Griffins Point 2	7882.4	3.896660
Lone pita, double highest point,[1] 1912.	27 22 23.92	736.2	69 24 50	249 23 04	Rox	6757.0	3.829757
	97 21 03.12	85.7	112 36 19	292 35 26	Lonehill	3429.8	3.535265
Buena Vista Hotel, south chimney,[1] 1912.	27 17 17.75	546.3	247 00 43	67 03 30	Agua	10904.6	4.037608
	97 40 00.79	21.7	264 31 50	84 36 09	Rabbit 2	15612.3	4.193468
Buena Vista Hotel, north chimney,[1] 1912.	27 17 18.25	561.7	247 04 59	67 07 46	Agua	10897.6	4.037332
	97 40 00.75	20.6	264 35 08	84 39 27	Rabbit 2	15609.8	4.193397
Buena Vista Hotel, elevated wooden tank,[1] 1912.	27 17 17.89	550.7	247 18 19	67 21 08	Agua	11027.6	4.042480
	97 40 05.70	156.7	264 35 30	84 39 51	Rabbit 2	15746.6	4.197186
Windmill with tank, 1912.	27 14 35.117	1080.9	315 52 38.5	135 54 42.8	Murdock	10752.9	4.031526
	97 26 45.762	1259.0	93 46 56.4	273 45 35.8	Penescal 2	4854.9	3.686178
			135 44 31.4	315 42 46.1	Rabbit 2	9055.6	3.956919
Kenedy ranch standpipe, 1912.	27 13 00.347	10.7	226 29 29.5	46 33 03.4	Agua	17697.2	4.247905
	97 41 42.518	1170.1	242 49 31.1	62 54 36.5	Rabbit 2	20614.0	4.314163
			260 41 06.0	80 46 35.7	Penescal 2	20091.3	4.303009

[1] No check on this position.

For the convenience of the draftsmen of this office there are given the following unadjusted positions of stations which are lost or for some reason have no value except for the coordination of the old work:

Lost stations.

POINT ISABEL TO CORPUS CHRISTI.

Station.	Latitude and longitude.	Seconds in meters.	Station.	Latitude and longitude.	Seconds in meters.
	° ′ ″			° ′ ″	
Shamrock Island barn, southwest gable, 1905.	27 45 47.68 97 10 08.51	1467.8 233.1	Wheelbarrow, 1877	27 20 45.47 97 19 41.14	1399.5 1130.8
Thompsons, 1876	27 43 11.50 97 08 37.95	354.0 1039.6	Willow, 1877	27 19 11.64 97 21 27.49	358.3 755.8
Flour Bluff, 1860	27 42 00.46 97 16 12.88	14.2 352.9	Kenedy, 1877	27 18 53.43 97 26 38.58	1644.5 1060.7
Windmill No. 2, 1905	27 41 33.15 97 15 35.02	1020.2 959.7	Tree, 1877	27 17 54.17 97 35 56.81	1667.3 1562.2
Windmill No. 1, 1905	27 40 34.40 97 17 16.30	1058.9 446.8	Bovido, 1877	27 17 27.08 97 39 35.62	833.5 979.6
Water tank near Laguna Madre, north base, 1905.	27 40 12.63 97 16 21.23	388.8 581.7	Rabbit, 1877	27 17 49.08 97 30 47.27	1510.6 1299.9
Jack, 1877	27 39 22.06 97 16 31.37	679.0 859.8	Kenedy's warehouse, south gable, 1877.	27 16 39.31 97 30 54.48	1209.9 1498.4
Ritter's windmill, 1905	27 39 13.34 97 16 57.89	410.5 1586.7	Griffins Point, 1877	27 15 44.36 97 26 17.86	1365.4 491.3
Grants, 1877	27 38 28.42 97 11 17.31	874.8 474.5	Penescal, 1877	27 14 54.79 97 29 19.02	1686.4 523.2
Camp, 1876	27 37 35.87 97 13 32.40	1104.1 888.3	Crawford, 1877	27 14 28.56 97 35 30.76	879.0 846.3
Padre, 1905	27 36 56.35 97 13 45.40	1734.4 1244.8	Penescal house, north gable, 1877.	27 14 26.25 97 30 04.20	807.9 115.6
Brighton post office, north gable,[1] 1905.	27 36 41.82 97 18 00.01	1287.2 0.3	Shells, 1877	27 13 54.71 97 21 35.82	1683.9 985.6
Ford, 1877	27 36 16.33 97 13 46.10	502.6 1264.2	Rock Pen, 1877	27 12 57.54 97 25 55.06	1771.0 1515.1
Peat Island, 1877	27 34 48.15 97 18 42.71	1482.1 1171.5	Murdock's landing, 1877	27 11 16.55 97 22 51.43	509.4 1415.6
Chappa, 1877	27 32 59.77 97 14 14.07	1839.7 386.0	Coyote, 1877	27 09 05.55 97 26 49.34	170.8 1358.6
Bird, 1877	27 31 00.87 97 16 08.26	26.8 226.7	Venando, 1877	27 08 11.35 97 22 30.37	349.3 836.3
Peg, 1877	27 31 47.05 97 20 14.06	1448.2 385.8	Gum Pen, 1878	27 05 04.86 97 23 08.90	149.6 245.2
Mott, 1877	27 28 21.14 97 21 59.70	650.7 1639.1	Indian, 1878	27 01 37.01 97 27 32.51	1139.1 896.4
Richards, 1877	27 26 20.51 97 17 34.29	631.3 941.7	Station Hill, 1878	27 00 52.50 97 22 48.22	1615.8 1329.3
Cow, 1877	27 25 20.29 97 22 13.97	624.5 383.7	New, 1878	26 59 44.10 97 27 04.49	1357.3 123.8
Camp No. 2, 1877	27 23 15.29 97 20 22.11	470.6 607.5	Sand, 1878	26 57 25.25 97 23 18.36	777.1 506.4
Frank, 1877	27 22 45.79 97 28 35.97	1409.4 988.4	Stoley, 1878	26 54 34.85 97 22 18.99	1072.6 524.0
Point of Rocks, 1877	27 21 42.79 97 23 57.97	1317.0 1593.1	Avoca, 1878	26 53 35.78 97 28 40.08	1101.2 1106.1

[1] No check on this position.

Lost stations—Continued.

POINT ISABEL TO CORPUS CHRISTI—Continued.

Station.	Latitude and longitude.	Seconds in meters.	Station.	Latitude and longitude.	Seconds in meters.
	° ′ ″			° ′ ″	
Crossing, 1878	26 50 56.85 97 22 30.51	1749.7 842.3	Santa Cruz, 1879	26 24 35.30 97 14 04.32	1086.4 119.7
Mosquito, 1878	26 48 15.84 97 28 47.84	487.5 1321.3	Crane, lone palmetto tree, 1879.	26 22 19.16 97 14 59.64	589.6 1653.4
Tank, 1878	26 46 29.67 97 20 36.98	913.2 1021.6	Oil, 1879	26 20 27.53 97 12 17.54	847.2 486.4
Rainy, 1878	26 41 57.55 97 20 00.78	1771.2 21.6	Cat, 1879	2 6 19 42.91 97 19 33.48	1320.6 928.5
Portalis, 1878	26 38 34.44 97 26 53.74	1059.9 1486.3	Snipe, 1879	26 14 30.80 97 18 23.18	947.8 643.3
Gladiator, 1878	26 37 12.10 97 17 46.09	372.4 1275.0	Mesena, 1867	26 05 07.46 97 17 02.04	229.7 56.6
Brant, 1879	26 34 17.02 97 17 21.73	523.8 601.4	Brazos Beacon, 1867	26 03 40.13 97 09 14.91	1234.9 414.4
Bonnet, 1878	26 30 27.81 97 24 42.48	855.9 1176.3	Wolf Trap, 1854	26 00 29.28 97 12 53.76	901.2 1494.9
Waterhole, 1879	26 30 42.78 97 15 25.11	1316.6 695.3	Boca Chica 2, 1867	26 00 19.31 97 09 08.91	594.3 247.7
Duck, 1879	26 27 47.34 97 14 48.78	1456.9 1351.3	Rio Grande Observatory, 1853.	25 57 17.15 97 08 49.31	527.8 1371.9
Pelican, 1879	26 24 33.48 97 22 45.76	1030.3 1268.0			

DESCRIPTION OF STATIONS.

This list may be conveniently consulted by reference to the illustrations at the end of this publication or to the index. All azimuths given in the descriptions are reckoned continuously from true south around by west to 360°, south being 0°, west 90°, north 180°, and east 270°. Where magnetic azimuths are given they are indicated as such.

In general, except where the contrary is specificially stated, the surface and underground mark are not in contact, so that a disturbance of the surface mark will not necessarily affect the underground mark. The underground mark should be resorted to only in cases where there is evidence that the surface mark has been disturbed.

The name and dates given in each description immediately after the county refer to the chief of party by whom the station was established, the date of the establishment of the station, and the date when the station was last recovered.

Any person who finds that one of the stations herein described has been 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.

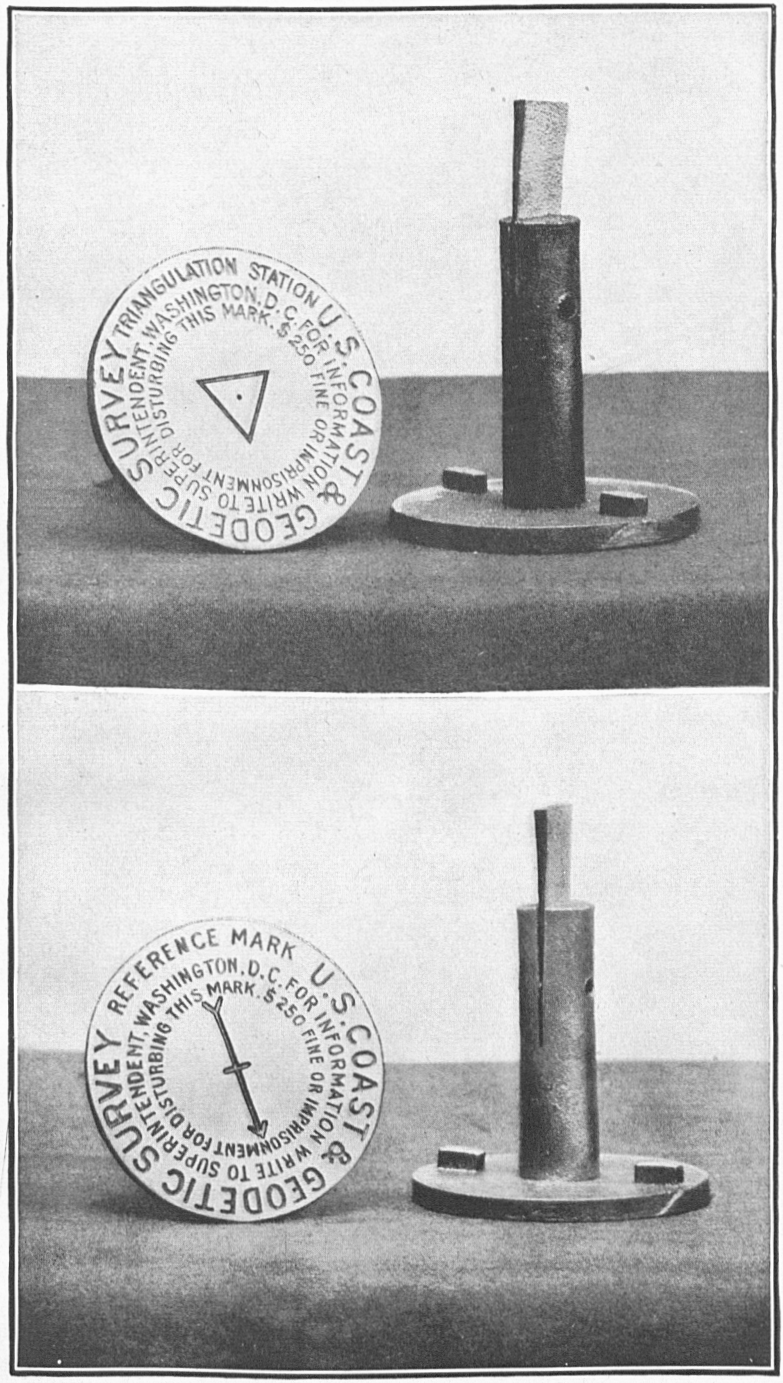

Fig. 10.—STANDARD TRIANGULATION STATION AND REFERENCE MARKS.

MARKING OF STATIONS.

The standard disk station and reference marks referred to in the following descriptions and notes consist of a disk and shank of brass cast in one piece, as shown in figure No. 10. The disk of the station mark is 90 mm. in diameter, with a hole at the center surrounded by a 20 mm. equilateral triangle, and has the following inscribed legend: "U. S. Coast and Geodetic Survey Triangulation Station. For information write to the Superintendent, Washington, D. C. $250 fine or imprisonment for disturbing this mark." The shank is 25 mm. in diameter and 80 mm. long, with a slit at the lower end into which a wedge is inserted so that when it is driven into a drill hole in the rock it will bulge at the bottom and hold the mark firmly in place.

The standard disk reference mark, shown in figure No. 10, is the same size and shape as the station mark, with an arrow on the top in place of the triangle, which, when properly set, points to the station. The legend is the same, except the words "reference mark" take the place of the words "triangulation station."

The following notes on the marking of stations are made as general as possible in order that it may not be necessary in the field to describe small and unimportant variations:

NOTES DESCRIBING SURFACE AND SUBSURFACE STATION MARKS, REFERENCE, AND WITNESS MARKS.

Note 1.—A standard disk station mark set in the top of (*a*) a square block or post of concrete, (*b*) a concrete cylinder, (*c*) an irregular mass of concrete.

Note 2.—A standard disk station mark wedged in a drill hole in outcropping bed rock (*a*) and surrounded by a triangle chiseled in the rock, (*b*) and surrounded by a circle chiseled in the rock, (*c*) at the intersection of two lines chiseled in the rock.

Note 3.—A standard disk station mark set in concrete in a depression in outcropping bedrock.

Note 4.—A standard disk station mark wedged in a drill hole in a bowlder.

Note 5.—A standard disk station mark set in concrete in a depression in a bowlder.

Note 6.—A standard disk station mark set in concrete at the center of the top of a tile (*a*) which is embedded in the ground, (*b*) which is surrounded by a mass of concrete, (*c*) which is fastened by means of concrete to the upper end of a long wooden pile driven into the marsh, (*d*) which is set in a block of concrete and projects from 12 to 20 inches above the block.

Note 7.—A block of concrete 3 feet below the ground containing at the center of its upper surface (*a*) a standard disk station mark, (*b*) a copper bolt projecting slightly above the concrete, (*c*) an iron nail with the point projecting above the concrete, (*d*) a glass bottle with the neck projecting a little above the concrete, (*e*) an earthenware jug with the mouth projecting a little above the concrete.

Note 8.—In bedrock (*a*) a standard disk station mark wedged in a drill hole, (*b*) a standard disk station mark set in concrete in a depression, (*c*) a copper bolt set in cement in a drill hole or depression, (*d*) an iron spike set point up in cement in a drill hole or depression.

Note 9.—In a bowlder 3 feet below the ground (*a*) a standard disk station mark wedged in a drill hole, (*b*) a standard disk station mark set in concrete in a depression, (*c*) a copper bolt set with cement in a drill hole or depression, (*d*) an iron spike set with cement in a drill hole or depression.

Note 10.—Embedded in earth 3 feet below the surface of the ground (*a*) a bottle in an upright position, (*b*) an earthenware jug in an upright position, (*c*) a brick in a horizontal position with a drill hole in its upper surface.

Note 11.—A standard disk reference mark with the arrow pointing toward the station set at the center of the top of (*a*) a square block or post of concrete, (*b*) a concrete cylinder, (*c*) an irregular mass of concrete.

Note 12.—A standard disk reference mark with the arrow pointing toward the station (*a*) wedged in a drill hole in outcropping bedrock, (*b*) set in concrete in a depression in outcropping bedrock, (*c*) wedged in a drill hole in a bowlder, (*d*) set in concrete in a depression in a bowlder.

Note 13.—A standard disk reference mark with the arrow pointing toward the station, set in concrete at the center of the top of a tile (*a*) which is embedded in the ground, (*b*) which is surrounded by a mass of concrete, (*c*) which is fastened by means of concrete to the upper end of a long wooden pile driven into the marsh, (*d*) which is set in a block of concrete and projects from 12 to 20 inches above the block.

Note 14.—A conical mound of earth surrounded by a circular trench.

Note 15.—A tree marked with (*a*) a triangular blaze with a nail at the center and each apex of the triangle, (*b*) a square blaze with a nail at the center and each corner of the square, (*c*) a blaze with a standard disk reference mark set at its center into the tree.

Note 16.—This station is marked by a cement post which is 2½ feet long and 7½ inches in diameter, incased in a pipe of tin. A standard disk station mark is set into the center of the top of the column. The subsurface mark is a nail or small wooden peg set into a small quantity of cement, which is 6 inches below the cement post. Six inches of sand or earth separates the surface and subsurface marks. The top of the surface mark projects about 2 inches above the ground.

Note 17.—The reference mark is a cement post 2½ feet long and 7½ inches in diameter, incased in a pipe of tin. A standard disk reference mark is set into the top of the post. The tablet has an arrow which points toward the station. The top of the cement post is about 6 inches above the ground.

Note 18.—The station is marked by a cement post which is 2½ feet long and 7½ inches in diameter, incased in a pipe of tin. A standard disk station mark is set into the center of the top of the post. The subsurface mark is a piece of lead or copper set into a piece of coral rock. Six inches of sand or earth separates the surface and subsurface marks. The top of the surface mark projects about 2 inches above the ground.

Note 19.—The station mark is a standard disk station mark set into a cement post which is incased in a square wooden box. The cement post is 6 inches square and 2 feet long and projects from 2 to 6 inches above the surface of the ground. The subsurface mark is a small amount of concrete into which is placed a small round stick to mark the center of the station. About 3 inches of earth or sand separates the surface and subsurface marks.

Note 20.—The reference mark is a standard disk reference mark set into a cement post which is incased in a square wooden box. The cement post is 6 inches square and 2 feet long and projects from 2 to 6 inches above the surface of the ground.

Note 21.—The reference mark is a cement post 2½ feet long and 5½ inches in diameter, incased in a pipe of tin. A standard disk reference mark is set into the top of the post. The tablet has an arrow which points toward the station. The top of the cement post is about 6 inches above the surface of the ground.

Note 22.—Trenches about 1½ feet deep and 2 feet wide were dug out from the station in north, east, south, and west directions to serve as reference or witness marks.

Note 23.—The station is marked with the point of a nail projecting from a block of concrete set about 3 feet below the surface. Above this block are several inches of earth or sand, then a larger cylinder or block of concrete extending to the surface, with the point of a large nail projecting from it. The nails indicate the center of the station. The letters U. S. C. & G. S., with date of establishment of the station, are cut into the top of the surface mark.

Note 24.—The underground mark is a block of concrete set into the ground with its top about 3 feet below the surface. The point of a large nail projecting from the concrete indicates the center of the station.

Note 25.—The reference mark is a cylinder of concrete about 3 feet long from the center of the top of which projects the point of a large nail.

Note 26.—The surface mark is the point of a nail projecting from the top of a column of concrete about 2 feet long, which is imbedded in the ground.

Note 27.—The surface mark consists of a piece of terra-cotta sewer pipe 4 inches in diameter and 2 feet long, filled with concrete and incased in a cylinder of concrete about 18 inches in diameter and 2 feet long. In the center of the top of the pipe is placed a large wire spike, the point of which projects about ¼ inch above the concrete and indicates the center of the station. The top of the column of concrete is marked U. S. C. & G. S. 1905. The subsurface mark consists of a piece of terra-cotta sewer pipe, 4 inches in diameter and 2 feet long, filled with concrete and incased in a cylinder of concrete 12 inches in diameter and 2 feet long. The point of a spike projects about ¼ inch above the center of the top of the concrete and indicates the center of the station. The surface and subsurface marks are separated by about 6 inches of sand. The reference mark is a piece of terra-cotta sewer pipe, 4 inches in diameter and 2 feet long, filled with concrete and incased in a concrete cylinder about 12 inches in diameter and 2 feet long. The point of a large spike projecting from the center of the top of the column of concrete is the center of the reference mark. The top of the column of concrete is even with the surface of the ground.

Note 28.—The station is marked at the surface by a cedar stub with a copper tack in its top; the stub projects from 6 to 18 inches above the surface of the ground. The subsurface mark is a concrete pyramid or coral rock, buried from 3 to 4 feet below the surface of the ground, with a hole in the center of the top filled with lead. Four reference stubs were placed around the station at distances of from 4 to 6 feet from the station. These stubs were usually of cedar.

Note 29.—The subsurface mark is a concrete pyramid or coral rock, buried from 3 to 4 feet below the surface of the ground, with a hole in the top filled with lead. There is no surface mark except the center pole of the signal on which observations were made.

NINETY-EIGHTH MERIDIAN, ALICE TO RIO GRANDE AND POINT ISABEL.

PRINCIPAL POINTS.

Wood (Jimwells County, W. H. Burger, 1904; 1913).—Nine miles S. 87° E. of Alice, 3½ miles south of the Mexican National Railway, in a large pasture owned by John H. Wood, who lives in Beeville, and leased to a Frank A. Welder, of Victoria. The station is near a windmill and circular tank in the pasture, being 35.73 meters from the windmill, in azimuth 25° 27.9′, and 22.50 meters from the nearest edge of the tank. The tank and windmill are on a small ridge and are inclosed in a fence. The station was marked in the following manner: A hole was dug 18 inches in diameter to a depth of 2 feet, then 1 foot in diameter to a depth of 4½ feet. In this was set the lower or underground mark, a 2-inch iron pipe, 2 feet long; the hole was then filled level with the top of the pipe with a concrete made of Portland cement, sand, and broken rock.

The pipe was filled with concrete and a 60-penny steel wire nail was set in the center of the top, with its point projecting ¼ inch, to mark the center of the station. Over this was placed 6 inches of sand. Then the surface mark, a similar piece of pipe, was plumbed directly over the lower mark, and the hole and pipe filled with concrete level with the surface. A 60-penny steel wire nail set in the center of the top of this pipe, with its point projecting, marked the center of the station. The top of the concrete was then covered with ½ inch of cement, on which were inscribed the letters U. S. C. & G. S. and the year. The reference mark, an iron pipe, 2 feet long, set in a hole 1 foot in diameter, surrounded and filled with concrete, with a 60-penny wire nail projecting ¼ inch above the top of the pipe, which was level with the surface of the ground, is in the south corner of the inclosure in which the windmill stands, 2.87 meters from the windmill, and 33.738 meters from the station in azimuth 209° 15′. The following azimuths are from the triangulation station: Alice Methodist Church spire 101° 20′ 46″; chimney on large ranch house, distant 4 miles, 9° 33′ 45″. In 1913 the reference mark was not recovered, as the circular tank, or water hole, had been cleaned out and the mark was deeply covered with dirt. The windmill was still standing, but was no longer inclosed by fence.

Alice west base (Jimwells County, Stehman Forney, 1900; 1913).—Eleven miles by road from Alice, 3½ miles west of the Brownsville and Alice wagon road, on that part of the Coloraras ranch belonging to Luciano Garcia, and about 300 yards northeast of his house. To reach the station from Alice follow the Brownsville road, which runs S. 30° E., for 8 miles to a gate leading west to Joe Garcia's house; this gate is 438 meters north of the base line where it crosses the Brownsville road. Passing through the gate, go westward about 3½ miles, past the house of Joe Garcia, to the top of a small ridge on which is the triangulation station. The underground stone is 6 inches square and 12 inches long, embedded in concrete, with its top 24 inches below the top of the surface stone. This surface stone is of limestone, 24 inches square and 14 inches deep, and is embedded in a mass of concrete 48 inches square and 22 inches deep. In each stone the exact center of the station is marked by a station mark composed of copper and brass and having a shank 76 millimeters long with a slit in its lower end into which a brass wedge is inserted, so that when the bolt is driven home it bulges at the bottom of the hole, which is made larger there than at the top, and in this manner the mark is securely fastened in place. The top of the station mark is 80 millimeters in diameter, with an inner circle (countersunk) 37 millimeters in diameter. The letters U. S. C. & G. S. are cast on the space between the inner and outer circles. The station mark in the underground stone is protected by a wooden box. The reference mark, an iron pipe 2 feet long, set in a hole 1 foot in diameter, surrounded and filled with concrete, with a 60-penny nail projecting ¼ inch above the top of the pipe, which was level with the surface of the ground, is at the same elevation as the station and 36.335 meters from it in azimuth 197° 54′ 54″; it is 18 paces south of the wagon road leading south to several Mexican shacks. The following azimuths are from the triangulation station: North gable Mexican shack, distant ⅛ mile, 70° 24′ 07″; north gable of ranch house, distant 3 miles, 155° 53′ 44″; north chimney of Mexican shack, distant ⅛ mile, 201° 14′ 48″; Joe Garcia's windmill, distant ⅜ mile, 262° 49′ 33″.

King (Nueces County, C. V. Hodgson, 1913).—On a rather prominent low knoll about 5½ miles from Kingsville, in azimuth 296° 53′ 03″, from the standpipe there and 3 miles from the King home ranch, in azimuth 328° 11′ 42″ from it, a few meters east of the Alice-Kingsville and King ranch wagon road in a pasture owned by Mrs. King. The station is marked as in notes 1b and 7a,[1] with a reference mark as described in note 11b,[1] set 16.338 meters (53.60 feet) from the station, in azimuth 52° 25′ 07″, at the same elevation as the station mark and almost in the line of the telephone poles at the west side of the road.

[1] See pp. 57-59.

Bishop (Kleberg County, C. V. Hodgson, 1913).—About 1¼ miles east and ¼ mile south from Bishop, in south side of small pasture on land owned by R. T. Moudy, and about ¼ mile south of his house, near the main road leading east from Bishop. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set 204.29 meters (670.2 feet) from the station, in azimuth 287° 36′ 32″, in a boundary fence line at same elevation as station mark.

Kleberg ecc. (Kleberg County, C. V. Hodgson, 1913).—About 7 miles south and 4 miles east from Kingsville, 2½ miles east and 1 mile south from Ricardo, on land owned by the Kleberg Land & Improvement Co., near the east side center of block 57, on a small ridge covered by mesquite trees and about 75 meters (246 feet) west of the wagon road. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set 20.070 meters (65.8 feet) from the station, in azimuth 190° 16′ 37″, and at same elevation as the station. Station is occupied eccentrically and all lights shown from the eccentric station.

Ricardo (Kleberg County, C. V. Hodgson, 1913).—About 6½ miles west and 2 miles south from Ricardo, 7 miles south 10 degrees west from the King home ranch, on a small knoll covered with mesquite trees on land owned by Mrs. King. A wind pump at an artesian well is about 1 mile distant, in azimuth 283° 04′ 38″. No roads opened near-by at present. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set 29.465 meters (96.7 feet) from the station, in azimuth 278° 04′ 56″, and at the same elevation as station mark.

Riviera (Kleberg County, C. V. Hodgson, 1913).—About 4 miles due west from Riviera, near the center of the top of a rather prominent round knoll, on pasture land owned by Mrs. King, the only elevation of the kind in the vicinity. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set 30.780 meters (101.0 feet) from the station, in azimuth 265° 45′ and at the same elevation as station mark.

Robbins (Kleberg County, C. V. Hodgson, 1913).—About 4½ miles, in azimuth 81° 27′ 25″, from the Riviera schoolhouse and ¾ of a mile north of the Riviera Beach Railroad, on land owned by Mr. S. C. Kile, of San Antonio, and now rented by Mr. Charles Robbins. The southeast corner of Mr. Robbins's house is 22.6 meters (74.1 feet) distant, in azimuth 70° 53′ 28″. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set 25.442 meters (83.5 feet) from the station, in azimuth 172° 17′ 33″ and at the same elevation as the station mark.

Sarita (Willacy County, C. V. Hodgson, 1913).—About 5½ miles southeast from Sarita, in azimuth 141° 41′ 22″, from the standpipe there, in one of John Kenedy's pastures, on a high sand knoll known locally to the range riders as La Cruz, owing to its being at the intersection of two ridges. The knoll is covered with live oak bushes and surrounded by live oak timber for several miles, being about 2 miles from the north edge of the timber. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set 16.44 meters (53.9 feet) from the station (horizontal distance) and 3.45 meters (11.3 feet) below it, in azimuth 293° 05′ 36″.

Roza (Willacy County, C. V. Hodgson, 1913).—About 6½ miles southwest from Sarita, on the Santa Roza ranch, about 300 meters southeast of the ranch house and 32 paces southeast of a Mexican shack. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set on the south side of a wire fence, 21.120 meters (69.3 feet) from the station, in azimuth 94° 11′ 56″ and at the same elevation as the station.

Turcotte (Willacy County, C. V. Hodgson, 1913).—About 4¾ miles from the section house at Turcotte, in azimuth 302° 20′ 50″ from it, at the center of the top of a prominent knoll on the north side of a large salt lake, about 10 meters (33 feet) from the top of the bluff at the edge of the lake, on land owned by John Kenedy. The station is

[1] See pp. 57–59.

marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set 19.640 meters (64.4 feet) from the station (horizontal) and 1.22 meters (4.00 feet) below it, in azimuth 82° 25′ 22″.

Kenedy (Willacy County, C. V. Hodgson, 1913).—About 3 miles from the section house at Turcotte, in azimuth 68° 30′ 27″ from it, on a sand knoll in the Kenedy pastures, about 75 meters (246 feet) to the eastward of an old wagon trail leading from the southwest to an artesian well, which is at the north edge of a large thicket of bushes about 1 mile from the station, in azimuth 192° 01′ 13″. The station is marked as in notes 1b and 7a.[1] The last time the station was visited, in 1913, the reference mark was covered by sand and could not be found.

Armstrong (Willacy County, C.V. Hodgson, 1913).—About 3 miles from the railroad water tank at Armstrong, in azimuth 124° 13′ 54″ from it, about 2 miles from the Armstrong ranch house in azimuth 163° 31′ 16″, on a sand knoll in the vicinity of a number of shifting sand hills in the Armstrong pastures. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set 23.325 meters (76.5 feet) from the station in azimuth 341° 57′ 28″ and at the same elevation as the station.

Katherine (Willacy County, C.V. Hodgson, 1913).—About 5 miles from the railroad water tank at Armstrong in azimuth 249° 13′ 34″ from it, on a rounded knoll in the Armstrong pastures and about 1 mile south of an artesion well which is about on the line to Turcotte from the station. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set 27.280 meters (89.5 feet) from the station in azimuth 355° 08′ 37″ and at the same elevation as the station.

Vinson (Willacy County, C. V. Hodgson, 1913).—About 7 miles from Norias railroad station in azimuth 252° 48′ 31″ from the large white house about 50 meters (164 feet) north of the section house there, about 46 meters (151 feet) north of the plain wagon road leading west from Norias, near the center of a rounded prominent bare knoll. A salt lake is at south edge of knoll and another at north edge, and a wind pump at south edge of a grove of bushes is about 1½ miles from the station in azimuth 250° 59′ 52″ and just north of the road leading east to Norias. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set 22.454 meters (73.7 feet) from the station in azimuth 346° 59′ 50″, and at the same elevation as the station.

Norias (Willacy County, C. V. Hodgson, 1913).—About 3 miles south from Norias railroad station and 200 meters (656 feet) east of the tracks, between mile posts 64 and 65, in the King pastures on a knoll covered with various kinds of bushes. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b[1], set 32.17 meters (105.6 feet) from the station in azimuth 275° 46′ 14″ and at the same elevation as the station.

Yturria (Willacy County, C. V. Hodgson, 1913).—In the Yturria pastures about 3½ miles east of north from the Yturria railroad station, 5 miles east of south from Rudolph railroad station in azimuth 170° 05′ 49″ from the water tank there, ¾ of a mile east of the railroad tracks, and a little south of east from the section post marking the south end of section 8 and the north end of section 7, about midway between mileposts 55 and 56. The station is on a small knoll about 200 meters (656 feet) southwest from shifting sandhills, with no trees within a radius of 200 meters (656 feet), but with mesquite scattered over most of the country roundabout. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set 24.44 meters (80.2 feet) from the station in azimuth 352° 53′ 00″ and at the same elevation as the station.

Stillman (Willacy County, C. V. Hodgson, 1913).—About 6½ miles west and 4 miles north from Yturria Railroad station, 14 miles west of north from Raymondville, 3 miles west of north from the Stillman ranch house, and ½ mile east of wagon road

See pp. 57–59

which leads from Raymondville to the Stillman ranch and thence north through the King pastures to the west of *Vinson*. An old well lined with hewn curved mesquite blocks, surrounded by piles of dirt and a wire fence, is 201.4 meters (660.8 feet) from the station in azimuth 178° 57′ 47″, and an old road leading to the well is 45 paces to the west of the station. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] at the west edge of a small clump of mesquite, about a meter from the nearest tree, 23.34 meters (76.6 feet) from the station in azimuth 259° 41′ 28″ and at the same elevation as the station.

Brenner (Hidalgo County, C. V. Hodgson, 1913).—About 5 miles west of Raymondville, ¼ of a mile west of the Cameron-Hidalgo County line, and 75 meters (246 feet) north of center of wagon road leading west from Raymondville, near the center of a small cleared but uncultivated field belonging to J. P. Brenner, of Raymondville. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set in the line of the telephone poles along the road, 70.75 meters (232.1 feet) from the station in azimuth 346° 10′ 59″ and at the same elevation as the station.

Raymond (Cameron County, C. V. Hodgson, 1913).—About 2½ miles east of Raymondville, ¾ of a mile east of the cross road at the northwest corner of the Raymond farm, ¼ mile east of a small lake at the side of the road, and about 25 meters (82 feet) north of the center of the wagon road. The station is marked as in notes 1b and 7a,[1] with a reference mark as described in note 11b,[1] set in the fence line on the south side of the road 32.26 meters (105.8 feet) from the station in azimuth 340° 42′ 26″ and at the same elevation as the station.

Sebastian (Cameron County, C.V. Hodgson, 1913).—About 1½ miles east and ½ mile south from Sebastian and 70 meters south of a line fence with an unfenced wagon road along its south side, on a slight rounded elevation in a pasture covered with mesquite brush. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set in the line of the fence mentioned above, 73.40 meters (240.8 feet) from the station in azimuth 211° 19′ 19″ and at the same elevation as the station.

Hidalgo (Hidalgo County, C. V. Hodgson), 1913.—About 4½ miles west and ¼ mile south from Sebastian, ⅜ of a mile west of north from the Asadon ranch owned by Sr. Cavazos and in azimuth 168° 51′ 38″ from the ranch wind pump, about 75 meters (246 feet) west of the Cameron-Hidalgo County line, and about 5 meters (16 feet) west of a wagon road which runs north and south near the county line. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set at the west side of the wagon road, 29.40 meters (96.5 feet) from the station in azimuth 180° 10′ 28″ and at the same elevation as the station.

Mercedes (Hidalgo County, C. V. Hodgson, 1913).—About 3½ miles east and 3¾ miles north of Mercedes, ½ mile west of the Cameron-Hidalgo County line on land belonging to a Mr. Woltz, of Missouri, and at present rented by T. E. Blacklock, about 68 meters (223 feet) from the northeast corner of Mr. Blacklock's house in the fence line on the east side of a lane leading north and about 10 meters (33 feet) north of the turn in an irrigation ditch. Heidelberg church is about 1 mile distant in azimuth 56° 44′ 55″. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set in the fence line on the east side of the lane mentioned above, 40.622 meters (133.3 feet) from the station in azimuth 178° 48′ 46″ and at the same elevation as the station.

Harlingen (Cameron County, C. V. Hodgson, 1913).—About 3 miles west of Harlingen and 35 meters (115 feet) north of the center of the Harlingen-Mercedes wagon road, on land now covered by mesquite brush. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set in the fence line on the north side of the road, 27.448 meters (90.1 feet) from the station in azimuth 2° 04′ 09″ and at the same elevation as the station.

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[1] See pp. 57–59.

Maria (Hidalgo County, C. V. Hodgson, 1913).—About 1½ miles northwest of Santa Maria and 22 meters (72 feet) east of the old military wagon road, in the yard in front of the house rented and occupied by F. N. Johnson and 5 meters (16 feet) south of the road leading to his house. Mr. Johnson's wind pump is about 62 meters (203 feet) distant in azimuth 230° 21′ 24″, a small Mexican cemetery surrounded by bushes is about 160 meters (525 feet) distant in azimuth 291°, and the north steeple of the Christian Church at Santa Maria is in azimuth 290° 40′ 16″. The station is marked as in notes 1b and 7a.[1] The reference mark is Reference Point No. 31 of the International Boundary Commission Survey and is 41.120 meters (134.9 feet) from the station in azimuth 212° 54′ 26″.

Mitla (Cameron County, C. V. Hodgson, 1913).—About 6 miles east of Santa Maria and 95 meters (312 feet) from the southwest corner of the railroad station at Mitla in azimuth 259° 26′ 18″ from it, and about 16 meters (52 feet) south of the center of the railroad track. There is only a station at Mitla; no houses are near. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] which is set on the north side of the railroad track 42.998 meters (141.1 feet) from the station in azimuth 181° 52′ 23″ and at the same elevation as the station.

Donna (Hidalgo County, C. V Hodgson, 1913; 1917).—About ½ mile southeast of Donna, on the west side of a large irrigation canal, on land owned by Dr. Roberts, of Donna. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] 31.58 meters (103.6 feet) from the station in azimuth 8° 07′ 08″, and at the same elevation as the station. In 1916 the concrete longitude pier of 1913 had been broken off even with the surface of the ground, but the base is still in place. A Mexican jacal is about 25 meters (82 feet) east of north of the station. "Donna 1913" was stenciled on the metal station and the reference marks. The central tack of transit pier is 31.607 meters (103.7 feet) from the station, in azimuth 90° 18′ 33″.

Rio (Hidalgo County, C. V. Hodgson, 1913; 1917).—About 40 meters (131 feet) south of the old military road in an open space directly in front of Progresso Village. The church at Progresso is about 400 meters (1312 feet) distant, in azimuth 358° 24′ 52″. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set in the fence line, 1 meter (3 feet) east of the gate on the road leading from the main road to Progresso postoffice and church, 42.61 meters (139.8 feet) from the station, in azimuth 354° 05′ 56″, and at the same elevation as the station. In 1917, "Rio 1913" was stenciled on the metal station and reference marks.

Colombres, (State of Tamaulipas, Mexico, 1911; 1916).—At the extreme west of the base measured along the side of a tangent of a railroad running from Monterey to Matamoras, about 100 meters (328 feet) to the west of the railroad station of the same name, and 9½ meters (31 feet) to the south of the road. The station is marked by a cross on the top of a piece of iron about 1 meter (3.3 feet) in height. The station has an elevation of about 30 meters (98 feet).

Tenacitas (State of Tamaulipas, Mexico, 1911; 1916).—At the extreme eastern end of the base Colombres-Tenacitas, about ½ kilometer (⅓ mile) to the west of the railroad station Tenacitas, and about 10 meters (33 feet) to the south of the road. The station is marked by a cross on the top of a piece of iron about 1 meter (3.3 feet) in height. The station has an elevation above sea level of about 24 meters (79 feet).

Benito (Cameron County, C. V. Hodgson, 1913).—About 4 miles from the standpipe at San Benito in azimuth 173° 59′ 23″ from it, and about 1 mile from the residence of Mr. Thomas in azimuth 106° 30′ 38″, on land belonging to the San Pedro de Carrecitos estate and probably on Portion No. 8. To reach station, take road running east from Mr. Thomas's residence for ¼ mile to where it crosses a large resaca and take faint road to the south along the east bank of the resaca for about ¾ of a mile to where the resaca

[1] See pp. 57–59.

makes a large horseshoe loop to the west for about ½ mile. The distance across the loop at the base of the horsehoe is only about 275 meters (902 feet) and the station is about midway of the distance and about 45 meters (148 feet) east of the faint wagon road which crosses the base of the loop and continues down the east side of the resaca. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set on the east side of the faint wagon road, 42.730 meters (140.2 feet) from the station in azimuth 10° 15′ 59″ and at the same elevation as the station.

Cowgill (Cameron County, C. V. Hodgson, 1913).—About 4 miles northeast from San Benito and 1 mile northeast of the residence of Mr. Cowgill, on the right of way of the Boulevard road on a low ridge between two old resacas, on the southeast side of the road about 3 meters (10 feet) from the present road fence. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set in the line of the telephone poles on the opposite side of the road, 18.095 meters (59.4 feet) from the station in azimuth 133° 49′ 55″ and at the same elevation as the station.

Olmito (Cameron County, C. V. Hodgson, 1913).—About 2 miles north from Olmito on the west side of the road leading north from the railroad station and about 100 meters (328 feet) south of the county drain ditch, on land belonging to Mr. Gay of Olmito. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set on the opposite side of the road 24.599 meters (80.7 feet) from the station in azimuth 258° 44′ 45″ and at the same elevation as the station.

Resaca (Cameron County, C. V. Hodgeon, 1913).—About 3 miles north of the new road between San Benito and Point Isabel, 2 miles northwest of Los Soldados ranch, on the south bank of the southernmost and smaller of two large resacas and about 75 paces west of a Mexican shack. The station is marked as in notes 1b and 7a,[1] with a reference mark, as described in note 11b,[1] set just east of where a fence line runs west from a north-and-south fence with a wagon road on its east side, 32.11 meters (105.3 feet) from the station in azimuth 92° 57′ 20″ and at the same elevation as the station.

Arista (Cameron County, R. E. Halter, 1885; 1913).—On the highest part of a hill about half way between Point Isabel and Brownsville, and 650 meters (2133 feet) from the railway. The station is marked as follows: The subsurface mark is a beer bottle 8 inches long filled with concrete and incased in a cylinder of concrete. The bottle is 2½ feet below the surface of the ground. Over the subsurface mark was placed a layer of sand and earth 6 inches thick, and upon this was set the surface mark, consisting of a piece of terra cotta sewer pipe 6 inches in diameter and 26 inches long, filled with concrete and incased in a cylinder of concrete 18 inches in diameter and 26 inches long; in the center of the top of the pipe was embedded a bottle. A nail has its point projecting ¼-inch above the concrete. The top of the cylinder of concrete bears the letters U. S. C. & G. S. 1905, around the top. The reference mark is a piece of sewer pipe 6 inches in diameter and 26 inches long; the pipe is set in concrete and then filled with concrete, with a 12-penny nail set head down in the center of the top of the pipe, its point projecting ¼ inch above the concrete. The reference mark is 11.330 meters (37.17 feet) S. 63° 30′ E. from the station. In 1913 the top of the reference mark had been shattered and broken off.

Point Isabel, west base (Cameron County, O. B. French, 1906; 1913).—About 2 miles west of a small ranch house and windmill, in the town of Laguna Vista, and about ½ mile south of the road between San Benito and Point Isabel. The station is marked as follows: The subsurface mark is a beer bottle 8 inches long filled with concrete and incased in a cylinder of concrete. The bottle is 2½ feet below the surface of the ground. Over the subsurface mark was placed a layer of sand and earth 6 inches thick, and upon this was set the surface mark, consisting of a piece of terra cotta sewer pipe 6 inches in diameter and 26 inches long, filled with concrete and incased in a cylinder

[1] See pp. 57-59.

of concrete 18 inches in diameter and 26 inches long; in the center of the top of the pipe was embedded a bottle. A nail has its point projecting ¼ inch above the concrete. The top of the cylinder of concrete bears the letters U. S. C. & G. S. 1906, around the top. The reference mark is a piece of sewer pipe 6 inches in diameter and 26 inches long; the pipe is set in concrete and then filled with concrete with a 12-penny nail set head down in the center of the top of the pipe, its point projecting ¼ inch above the concrete. The reference mark is 24.25 meters (79.6 feet) from the station near the line to *Point Isabel, east base.*

SUPPLEMENTARY POINTS.

United States and Mexico Boundary Monument R. P. No. 28.—Recovered as described in the Commission's report. Not occupied but connected to *Rio* by angles and tape measurement, from which it is distant 358.920 meters (1177.6 feet) in azimuth 352° 55′ 30″. (See description of *Rio.*)

United States and Mexico Boundary Monument R. P. No. 31.—Recovered as described in the Commission's report. Not occupied but connected to *Maria* by angles and tape measurements. It is 41.120 meters (134.9 feet) from *Maria* in azimuth 212° 54′ 26″. (See description of *Maria.*)

POINT ISABEL TO CORPUS CHRISTI.

PRINCIPAL POINTS.

Point Isabel south base (Cameron County, R. E. Halter, 1886; 1917).—About 4 miles from Point Isabel, on a hill between two salt lagoons. The station is marked as follows: The subsurface mark is a beer bottle 8 inches long filled with concrete and incased in a cylinder of concrete. The bottle is 2½ feet below the surface of the ground. Over the subsurface mark was placed a layer of sand and earth 6 inches thick, and upon this was set the surface mark, consisting of a piece of terra cotta sewer pipe 6 inches in diameter and 26 inches long, filled with concrete and incased in a cylinder of concrete 18 inches in diameter and 26 inches long; in the center of the top of the pipe was embedded a bottle. A nail has its point projecting ¼ inch above the concrete. The top of the cylinder of concrete bears the letters U. S. C. & G. S. 1905 around the top. The reference mark is a piece of sewer pipe 6 inches in diameter and 26 inches long; the pipe is set in concrete and then filled with concrete with a twelvepenny nail set head down in the center of the top of the pipe, its point projecting ¼ inch above the concrete. The reference mark is 11.630 meters (38.16 feet) N. 71° W. from the station.

Point Isabel east base (Cameron County, R. E. Halter, 1886; 1913).—About 2.8 miles from Point Isabel, about 250 meters (820 feet) from the shore of the Laguna Madre, on hard land near a motte. The station is marked as follows: The subsurface mark is a beer bottle 8 inches long filled with concrete and incased in a cylinder of concrete. The bottle is 2½ feet below the surface of the ground. Over the subsurface mark was placed a layer of sand and earth 6 inches thick, and upon this was set the surface mark, consisting of a piece of terra cotta sewer pipe 6 inches in diameter and 26 inches long filled with concrete and incased in a cylinder of concrete 18 inches in diameter and 26 inches long; in the center of the top of the pipe was embedded a bottle. A nail has its point projecting ¼ inch above the concrete. The top of the cylinder of concrete bears the letters U. S. C. & G. S. 1905 around the top. The reference mark is a piece of sewer pipe 6 inches in diameter and 26 inches long; the pipe is set in concrete and then filled with concrete with a twelvepenny nail set head down in the center of the top of the pipe, its point projecting ¼ inch above the concrete. The reference mark is 11.685 meters (38.34 feet) N. 52° 30′ W. from the station.

Fronton (Cameron County, C. H. Boyd, 1867; 1906).—In the town of Point Isabel on the same ridge and about 90 meters (295 feet) north of the lighthouse and in the yard of Mrs. Wren. The station is marked as follows: The subsurface mark is a beer bottle 8 inches long filled with concrete and incased in a cylinder of concrete. The bottle is 2½ feet below the surface of the ground. Over the subsurface mark was placed a layer of sand and earth 6 inches thick, and upon this was set the surface mark, consisting of a piece of terra cotta sewer pipe 6 inches in diameter and 26 inches long, filled with concrete and incased in a cylinder of concrete 18 inches in diameter and 26 inches long; in the center of the top of the pipe was embedded a bottle. A nail has its point projecting ¼ inch above the concrete. The top of the cylinder of concrete bears the letters U. S. C. & G. S. 1905 around the top. The reference mark is a piece of sewer pipe 6 inches in diameter and 26 inches long; the pipe is set in concrete and then filled with concrete with a twelvepenny nail set down in the center of the top of the pipe, its point projecting ¼ inch above the concrete. From the station the northwest corner of Mrs. Wren's house bears N. 37° E., 12.210 meters (40.06 feet); the southwest corner of the porch bears N. 78° E., 3.310 meters (10.86 feet); the southwest corner of the yard fence bears S. 56° E. 6.570 meters (21.56 feet); and the southwest yard fence in the direction S. 37° W. is distant 1.010 meters (3.31 feet). Azimuth observations were made in 1905 at a point 5.51 meters (18.1 feet) from the triangulation station in line to Point Isabel south base. The longitude station of 1906 is 21.21 meters (69.6 feet) north of and 10.60 meters (34.8 feet) east of the triangulation station and is marked by a concrete pier 16 by 26 inches in plan, 18 inches below and 34 inches above the ground.

Cameron (Cameron County, C. H. Boyd, 1867; 1913).—On the second point of any prominence projecting into the Laguna Madre above Point Isabel. Just south of the station is a bay with a high island at its entrance. The hill on which the station stands is about 25 feet high. The lighthouse at Point Isabel bears S. 54° W., and the next point up the Laguna Madre bears N. 10° W. The station was remarked in 1905 as follows: The subsurface mark was a beer bottle incased in a cylinder of concrete. Over the subsurface mark was placed a layer of sand and earth 6 inches thick and on this was set the surface mark, consisting of a piece of terra cotta sewer pipe 6 inches in diameter and 26 inches long, filled with concrete and incased in a cylinder of concrete. In the center of the top of the pipe was embedded a beer bottle. The top of the cylinder of concrete bears the letters U. S. C. & G. S. 1905, around the top. The reference mark was as follows: A hole was dug 12 inches in diameter and 24 inches deep, and in it was set a piece of sewer pipe 6 inches in diameter and 26 inches long; the pipe and the hole around the pipe were then filled with concrete. The reference mark is 26.145 meters (85.78 feet), N. 62° W. from the station. In 1913, the bank had eroded in the vicinity of the station, one gulley extending to within 2 feet of the station. A post, 4 inches square and 40 inches long, was made of two stakes, 2 by 4 inches in cross section, and placed on range with the reference mark and the station mark and 10 meters (33 feet) beyond the reference mark. It is exposed 8 inches; four nails were driven in the top and bottom of it. Another post 2 by 4 inches and 40 inches long is on range and 20 meters (66 feet) beyond the reference mark. It has one nail in the top and one in the bottom. A trench 6 inches in diameter was dug around each post and the dirt was heaped about it. The station is in a bank known locally as Moranco Blanco.

Fox (Cameron County, R. E. Halter, 1867; 1913).—The station is located on the west side of Laguna Madre, on the mainland 2 miles north of Cameron (known locally as Moranco Blanco). The old station of 1879 was found and reoccupied. Note 16 [1] describes the new station mark. The distance to reference mark is 62.64 meters (205.5 feet); to high-water line it is 45 meters (148 feet), and to lone Spanish dagger

[1] See pp. 57-59.

it is 100 meters (328 feet) approximately. Note 17 [1] describes the reference mark. The reference mark, triangulation station, and head of the bight (yellow bank ⅝ mile northwest) are in range. The reference mark is on the hillside protected from the sea, in a small grassy patch 25 feet in diameter, in which no bushes grow. The azimuth to the reference mark is 131° 49′ 22″ and to the Spanish dagger it is 353° 13′.

Pool (Cameron County, C. H. Boyd, 1867).—On Padre Island, on a high sand hill near the outer beach and about 5 miles north of Brazos Santiago entrance. Point Isabel lighthouse bears S. 25° W. The station was marked with a mesquite post and a small framework of boards filled with sand; in the top of the post was a copper tack.

Singer (Cameron County, C. H. Boyd, 1867; 1879).—On Padre Island, about 10 miles north of Brazos Santiago, on a sand hill about 12 feet high, the hill being covered with grass about one-third of the distance from the Gulf to the Laguna Madre. The station was marked underground by a glass bottle with a copper nail in the cork, while the surface mark was a mesquite post cut to the form of a triangle with a copper tack in its top. Four mesquite posts, with copper tacks in the tops, were placed 1 meter (3 feet) from the station, lines joining them diagonally intersecting at the center. In 1879 four additional stubs (of cedar) were placed around the station and 6 feet (1.8 meters) from the station.

Black Hill (Cameron County, R. E. Halter, 1879).—On Padre Island on the highest hill in the vicinity, about 40 yards (36.6 meters) north of the highest part of the hill. The station is marked according to note 28,[1] and in 1913 was reported probably lost.

Armadillo (Cameron County, R. E. Halter, 1879).—On the northeastern end of an island on the mainland side of Laguna Madre, in a clump of mesquite bushes by which the island may be easily recognized. The station is marked according to note 28.[1] In 1913 the station was not recovered.

Mesena 2 (Cameron County, R. E. Halter, 1885).—About 4¾ miles west from Point Isabel lighthouse; near the shore of Laguna Larga. The station is reached from Point Isabel by following the road to Brownsville for 4 miles, to where it forks, one branch following the Leguna Madre and the other or left-hand branch approaching the shore of the Laguna Larga, and traversing the long hill on which the station is situated; this hill is nearly abreast of the point where the right-hand road recedes from the shore of the Laguna Madre, and viewed from the forks of the road is the most prominent hill in sight. The center mark was the bottom of a beer bottle buried 2½ feet below the surface of the ground, while 10 inches below the surface four beer bottles were placed 1 foot from the center on lines intersecting at right angles; a mesquite stub was placed for a surface mark. In 1905 the apparent location of the station was recovered, as indicated by three signal stakes and three instrument stakes, but no other marks were recovered.

Armadillo 2 (Cameron County, E. H. Pagenhart, 1913).—The station is on the northeastern end of the most easterly of the group of islands known as the Three Islands. It is about 3 meters (10 feet) south from a bunch of Spanish daggers, about 20 feet above high water and 9 meters (30 feet) from the steep bank to the eastward. It is marked according to note 16.[1] Note 21[1] describes the reference mark which is just south of an old mesquite bush, and is 23.24 meters (76.2 feet) from the station, in azimuth 75° 11′ 44″.

Hike (Cameron County, E. H Pagenhart, 1913).—The station is on the highest part of a range running north and south on the mainland, due west of Three Islands; it is about 75 meters (246 feet) from the high water line, on the southern side of the range. From the station the southern half of Green Island shows in a gap between the nearest island (in the direction of Cat 2) and the long point of land making out from the Isle de Caballo. The station is marked according to note 16.[1] Note 17 [1] describes the reference mark which is 56.98 meters (186.9 feet) (surface measurement) from the station

[1] See pp. 57–59.

in azimuth 116° 14′ 38″. It is 20 feet below the station. An old mesquite tree, blazed and with a copper wedge driven into the blazed part, is 61.52 meters (201.8 feet) (surface measure) from the station in azimuth 61° 36′ 44″.

Bank (Cameron County, E. H. Pagenhart, 1913).—The station is on the west side of a large lagoon, making in about 3 miles north of signal Fox and about 2 miles east of Granjeno ranch. The bank is high and the shore line ragged. A small knob is about 12 meters (39 feet) southeast of the station. Note 16[1] describes the station mark. Note 21[1] describes reference mark No. 1. It is 8 feet below the station and 50.81 meters (166.7 feet) distant (surface measure) in azimuth 169° 53′ 01″. Reference mark No. 2 is a blazed mesquite tree with copper wedge driven into the blazed area. It is about 115 meters (377 feet) from the station, in azimuth 134° 24′ 16″. The azimuth to a tall pole at Granjeno ranch is 99° 03′ 16″.

Cat 2 (Cameron County, E. H Pagenhart, 1913).—The station is on the top of the high ground at the eastern end of an island, is 10 meters (33 feet) from the edge of the steep east bank, and about midway between the north and south sides of the island. The station is located about 4 miles south of Green Island. The station was marked according to Note 16[1] except that there is no subsurface mark. Note 17[1] describes the reference mark which is 13.50 meters (44.3 feet) from the station in azimuth 41° 31′ 44″.

Colorado (Cameron County, R. E. Halter, 1879; 1913).—On the western side of Laguna Madre, on a high island south-southeast from Green Island. In 1913 a large hole 5 feet and 4 inches in diameter was dug to the southeast of the station while search was made for the station. This hole will probably remain as it is for some time; its center is about 1.9 meters (6.2 feet) from the station and bears S. 40° E. The island is known to the natives as Morro Island. The old station marks of 1879 were found and used in 1913. The station was re-marked according to note 18.[1] It is 25 feet above high-water mark and 5 meters (16 feet) from a steep east bank, 27 meters (89 feet) from the west bank, and 30 meters (98 feet) from the north bank. Note 17[1] describes the reference mark, which is distant 14.62 meters (48.0 feet) from the station in azimuth 65° 01′ 44″. It is 20 meters (66 feet) from the east and 12 meters (39 feet) from the west bank of the island.

Green (Cameron County, E. H. Pagenhart, 1913).—On Green Island about the middle of the eastern side, and about 9 meters (30 feet) from the edge of the high bank on that side. The island is covered by a dense growth of bushes, cacti, and Spanish daggers. A clear space is left where the station is located, on one of the highest parts of the island. The large mesquite trees should identify the station. The station is marked according to note 16.[1] Note 21[1] describes the reference mark which is 8.37 meters (27.5 feet) from the station, in azimuth 92° 56′ 46″. A copper wedge driven into a blaze in a large mesquite tree is 12.25 meters (40.2 feet) distant and bears S. 77° W. (magnetic). A copper wedge driven into a blaze in a large mesquite tree is 2.51 meters (8.2 feet) distant and bears N. 70° E. (magnetic).

Skin (Cameron County, E. H Pagenhart, 1913).—Eight meters (26 feet) from the edge of the steep bank facing eastward, 25 feet above high-water line and 2 feet above the reference mark. The station is marked according to note 16.[1] Note 17[1] describes the reference mark which is 18.27 meters (59.9 feet) from the station, in azimuth 54° 30′, and is also in range with the right tangent of the nearest island northeast. The left tangent of the same island bears N. 2° E. (magnetic).

Pelican 2 (Cameron County, E. H Pagenhart, 1913).—On one of the highest points near the most northern mouth of the Arroyo Colorado. A small bight makes in on the steep bank to the southeastward from the station about 40 meters (131 feet) distant. The station is near the middle of the point and can easily be reached from the south or west. The station is marked according to note 16.[1] Note 17[1] describes the reference mark except that it is incased in a pipe made of stakes. The reference mark is in

[1] See pp. 57-59.

range with the tangent to the nearest point of land to the westward, and is distant 9.32 meters (30.6 feet) from the station, in azimuth 96° 12′ 29″. There is a large mesquite tree, distant 50 meters (164 feet), S. 3° W. (magnetic); and a large mesquite tree distant 100 meters (328 feet) S. 26° E. (magnetic).

Water (Cameron County, E. H. Pagenhart, 1913).—On the top of the highest hill south of the southern mouth of the Arroyo Colorado. A large fresh-water pond is about ¼ mile south of the station. The station is in a clump of live-oak brush. The hill shows prominently from the south and west. The station is marked according to note 16.[1] Note 17[1] describes the reference mark which is distant (surface measure) 14.60 meters (47.9 feet) from the station in azimuth 81° 38′ 04″ and 2 feet below it. Magnetic bearings to the following points are: Point 1, S. 73° 30′ W., Point 2, N. 20° W., Point 3, N. 24° 30′ E. The left tangent of the fresh-water pond is S 0° 30′ E. (magnetic), right tangent of the fresh-water pond is S. 19° W. (magnetic).

Rifle (Cameron County, R. E. Halter, 1879; 1913).—The station is located on the eastern side of a long narrow island near the south end of Topo Bay. The station is about 6 meters (20 feet) from the steep eastern bank, about 40 meters (131 feet) from the high-water line on the west side of the island, and about 10 feet above the water. Note 18[1] describes the station mark. Note 17[1] describes the reference mark which is 20.30 meters (66.6 feet) from the station and bears N. 69° W. (magnetic). The reference mark is on range with the station and the center one of three prominent Spanish daggers.

Sauz (Cameron County, E. H. Pagenhart, 1913).—The station is located on a high ridge about 1½ miles south of Sauz fish house. It is near a cattle trail and about 12 meters (39 feet) from the steep east shore bank. The bank at this place is bare and shows up prominently from Laguna Madre. The station is 12 feet above high-water line. The reference mark is on the side hill to the westward and is about 6 feet below the station. The station was marked according to note 19,[1] and the reference mark according to note 20.[1] The distance to the reference mark is 15.02 meters (49.3 feet). Azimuths from station are as follows: Left tangent of lagoon to westward, 234° 19′; middle of gap of same lagoon, 252° 13′; reference mark, 286° 35′; windmill, 306° 46′ 43″; Sauz fish house, back door, 168° 10′ 30″.

Storm (Cameron County, E. H. Pagenhart, 1913).—The station is in 1 foot of water at mean high water, on the eastern side of the deep water at the southern end of Topo Bay. The center pole made of two stakes, 2 by 4 inches in cross section and 24 feet long, was made fast at the foot to two stakes 2 by 4 inches in cross section, driven well into the mud. The center stubs should last some time.

Windy (Cameron County, E. H. Pagenhart, 1913).—The station is about 3 miles off the mainland in Topo Bay (Laguna Madre) in about 2 feet of water. A platform for observing was supported by stakes 2 by 4 inches in cross section. The observing stand for instruments was made of three stakes, 4 by 4 inches square and 6 feet long, driven well into the mud. The tops of the stakes projected about 8 inches above medium high water. The center pole was made fast at the foot to two stakes, 2 by 4 inches in cross section, driven well into the mud. The instrument stand should last for some time.

Lomalto (Cameron County, R. E. Halter, 1879; 1913).—The old station of 1879 was recovered and reoccupied. It is on the eastern end of a long range on the west side of Laguna Madre, 3 miles north of Sauz Landing and on the north side of a small lagoon. The station is about 6 meters (20 feet) from the south bank, which is much eroded. The eastern bank is about 18 meters (59 feet) distant. The reference mark is nearly in range with two prominent Spanish daggers which are about 12 meters (39 feet) from it. The station was marked according to note 19,[1] except that the subsurface mark is a triangular-shaped piece of coral, with a drill hole in the center. Note 20[1]

[1] See pp. 57–59.

describes the reference mark which is 27.335 meters (89.68 feet) from the station, in azimuth 119° 16′. Other azimuths from the station are: Right one of twin windmills, 35° 05′ 25″; left one of twin windmills, 34° 52′ 10″; left tangent to lagoon, 51° 33′.

Back (Cameron County, E. H. Pagenhart, 1913).—The station is about 3 miles from the mainland in Laguna Madre, in about 2 feet of water. The station mark is two 2 by 4 inch stakes driven well into the mud.

Portalis 2 (Cameron County, E. H. Pagenhart, 1913).—The station is on the eastern end of a hill about 9 meters (30 feet) from the water of Laguna Madre. Portalis ranch is about 3 miles west. A small lagoon makes to the southward from the station, a narrow sand bar separating it from the Laguna Madre at low water. A prominent clump of Spanish daggers, distant about 18 meters (59 feet) bears northwest from the station. The old station is lost. The station is marked according to note 19.[1] Note 20[1] describes the reference mark, which is 19.64 meters (64.4 feet) from the station, in azimuth 65° 06′ 20″. Other azimuths are: Left one of twin windmills, 58° 12′ 15″; right one of twin windmills, 58° 24′ 30″; windmill at Portalis ranch (about 3 miles), 98° 59′ 45″.

Last Resort (Willacy County, E. H. Pagenhart, 1913).—The station is on the mainland, near a small point making out just south of a steep-sided bank. It is on the higher ground in a sandy place almost bare of grass and about 5 feet above high-water line. The station and reference marks were set flush with the surface. The station was marked according to note 16,[1] and note 21[1] describes the reference mark, except as above stated. It is in azimuth 35° 44′ and is 18.84 meters (61.8 feet) from the station. Other distances are: To fence line 300 meters (984 feet); to east bank 10 meters (33 feet); to hill to west 200 meters (656 feet); to point of rock ledge (coarse gypsum rock) 150 meters (492 feet). Other azimuths are: To windmill 89° 41′ 38″; to first point of land to north 174° 29′.

Topo (Willacy County, R. E. Halter, 1878; 1913).—The station is located on a small island near the west shore of Laguna Madre, connected at low tide with the mainland to the south by a narrow strip of sand. The station is about 7 meters (23 feet) north of the south shore and about 50 meters (164 feet) east of the west shore of the island, which is about 10 feet above the water. The island is the most southerly of the group in this vicinity. The subsurface mark is a block of concrete about 3 feet below the ground with a drill hole in its top filled with lead. The surface mark is the point of a copper nail projecting from a drain tile 2 feet long set into the ground and filled with concrete. The reference mark is described by note 11b.[1] It is 60.70 meters (199.1 feet) from the station and bears N. 68° E. (magnetic). It is in line with the station and the only Spanish dagger on the island. This plant is about 45 meters (148 feet) from the reference mark. Other bearings are: To windmill (about 3 miles distant), S. 6° W.; to windmill (about 2½ miles) seen over large sand hill, N. 81° W.; to small round island in Laguna Madre, N. 26° W.

Sea (Willacy County, E. H. Pagenhart, 1913).—The station is about 2 miles from the mainland and is in Topo Bay (Laguna Madre), opposite station *Topo*. It is in 2 feet of water at the eastern edge of deep water. Marked by tripods constructed of 4-inch lumber well driven into the mud, also by stakes under the tripod to which the center pole was fastened.

Mosquito 2 (Willacy County, E. H. Pagenhart, 1913).—The station is near the northeast end of an island, on the highest ground in its vicinity; about 1 mile east of the corner of the boundary fence between the Kenedy and King property. The island on which the station is located is the fourth one west of the Laguna, the first one being a long island about 2½ miles long, the most easterly in the Laguna. There is no land to the north of the island on which the station is located for a distance of

[1] See pp. 57–59.

more than 2 miles. The station is about 54 meters (177 feet) south of the northern edge of the island, 21 meters (69 feet) west of the east edge, and 14 meters (46 feet) north of the south edge. The station mark is described by notes 1b and 7a.[1] Note 11b[1] describes the reference mark, which is located 81.0 meters (265.7 feet) from the station, in true bearing 232° 34′ 22″. Other bearings and distances are: Spanish dagger S. 75° W. (magnetic), distant approximately 60 meters (197 feet); last fence post in Laguna (Kenedy-King line) N. 42° W. (magnetic); Spanish dagger N. 26° E. (magnetic); post 6 by 6 inches, 4 feet high, in small island about $\frac{3}{16}$ mile to southeast, 317° 48′ 27″ (true).

Norwest (Willacy County, E. H. Pagenhart, 1913).—On a shifting sand dune about 1 mile from the beach and about 3 miles south of triangulation station *Plank*. The station will probably not last the first heavy storm.

Southeast (Willacy County, E. H. Pagenhart, 1913).—The station is on the most southeasterly island of the group known as the Mesquites. It is toward the southeast point of the island, and about 300 meters (984 feet) from it. The land is sandy and moderately grassy in the vicinity of the station but not distinguishable by any prominence. The station is marked according to note 16[1] (except that it is exposed 6 inches). The distance to east high-water line is 135 meters (443 feet).

Avoca 2 (Willacy County, E. H. Pagenhart, 1913).—On the most easterly island of the group known as Rincon del Mezquite in Laguna Madre. The island is the most southerly of a group of four, which make up the northeast part of Rincon del Mezquite. The station is at the south end of the island on the highest ground and at the edge of a deep cut from 10 to 12 feet. The station is about ¼ mile west of the east shore, and is marked according to notes 1b[1] and 7a.[1] Note 11b[1] describes the reference mark, which is 100.30 meters (329.1 feet) from the station in azimuth 247° 41′. A 4 by 4 inch pole, 20 feet high, is in azimuth 336° 42′.

Plank (Willacy County, E. H. Pagenhart, 1913).—The station is on a high sand hill about 30 feet high and about 100 meters (328 feet) from the high-water line. The station mark is a 2 by 10 inch plank which is eccentric to the station. The station is 1 inch west of the center of the west face of the plank. The stake projects about 2 feet above the ground.

Beat (Willacy County, E. H. Pagenhart, 1913).—The station is on a high sandy hill opposite a fresh-water pond. A grassy meadow extends northwest from the station. Directly behind the station is a barren sandy area devoid of any large hills. The station is about 100 meters (328 feet) from high-water line and 30 feet above water. It is marked by a post 5 inches square in cross section. On two of the sides of this post are 2 by 4 inch stakes driven well into the mud.

Lopeña (Willacy County, E. H. Pagenhart, 1913).—The station is on the southern end of a large island, known as Lopeña, on the western side of Laguna Madre. The station is on a high sandy ridge, covered with a moderate growth of grass. The station was marked according to note 16.[1] Note 21[1] describes the reference mark. It is 81.62 meters (267.8 feet) from the station, in azimuth 352° 16′ 09″. Other azimuths are: The right one of the twin windmills to westward, 139° 00′ 51″; windmill to right, 248° 00′.

Buoy (Willacy County, E. H. Pagenhart, 1913).—The station is on a prominent sand hill about 2 miles south of Dunn's ranch house. It is marked by a plank 2 by 8 inches set eccentrically. The station is 1½ inches southeast of the center of the Gulf face of the plank.

Indian 2 (Willacy County, E. H. Pagenhart, 1913).—On the fifth island from the Rocky Bayou east of the Carnestoliendos Camp, a large and high island, known as Potrero Farias. This island is separated from the mainland by salty bogs, almost impossible to cross, except on foot. The island is about 2½ miles long and 1 mile

[1] See pp. 57–59.

wide, and has three distinct high ridges running the length of it, with the highest ridge near the Laguna Madre shore. The station is on this high ridge, about 1 mile from the northern end of the island and about 100 meters (328 feet) from the bank of the island along the shore of the Laguna, there being a mud flat extending out ⅔ mile toward Padre Island. This island is covered with grass as are all other islands. The station is marked according to notes 1b and 7a.[1] Note 11b[1] describes the reference mark, which is 60.00 meters (196.8 feet) from the station, in azimuth 306° 36′ 56″. Other bearings are: Windmill, 44° 21′ 15″; windmill, 47° 49′ 15″; windmill, 212° 02′; left tangent first island to northward, 228° 31′; right tangent of same island, 238° 51′.

Gum (Willacy County, E. H. Pagenhart, 1913).—The station is on a prominent sand hill about 2 miles south of Dennis's ranch house on the highest hill in the vicinity. The station mark is eccentric and is a timber 4 by 8 inches driven into the sand 4 feet and projecting 3 feet above the surface of the ground. The center of the station is 1½ inches southeast of the broad face of the stake (toward the Gulf).

Gap (Willacy County, E. H. Pagenhart, 1913).—The station is on Padre Island, about ½ mile south of a prominent gap visible from Laguna Madre and ¼ mile south of two large timbers (8 by 8 inches) projecting 5 feet on a lower sand hill. The station is on the highest hill in the immediate vicinity and shows up prominently from the Gulf beach in both directions. It is on the highest point and is marked by a 4 by 8 inch post, projecting 3 feet. The station is 2 inches southeast (Gulf side of the broad face) of the center of the southeast face. The post is placed securely in the ground. The station is 100 meters (328 feet) from the Gulf beach, and 11 meters (36 feet) above the water. The azimuth to the two timbers mentioned above is 183° 33′.

Con (Willacy County, E. H. Pagenhart, 1913).—The station is on a small high island just northwest of a gap between two high islands on the west side of Laguna Madre. The vicinity is somewhat sandy with a moderate growth of grass. The station was marked according to note 16.[1] Note 21 [1] describes the reference mark which is distant 52.70 meters (172.9 feet) and in azimuth 322° 11′. Other azimuths and distances are: Right one of twin windmills, 37° 26′ 24″, 6 miles; windmill, 100° 52′ 39″, 4 miles; windmill near Carnestolienda Motte, 169° 20′ 54″.

Coyote 2 (Willacy County, E. H Pagenhart, 1913).—The station is about 1 mile east from Carnestoliendos ranch and a motte, on a small piece of land which is an island at high water. The island is about one-fourth mile from the west shore of Laguna Madre and a little southwest from a rocky bayou between two long narrow islands. The ground is hard and is covered with many large Spanish daggers. The station mark is described by notes 1b and 7a.[1] Note 11b [1] describes the reference mark, which is 143.6 meters (471.1 feet) from the station in azimuth 83° 41′ 32″. Other azimuths and distances are: To windmill, 57° 01′ 02″, 2 miles; windmill, 81° 39′ 52″; windmill at Carnestoliendos ranch, 82° 37′ 07″.

Mustang (Nueces County, H. D, King, 1905; 1912).—On the inside shore of Mustang Island, about 6 miles north of the south end of the island, and 2 miles northwest of Grant's ranch house; 1¼ miles north of anchorage behind the "Bulkhead," and about 2 miles from the south end of a long and narrow tongue separated from the main body of Mustang Island by a shallow slough about 3 miles long. The station is 15 meters (49 feet) from the high-water mark of the bay shore, 40 meters (131 feet) from the high-water mark of the shore of the slough, and 330 meters (1,083 feet) north of an old fence. The station was marked according to note 27,[1] the reference mark being 12 meters (39 feet) from the high-water mark of the bay shore, 18 meters (59 feet) from the high-water mark of the shore of the slough, and 29.213 meters (95.8 feet) from the station, in azimuth 196° 07′ 05″. The following azimuths are from the triangulation station: Northeast gable of sheep barn at Grant's ranch, distant 2 miles, 11° 47′ 43″; north

[1] See pp. 57–59.

gable of Grant's ranch house, 12° 09′ 27″; middle ground stake, Bulkhead Anchorage, 49° 30′ 55″; chimney of farmhouse, three-fourths mile south of north base, 65° 57′ 31″.

Laguna Madre north base (Nueces County, R. E. Halter, 1883; 1912).—About 2½ miles south of Flour Bluff and about 250 meters (820 feet) back from the west shore of the Laguna Madre in a cleared field belonging to William Hoffman. The station is 67 paces from Hoffman's windmill, and 162 paces S. 34° W. from the place where his house once stood. The station was marked in 1883 as follows: A pit 7 feet square was excavated to a depth of 2 feet; in the center of the pit an irregular stone about 14 inches square and 10 inches thick was set. A hole was drilled in the top of this stone and filled with lead. Resting on this stone stands a piece of white marble 2½ feet long and 6 inches square with the letters U. S. on its south face, C. & G. on its east face, and SUR and VEY on its north and west faces, respectively. In the top of the marble post was drilled a hole 1 inch in diameter and 3 inches deep. This hole was filled with lead. Around this post were placed bricks, broken rock, and sand, forming a compact mass. A reference mark similar to that described in note 27,[1] was set 13.99 meters (45.9 feet) from the station in azimuth 135° 21′. It bears the letters U. S. R. M. 1905. Other azimuths are: North gable of Grant's ranch house on Mustang Island, 272° 14′ 40″; east end of ridge of farmhouse, distant 2 miles, 35° 32′ 09″; windmill, distant 1½ miles, 206° 07′ 38″.

Laguna Madre south base (Nueces County, R. E. Halter, 1882; 1912).—About 5½ miles south-southwest from Flour Bluff and one-half mile north-northeast from Brighton postoffice; about 100 meters (328 feet) back from the shore line in an opening in a live-oak motte; about 100 meters (328 feet) north-northeast from the old Thompson house, and 5.2 meters (17.1 feet) north of a fence which is the north line of the Thompson property. In 1882 the station was marked as follows: A pit 7 feet square was excavated to a depth of 2 feet; in the center of this, with its upper surface flush with the bottom of the pit, an irregular stone about 14 inches square and 10 inches thick was set; a hole was drilled in the top of this stone and filled with lead and the center of the station marked thereon by crosslines. Resting on this stone stands a piece of white marble 2½ feet in length and 6 inches square with the letters U. S.–C. & G.–SUR–VEY deeply cut thereon near the top, one group on each face. Around this post were laid symmetrically layers of brick. The marble block has a hole about 1 inch in diameter and 3 inches deep drilled in its top; this hole was filled with lead and the center of the station marked thereon by crosslines. In 1905 a reference mark, such as is described in note 27,[1] was set 31.80 meters (104.3 feet) from the station in azimuth 309° 06′ 25″. The reference mark bears the letters U. S. R. M. 1905, and an arrow pointing to the station. The following azimuths are from the triangulation station: Chimney of old Thompson house, distant 100 meters (328 feet), 29° 33′ 42″; south gable of William Code's house, distant three-fourths mile, 185° 09′ 33″. In 1912 the station was found in good condition, but concrete was placed around the marble post to protect it better.

McGloins Bluff (San Patricio County, S. A. Gilbert, 1860; 1912).—On McGloins Bluff, on the northeast shore of Corpus Christi Bay, on a small sand hill near the extreme western end of the bluff overlooking Ingleside Cove. Two cast-iron reference marks are about 6 feet (1.8 meters) from the station. The station mark is described by notes 1b and 7a.[1] A concrete reference mark was made in 1912 which is 19.2 meters (63.00 feet) from the station. The angle at the station between the reference mark and the flagpole on the cupola of the Ingleside Inn is 61° 55′. The following azimuths are from the triangulation station: Water tower at Gregory, 147° 45′ 14″; southwest gable of farmhouse, distant 1 mile, 171° 11′; chimney on ell of a large 2½-story house near Ingleside Hotel, 178° 02′ 06″; chimney on James Stern's house, distant ½ mile, 179° 46′ 21″.

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[1] See pp. 57–59.

Oso (Nueces County, P. M. Trueblood, 1912).—On the south side of Corpus Christi Bay, at the head of blind Oso Creek, about 4.4 miles west of Flour Bluff. The station is on a strip of flat ground 350 meters (1,148 feet) west of the bridge over the Oso, and 153 paces east-northeast from a lone Spanish dagger and is just at the edge of the Corpus Christi–Flour Bluff road, and is 19.3 meters (63.3 feet) from a caving loam and clay bank 10 feet high. The station is about the middle of this strip of high bank which is 250 meters (820 feet) long. The station marks are described in notes 1b and 7a.[1] Note 11b[1] describes the reference mark, which is 48.58 meters (159.4 feet) west by north from the station and is on line, approximately, with the center of the old house 1 mile distant to the west, about 15 meters (49 feet) from the bank. The reference mark is in azimuth 112° 21′ 20″ from the station. Other azimuths are: To southwest corner of bridge, 295° 01′ 10″; to a Spanish dagger, 70° 09′; to chimney of old house, 112° 15′ 00″.

Shamrock (Nueces County, P. M. Trueblood, 1912).—On the western shore of the peninsula at the southern end of Shamrock Island, on the eastern side of Corpus Christi Bay, about 430 paces from the high-water line at the southern end of the point, and 475 paces from the Shamrock Point barn, on land owned by F. Oppikofer. It is on a low ridge of shell about 4 or 5 feet above high water and about 18 meters (59 feet) from high-water line of Corpus Christi Bay. It is 160 paces from a water hole. The station is marked as described in notes 1b and 7a.[1] The reference mark is described by note 11b.[1] It is set 2 feet from two sumac bushes and is 14.55 meters (47.74 feet) in azimuth from the station, 164° 59′ 05″. Other azimuths and distances are: To west gable of barn, 212° 58′ 25″; to stake at water hole, 222° 13′ 40″, about 160 paces; to mulberry tree, 236° 49′, 19.82 meters (65.0 feet); to Spanish dagger, 15° 27′, 35.25 meters (115.6 feet).

Grants 2 (Nueces County, P. M. Trueblood, 1912).—The station is on the most conspicuous and permanent looking hill in the vicinity; it is about 2 miles northeast from Corpus Christi Pass, and 100 meters (328 feet) from the Gulf beach. The small wharf on Mustang Island is ½ mile distant and bears south 86° east (magnetic). An old house at the wharf on the north end of Padre Island is 1½ miles distant and bears south 50° west (magnetic). A small frame house on the inner beach of Mustang Island is about 500 meters (1,640 feet) distant and bears N. 37° W. (magnetic). Grant's house is about 2 miles distant and bears N. 6° E. (magnetic). Note 23[1] describes the station marks and note 25[1] the reference mark, which is 12.86 meters (42.2 feet) distant and bears S. 12° E. (magnetic) from the station.

Island (Nueces County, P. M. Trueblood, 1912).—The station is on Peat Island, which is near the west shore of Laguna Madre and about 4 miles south of Flour Bluff, which is at the northern entrance to Laguna Madre. The station is on a low grassy ridge about 1 foot above the ground level of the island. The ridge runs east and west across the island and is covered with small clumps of cacti. The station is between the second and third clumps from the eastern end of the island. Notes 1b, 7a, and 22[1] describe the marking of the station.

Pass (Nueces County, P. M. Trueblood, 1912).—The station is on Padre Island, about 61 meters (200 feet) west from the Gulf shore and about ½ mile south of Corpus Christi Pass on the top of the second high sand hill from the Pass. The station is marked as described in note 23.[1] Azimuths are: To corner of old fence, distant 66.9 meters (219.5 feet), 108° 11′ 10″; to south gable house, 1 mile south of *Laguna Madre, south base*, 115° 16′ 55″; to schoolhouse at Brighton, east gable, 137° 42′ 45″; to south gable of house at Corpus Christi Pass, 187° 35′ 40″.

Sandhill (Nueces County, P. M. Trueblood, 1912).—The station is on the more northern of two high and conspicuous sand hills on Padre Island, about 1 mile north of the north end of North Bird Island. The station is about 300 meters (984 feet) from

[1] See pp. 57–59.

the Gulf beach. The station is marked as described in notes 1b and 24.[1] Note 25[1] describes the reference mark, which is located on a lower grassy slope of the hill on which is the station. It is 26.45 meters (86.8 feet) from the station, in azimuth 36° 11′ 36″. Other azimuths are: To William Barnes's house, 127° 32′ 16″; to southwest corner of corral, about 1 mile distant, 173° 10′ 10″; to Spanish dagger in Laguna Madre beach, 46° 22′ 20″.

Hardpan (Nueces County, P. M. Trueblood, 1912).—The station is located on the west shore of Laguna Madre, 65 meters (213 feet) from the water and about 3¼ miles below Peat Island, and 1 mile southerly from the old Barnes's house. It is about 600 meters (1,968 feet) north of a pond which lies just back of a rounding point in the shore line and on land about 8 or 10 feet above the water. Notes 1b, 7a, and 22[1] describe the station marks, except the trenches are parallel and normal to the beach. Note 25[1] describes the reference mark, which is 20.84 meters (68.4 feet) from the station in azimuth 211° 54′ 15″. Other azimuths are: To end of fence in water about 400 meters (1,312 feet), 2° 42′; to motte (1 mile distant), 36° 31′; to motte 350 meters (1,148 feet), 49° 28′; south gable Barnes's house, 177° 40′ 30″.

Landing (Nueces County, P. M. Trueblood, 1912).—On the mainland about 1 mile south of South Bird Island, and on the southern one of the two small rounding sandy points, 22.7 meters (74.5 feet) from the land end of the old wharf, in line with the wharf and a small prominent motte about ½ mile inland. There is a rock formation along the beach that crops out just at the old wharf. The station was marked according to notes 1b and 24.[1] Note 11b[1] describes the reference mark, which is in line with the above-mentioned motte, 29.9 meters (98.1) feet from the station in azimuth 95° 51′. An old stake projecting 4½ feet above the surface is 10.5 meters (34.4 feet) south 53° east (magnetic) and another projecting 1 foot is 27.1 meters (88.9 feet) north 38° west (magnetic). Other azimuths are: To southeast corner post of old landing, 274° 50′; double Spanish dagger on Padre Island, 304° 38′ 20″; windmill, 1½ miles southwest, 49° 07′ 15″; motte, ½ mile distant, 96° 18′.

Richards 2 (Nueces County, P. M. Trueblood, 1912).—On a prominent sand hill on Padre Island, about 4 miles north from the "Settlement," and about 100 meters (328 feet) from the Gulf beach. This is the highest hill in this locality, though not conspicuous from the Laguna on account of the high ridges of shifting sand on the middle and western parts of the island. The station is marked in accordance with note 23.[1] The only reference marks are the posts to which the guy wires of the tripod signal were attached. These are about 10 meters (33 feet) from the station, two in line parallel to the beach and two at right angles.

Spit (Nueces County, P. M. Trueblood, 1912).—On the west side of Padre Island, about 4 miles south of South Bird Island, about 2½ miles north of Griffin's house or the "Settlement." The station is on a little knoll near the south end of a long sand spit, that makes out toward the south, 30 meters (98 feet) from the shore of a long narrow lagoon, 42 meters (138 feet) north of the low flat, and 26 meters (85 feet) east of the Laguna Madre shore. The station is marked according to notes 1b and 24.[1] Note 11b[1] describes the reference mark which is 21.8 meters (71.5 feet) north 54° 31′ west (magnetic) and 5 meters (16 feet) from the bank at the Laguna Madre shore.

Lonehill (Nueces County, P. M. Trueblood, 1912).—On the mainland about 6½ miles south of South Bird Island. The station is on top of a prominent hill, at about 20 feet elevation, and 65 meters (213 feet) back from the high-water mark. Just across on Padre Island is a large clump of Spanish daggers, which stand out very prominently against the white sand. The station is marked according to note 23.[1] Note 25[1] describes the reference mark, which is about 4 meters (13 feet) from the bank, 51.97 meters (170.50 feet) south 55° east (magnetic) from the station.

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[1] See pp. 57–59.

Mid (Nueces County, P. M. Trueblood, 1912).—About 200 meters (656 feet) from the Gulf beach of Padre Island, on the largest sand hill, in the neighborhood of the "Settlement," and directly across the island from Griffin's house. The station is located about the center of the summit of the hill, which is partly overgrown with weeds, and is marked according to notes 1b and 7a.[1] Note 11b [1] describes the reference mark, which is 90 meters (295 feet) from the station and bears north 55° west (magnetic). Griffin's house at the Settlement is about 1½ miles north 76° west (magnetic).

Rox (Nueces County, P. M. Trueblood, 1912).—About 2 miles north of the Point of Rocks, 1 mile west of the Laguna shore, ½ mile back of the only white-topped sand hill along this beach, and near the center of the summit of the first big sand hill north of Baffins Bay. The station is marked according to notes 1b and 7a.[1] Note 11b [1] describes the reference mark, which is 42.03 meters (137.9 feet) from the station, in azimuth 166° 00′ 50″. The following azimuths are also given: Twin windmills, 166° 45′ 50″ and 167° 04′ 16″; center of large motte on Point of Rocks, 353° 30′ 50″; tangent to Griffins Point, 4° 01′ 06″.

Transient (Nueces County, P. M. Trueblood, 1912).—On the Gulf shore of Padre Island, about 100 meters (328 feet) from the high-water mark on the summit of the highest sand hill in this locality, but not visible from the Laguna immediately to the west on account of the sand hill on the center and western side of Padre Island. The station is marked according to notes 1b and 7a.[1] Note 11b or 25 [1] describes the reference mark, which is 23.65 meters (77.6 feet) from the station in azimuth 269° 27′ 35″. Other azimuths are: To windmill back of station *Rox*, 111° 37′ 30″; a second windmill back of the station *Rox*, 111° 40′ 30″. Point of Rocks tangent bears south 66° west (magnetic).

Shells 2 (Willacy County, P. M. Trueblood, 1912; 1913).—Near the outside beach of Padre Island, 2½ meters (8 feet) east of the summit of the highest and most conspicuous hill within 2 miles in either direction. The station is marked according to notes 1b and 7a.[1] Note 11b or 25 [1] describes the reference mark which is 25.61 meters (84.0 feet) from the station in azimuth 96° 52′ 28″. Other azimuths are: To center of motte Carnestoliendos, 44° 28′ 10″; to black hummock Padre beach, 121° 10′ 30″.

Griffins Point 2 (Willacy County, P. M. Trueblood, 1912; 1913).—On the south side of Baffins Bay, about 1 mile west of Griffins Point, 100 meters (328 feet) back from the shore, on the highest hill in this locality. The station is marked according to notes 1b and 7a.[1] Note 11b [1] describes the reference mark, which is 23.42 meters (76.8 feet) north 2° west (magnetic) from the station.

Murdock (Willacy County, P. M. Trueblood, 1912; 1913).—On a conspicuous, conical sand hill on the Gulf beach of Padre Island directly across from Murdocks Landing, about ½ mile south of Pat Dunn's corral, and 2 miles south of the Rock Pen landing on the Kenedy ranch. This hill is probably the highest in the vicinity; it has an elevation of about 40 feet and is 100 meters (328 feet) from the high-water mark. The station is marked according to notes 1b and 7a.[1] Note 11b or 25 [1] describes the reference mark, which is 50.36 meters (165.2 feet) from the station in azimuth 31° 23′ 34″. Other azimuths are: Windmill Carnestoliendos, 69° 20′ 24″; windmill near Rock Pen, 121° 20′ 26″; a second windmill near Rock Pen, 121° 38′ 56″.

Salt (Willacy County, P. M. Trueblood, 1912, 1913).—On the mainland shore of Laguna Madre, 2½ miles south of Griffins Point, at an old boat landing known as Rock Pen. It is on a slight rise in the shore line at an elevation of about 10 feet, and 20 meters (66 feet) back from the high-water line. The station is marked according to notes 1b and 7a.[1] Note 11b [1] describes the reference mark, which is 17.59 meters (57.7 feet) from the station in azimuth 105° 03′ 30.″ Other azimuths are: To corner of the old wharf, about 80 meters (262 feet) distant, 234° 16′; to windmill Carnestoliendos, 24° 15′ 05″; to pita, about 80 meters (262 feet) distant, 177° 35′; to right one of the

[1] See pp. 57-59.

two windmills, about 1 mile distant, 122° 21′ 10″; to windmill (2 miles), 27° 21′ 50″; to windmill (2 miles), 47° 57′ 55″.

Rabbit 2 (Nueces County, P. M. Trueblood, 1912).—On the peninsula between Baffins Bay and Agua Dulce Creek, just north of a clump of cactus, on a small grass-covered hill, about 300 meters (984 feet) from the north shore of the peninsula; about 500 meters (1,640 feet) to the south is a larger hill which is thickly wooded. About 700 meters (2,297 feet) southeast of the hill is a rather large salt water pond, with a high sand ridge blown up to the north of it. The station is marked according to notes 1b and 7a,[1] except that both the underground and the surface station marks have brass wedges with notches for center marks instead of nails. Note 11b [1] describes the reference mark, which is 129.6 meters (425.2 feet) north 67° 00′ west (magnetic) from the station.

Penescal 2 (Willacy County, P. M. Trueblood, 1912).—On a small peninsula entirely surrounded at high water, between Baffins Bay and a salt lagoon, on the south side of the bay, 3½ miles west of Griffins Point. The station is 6 meters (20 feet) east of a thick growth of cactus; 47 meters (154 feet) east of the west shore where the channel runs through to the lagoon; 40 meters (131 feet) south from the north shore and 15 meters (49 feet) north from the south shore. The station is marked according to notes 1b and 7a.[1] Note 11b [1] describes the reference mark, which is 45.99 meters (150.9 feet) from the station in azimuth 229° 06′ 57″. Other azimuths are: To elevated steel tank at La Parra, 80° 46′ 35″; windmill with tank 1 mile distant, 273° 45′ 35″.

Frank 2 (Nueces County, P. M. Trueblood, 1912.)—On the west shore of Agua Dulce Creek, known locally as Alazan Bay, and about 7 miles from Baffins Bay. The station is about 50 meters (164 feet) south of the summit of a conspicuous flat-topped hill, 50 or 60 feet high, 250 meters (820 feet) long east and west, and 600 meters (1,968 feet) from the shore. One-half mile to the southeast and 150 meters (492 feet) from the beach is a motte resembling a bushy hill, and ¾ mile to the northeast near another hill is a pair of twin windmills. The station is marked as described by notes 24 and 26 [1] except copper wedges instead of nails indicate the center of the station. The following directions were observed: Channel stake in the bay, 0° 00′; end of fence in the water, 4° 45′; left of the two windmills, 198° 36′; right of the two windmills, 199° 41′; a lone Spanish dagger on the beach, 357° 41′.

Agua (Nueces County, P. M. Trueblood, 1912).—About ½ mile west of Agua Dulce Creek, ½ mile north, 210 meters (689 feet) south and 125 meters (410 feet) east of the shores of a salt lagoon and 250 meters (820 feet) southwest of a small salt water pond. There is a low ridge of wooded hills about 1½ miles west. The station is on top of a hill in a clearing and is marked according to note 23,[1] with the exception that the subsurface and surface marks have pieces of brass with a notch in the top for center marks instead of nails. Note 11b[1] describes the reference mark, which is 16.7 meters (54.8 feet) from the station in azimuth 237° 08′. Other azimuths are: To elevated steel tank at La Parra, 46° 33′ 00″; elevated tank at Buena Vista Hotel, 67° 21′ 05″.

Crawford 2 (Willacy County, P. M. Trueblood, 1912).—On Kenedy's ranch, on the south side of Baffins Bay, on a point that projects into the bay, on a brush-covered hill about 20 meters (66 feet) from the shore and 15 feet high. The station is about 200 meters (656 feet) northwest of a pond, dry except in wet weather, and is marked according to notes 1b and 24,[1] with the exception that the underground mark has a small piece of brass instead of a nail. Note 11b [1] describes the reference mark, which is 50.42 meters (165.42 feet) from the station in azimuth 343° 02′ 35″. Other azimuths are: Tangent to Rabbit Point, 216° 45′ 25″; lone pita on the beach, 227° 33′ 30″; north gable of Pasadiso freight house, 107° 59′ 10″; north gable Pasadiso boathouse, 109° 03′ 25″.

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[1] See pp. 57-59.

Pasadiso (Willacy County, P. M. Trueblood, 1912).—On a small, hard clay hill, on the south side of Baffins Bay, about ¼ mile northwest from Kenedy's wharf and boathouse, 150 meters (492 feet) from the shore, 105 meters (344 feet) north of a salt pond, and 200 meters (656 feet) southeast of a small fresh-water pond. The station is marked according to notes 1b and 24.[1] Note 11b [1] describes the reference mark, which is about 60 meters (197 feet) from the end of the high point that projects into the salt pond, and is 112.75 meters (369.91 feet) from the station in azimuth 339° 42′ 23″. Other azimuths are: North gable of Kenedy's warehouse, near the wharf, 343° 31′ 50″; steel tank, La Parra, 47° 10′ 30″; lone Spanish dagger on hill, 400 meters (1312′ feet) distant, 72° 43′ 30″; middle chimney of Buena Vista Hotel, 141° 55′ 05″.

SUPPLEMENTARY POINTS.

Ranch (Cameron County, J. B. Boutelle, 1917).—On the south end of the point, known locally as Palanga Ranch, about 1¼ miles southwest from Point Isabel Lighthouse, on the western side of a ridge near a small house. The station is marked by a 4-inch drain tile pipe projecting a few inches above ground and filled with cement. A nail inserted in the cement, point up, marks the center of the station. The northwest corner of house is 28 meters (92 feet) in azimuth 330° 23′, and the southwest corner is 32 meters (105 feet) in azimuth 249° 08′ from the station.

Windmill (Willacy County, E. H. Pagenhart, 1913).—The northerly and higher of two windmills on Lopeña Island.

Demit (Nueces County, P. M. Trueblood, 1912).—The station is on Demit Island, at the northern entrance to Laguna Madre, and about ¼ mile east of Flour Bluff, which is on the mainland. Demit Island is low and covered with sand with some patches of grass. The station is on one of these grass patches. It is about 215 paces from the northern or outside shore of the island, about 281 paces from the southern shore, and about 156 paces from the western shore. The station is marked as described in notes 1b and 7a.[1] Note 11b [1] describes the reference mark, which is 31.95 meters (104.8 feet) from the station in azimuth 283° 11′ 20″. The reference mark is 11 meters (36 feet) west of the shore of a small inlet. Other azimuths are: To east gable of Welburn's house (post office), 96° 50′ 50″; to most northerly windmill at Flour Bluff, 101° 19′ 40″.

Puzzle (Nueces County, P. M. Trueblood, 1912).—On the mainland 2.2 miles below Peat Island, and 28 paces from the sand beach. It is 1 mile northeast of the abandoned Barnes' house, which had a windmill alongside about 300 meters (984 feet) south from the first opening in the beach below the Peat Island Channel, and 45 paces south of the next (blind) opening. The station is on land, which is composed of finely broken shells and is 3 feet above the ordinary stage of the water of the Laguna Madre. Parallel to the beach and distant 7 meters (23 feet) is a salty pool, about 8 meters (26 feet) long, and about 3 meters (10 feet) wide, about 1 foot deep; south of this pool are two similar pools 10 meters (33 feet) and 7 meters (23 feet) long, respectively. Beginning about 6 feet from the station, trenches 2 feet wide, 1½ feet deep, and 12 feet long were dug, two parallel to the beach and two normal to it. A mound of shells 2½ feet high and 4 feet in diameter was placed at the outer end of each trench. Hard pine stakes were set beyond these mounds. Notes 24 and 26 [1] describe the station marks.

South Bird (Nueces County, P. M. Trueblood, 1912).—Station is about ¾ mile west of Padre Island, on the highest part of South Bird Island, about 13 meters (43 feet) north of the largest clump of Spanish daggers, 49 meters (161 feet) south of a slightly smaller clump, and about 47 meters (154 feet) from each of three small ponds to the northwest, northeast, and east, respectively. The station is marked according to notes 1b and 7a and 22.[1]

[1] See pp. 57-59.

North Bird (Nueces County, P. M. Trueblood, 1912).—On North Bird Island in the Laguna Madre. The island is small and is covered with grass and small bushes. The station is on ground slightly above the general level, about 45 meters (148 feet), 60 meters (197 feet), and 57 meters (187 feet), respectively, from high water to the south, west, and east. The station is marked according to notes 1b, 7a, and 22.[1] There is no reference mark.

Caballos (Willacy County, P. M. Trueblood, 1912).—The geographic position of this station was not determined. It is located about 237 meters (778 feet) from the southern end of the long narrow island known as Potrero Los Caballos. This island is on the west side of Laguna Madre, 4.2 miles south of Rocky Bayou and 5 miles south of the north edge of the "Big Flats." The station is on the highest point of the island. The station is marked as described in notes 1b and 7a.[1] Note 11b [1] describes the reference mark, which is 36.00 meters (118.1 feet) directly north of the station.

LOST STATIONS.

POINT ISABEL TO CORPUS CHRISTI.

The stations in the following list have either been destroyed or they probably can not be recovered unless distances and directions are measured to them from some other stations more easily recoverable which have been established later near the older stations. In all cases where the stations are known to have been lost a note to that effect is made.

Padre (Nueces County, H. D. King, 1905).—In 1912 reported lost.

Grants (Nueces County, R. E. Halter, 1877; 1905).—Marked as described in note 28.[1]

Chappa (Nueces County, R. E. Halter, 1877; 1905).—Marked as described in note 28.[1]

Peat Island (Nueces County, R. E. Halter, 1877; 1882).—Marked as described in note 28.[1]

Mott (Nueces County, R. E. Halter, 1877).—Marked as described in note 28.[1]

Richards (Nueces County, R. E. Halter, 1877).—Marked as described in note 28.[1]

Wheelbarrow (Nueces County, R. E. Halter, 1877).—Marked as described in note 28.[1]

Point of Rocks (Nueces County, R. E. Halter, 1877).—Marked as described in note 28.[1]

Griffins Point (Willacy County, R. E. Halter, 1877).—Marked as described in note 28,[1] except that the center stake was palmetto.

Shells (Willacy County, R. E. Halter, 1877).—Marked as described in note 28.[1]

Coyote (Willacy County, R. E. Halter, 1877).—Marked as described in note 28.[1]

Venado (Willacy County, R. E. Halter, 1877; 1881).—Marked as described in note 28.[1] In 1913 reported probably lost.

Indian (Willacy County, R. E. Halter, 1878).—Marked as described by note 28.[1]

Station Hill (Willacy County, R. E. Halter, 1878).—Marked as described by note 28.[1] In 1913 reported probably lost.

Stoley (Willacy County, R. E. Halter, 1878).—Marked as described by note 28.[1]

Avoca (Willacy County, R. E. Halter, 1878).—Marked as described by note 28.[1]

Tank (Willacy County, R. E. Halter, 1878).—Marked as described by note 28.[1]

Gladiator (Cameron County, R. E. Halter, 1878).—Marked as described by note 28.[1]

Waterhole (Cameron County, R. E. Halter, 1879).—Marked as described by note 28.[1]

Santa Cruz (Cameron County, R. E. Halter, 1879).—Marked as described by note 28.[1]

Flour Bluff (Nueces County, S. A. Gilbert, 1860; 1876).—Marked by a bottle buried in the ground for center of the station; surrounded with iron reference marks at the surface. In 1876 the hill was reported as badly eroded.

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[1] See pp. 57-59.

Thompsons (Nueces County, R. E. Halter, 1876).—Lost.

Kenedy (Nueces County, R. E. Halter, 1877).—Marked as described by note 28.[1]

Penescal (Willacy County, R. E. Halter, 1877).—Marked as described by note 28.[1]

Rabbit (Nueces County, R. E. Halter, 1877).—Marked as described by note 28.[1]

Crawford (Willacy County, R. E. Halter, 1877).—Marked as described by note 28.[1]

Tree (Nueces County, R. E. Halter, 1877).—Marked as described by note 28.[1]

Bovido (Nueces County, R. E. Halter, 1877).—Marked as described by note 29.[1]

Camp (Nueces County, R. E. Halter, 1876).—Marked with a concrete pyramid with lead in its apex, buried 3 feet below the surface of the ground. A pine pole was placed above this.

Jack (Nueces County, R. E. Halter, 1877).—Marked as described in note 29.[1]

Peg (Nueces County, R. E. Halter, 1877).—Marked as described in note 29.[1]

Gum Pen (Willacy County, R. E. Halter, 1878).—Marked as described in note 29.[1] In 1913 it was reported as probably lost.

New (Willacy County, R. E. Halter, 1878).—Marked as described by note 29.[1]

Rock Pen (Willacy County, R. E. Halter, 1877).—Marked as described by note 29.[1]

Bird (Nueces County, R. E. Halter, 1877).—Marked as described by note 29.[1]

Frank (Nueces County, R. E. Halter, 1877).—Marked as described by note 29.[1]

Cow (Nueces County, R. E. Halter, 1877).—Marked as described by note 29.[1]

Willow (Nueces County, R. E. Halter, 1877).—Marked as described by note 29.[1]

Camp No. 2 (Nueces County, R. E. Halter, 1877).—Marked as described by note 29.

Murdock's Landing (Willacy County, R. E. Halter, 1877).—Marked as described by note 29.[1]

Ford (Nueces County, R. E. Halter, 1877).—Marked as described by note 29.[1]

Sand (Willacy County, R. E. Halter, 1878).—Marked as described by note 29.[1]

Mosquito (Willacy County, R. E. Halter, 1878).—Marked as described by note 29.[1]

Crossing (Willacy County, R. E. Halter, 1878).—Marked as described by note 29.[1] In 1913 reported as probably lost.

Portalis (Cameron County, R. E. Halter, 1878).—Marked as described by note 29.[1]

Rainy (Willacy County, R. E. Halter, 1878).—Marked as described by note 29.[1]

Bonnet (Cameron County, R. E. Halter, 1878).—Marked as described by note 29.[1] In 1913 it was reported as lost.

Brant (Cameron County, R. E. Halter, 1878).—Marked as described by note 28.[1]

Duck (Cameron County, R. E. Halter, 1879).—The station was marked by a lead plug in a coral rock and by four bottles buried with their tops level with the surface of the ground, 3 feet from the center, and on lines intersecting at right angles at the center.

Oil (Cameron County, R. E. Halter, 1879).—Marked as described by note 29.[1]

Cat (Cameron County, R. E. Halter, 1879).—Marked as described by note 29.[1]

Snipe (Cameron County, R. E. Halter, 1879).—Marked as described by note 29.[1]

Mesena (Cameron County, R. E. Halter, 1879).—In 1885 reported lost.

Wolf Trap (Cameron County, W. E. Greenwell, 1854).—Recovered in 1867, but then was marked only by stakes as reference marks. Should be considered as lost.

Boca Chica 2 (Cameron County, C. H. Boyd, 1867).—Marked only with mesquite post.

Rio Grande Observatory (Cameron County, W. E. Greenwell, 1854, 1867.)—Marked with monument of masonry. In 1867 only the base remained, and this was reported then as being in danger of being washed away. Should be considered as lost.

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[1] See pp. 57-59.

COMPUTATION, ADJUSTMENT, AND ACCURACY OF THE ELEVATIONS.

The zenith distances directly observed at each station were first computed. These zenith distances were corrected for height of the object observed and of instrument so as to refer them all to the ground at each station or to the surface marks at the station.

The difference of elevation of each pair of stations in the main scheme 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 elevations of the stations, ζ_2 and ζ_1 are the measured zenith distances as corrected for height of instrument and of object observed, s is the horizontal distance between the stations, and ρ is the radius of curvature of the earth.

As there are always two or more lines to each new station, many rigid conditions exist 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 elevations.

The elevations of stations of the primary scheme from the Alice base net to the Point Isabel base net and to the line Donna-Rio were adjusted in one set of equations. In this adjustment the elevation of Alice west base, Wood, and Point Isabel west base were held fixed at 51.75 meters,[1] 40.46 meters,[1] and 3.00 meters,[2] respectively.

The probable error of an observation of weight unity derived from this adjustment is ±0.95 meter. In other words, the reciprocal observations over a line 31.7 kilometers (19.7 miles) long, this being the length of the line corresponding to unit weight, determined 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 0.95 meter. The probable errors for other lines were assumed to be proportional to their lengths.

The probable errors of the elevations of Alice west base and Wood, determined from vertical angles, do not exceed ±0.39 meter. The probable error of the elevation of point Isabel west base, determined by connecting the leveling along the base with a tide staff, does not exceed ±0.10 meter.

Station Brenner was assumed to be the one least accurately determined, and its probable error was computed as a limiting value and found to be ±0.55 meter from the vertical angles alone, or when combined with the probable error of the stations fixed by previous vertical angle adjustment, it was ±0.67 meter.

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[1] See Appendix 5, Report of 1911, p. 409. [2] See Appendix 4, Report of 1907, p. 130.

The datum for all the elevations is mean sea level. The stations are in three classes: First, those fixed by direct connection with sea level whose elevations are subject to a probable error of ±0.1 meter; second, the stations in the main scheme fixed by reciprocal measures of vertical angles and subject to probable errors varying from ±0.1 to ±0.7 meter; and, third, the intersection stations, the elevations of which are fixed by measurements of vertical angles which are nonreciprocal, the intersection stations not being occupied, and having elevations subject to probable errors which may be as great as ±2 meters.

TABLE OF ELEVATIONS.

[Ninety-eighth meridian south.]

Station.	Point to which elevation refers.	Elevation.	
		Meters.	Feet.
Class 1.			
Point Isabel west base	Station mark	3.00	9.84
Class 2.			
Alice west base	do	51.75	169.8
Wood	do	40.46	132.7
King	do	38.03	124.8
Bishop	do	15.61	51.2
Ricardo	do	31.47	103.2
Kleberg, *ecc*	do	19.71	64.7
Riviera	do	23.47	77.0
Robbins	do	15.57	51.1
Roza	do	23.99	78.7
Sarita	do	23.40	76.8
Turcotte	do	21.73	71.3
Kenedy	do	13.04	42.8
Katherine	do	9.96	32.7
Armstrong	do	9.98	32.7
Vinson	do	14.60	47.9
Norias	do	9.98	32.7
Stillman	do	13.88	45.5
Yturria	do	10.86	35.6
Brenner	do	11.59	38.0
Raymond	do	9.82	32.2
Hidalgo	do	16.04	52.6
Sebastian	do	16.00	52.5
Mercedes	do	19.92	65.4
Harlingen	do	17.21	56.5
Maria	do	23.15	76.0
Mitla	do	18.69	61.3
Benito	do	15.42	50.6
Cowgill	do	9.97	32.7
Olmito	do	8.98	29.5
Resaca	do	7.18	23.6
Donna	do	29.94	98.2
Rio	do	24.15	79.2
Arista	do	10.27	33.7
Class 3.			
Alice standpipe	Top	105.6	346
Alice Catholic Church spire	do	80.6	264
Bishop standpipe	do	48.5	159
Kingsville standpipe	do	53.0	174
Kingsville Presbyterian Church	Top of steeple	44.1	145
Kingsville Methodist Church	Top of spire	37.3	122
Kingsville, H. M. King School	Top of cupola	41.1	135
Kingsville, taller of two metal stacks on Frisco railroad shops.	Top	48.2	158

Table of elevations—Continued.

Station.	Point to which elevation refers.	Elevation.	
		Meters.	Feet.
Class 3—Continued.			
Riviera schoolhouse	Top of cupola	29.6	97
Ricardo schoolhouse	do	24.5	80
Sarita standpipe	Top	44.7	147
Kenedy ranch standpipe	do	32.0	105
Kenedy ranch oil-well derrick[1]	Ground at foot of derrick	7.0	23
Do	Top of derrick	35.0	115
Turcotte section house	Top of north chimney	16.4	54
Katherine, railroad water tank[1]	Top	19.8	65
Norias's house	Top of south gable	13.1	43
Windmill ¼ mile north-northeast of Norias's house[1]	Ground	5.2	17
Rudolph, water tank	Top	19.2	63
Raymondville, water tank	do	20.8	68
Raymondville, cotton gin smokestack	do	27.8	91
Harlingen standpipe	do	54.5	179
Harlingen sugar mill	Top of steel derrick with yardarm.	53.4	175
Harlingen pumping station	Top of tall stack	55.0	180
Do	Top of low stack	41.7	137
Mercedes Canal pumping station	Top of tall stack	55.3	181
Mercedes standpipe	Top	48.1	158
Mercedes west church	Top of steeple	43.7	143
Mercedes east church	do	41.4	136
San Benito pumping station	Top of cylindrical short stack.	41.7	137
San Benito Bank and Trust Co. building[1]	Top of cupola on southwest corner.	26.5	87
San Benito sugar mill	Top of tall brick stack	55.2	181
San Benito standpipe	Top	45.7	150
United States and Mexico boundary monument R. P. No. 28.[1]	do	25.0	82
United States and Mexico boundary monument R. P. No. 31.[1]	do	23.8	78
United States and Mexico boundary monument R. P. No. 53.[1]	do	15.5	51
Progresso church	Top of steeple	43.1	141
La Feria pumping station first lift	Top of tall stack	48.5	159
La Feria pumping station second lift	Top of stack	45.6	150
Santa Maria Catholic Church spire	Top of ball at bottom of cross.	40.6	133
Heidelberg church	Top of steeple	41.0	135
Ohio-Texas Sugar Co. factory	Top of chimney	45.5	149
Cowgill water tank	Top	23.8	78
Olmito factory, northern of two chimneys	do	36.0	118
Olmito factory, southern of two chimneys	do	40.6	133

[1] No check on this elevation.

ASTRONOMIC WORK.

There are two longitude stations which were connected with stations of the primary triangulation covered by this report. One is near Point Isabel and the other is near triangulation station Donna. The methods employed by the observers are described in that part of Special Publication No. 14, which deals with the telegraphic determination of a difference in longitude.

The Rio Grande Observatory, now destroyed, is the only astronomic latitude station connected with the primary triangulation treated in this volume. Its geodetic position is given on page 56. It was established in August, 1853, when 127 observations were made on

20 pairs of stars for the determination. The resulting astronomic latitude is 25° 57′ 21″.64, with a probable error of ±0″.07.

Program of occupation of azimuth stations by party of Assistant C. V. Hodgson.

Station.	Date of occupation.	Number of positions.[1]	Probable error of result.
	1913.		
Robbins	Mar. 16	16	±0.23
Brenner	Apr. 11	14	± .32
Raymond	Apr. 13	16	± .23
Donna	May 23, 24	30	± .22

[1] Each new setting of the graduated circle with relation to the direction to the initial station or line is called a position. In any one position two pointings with the telescope are made on each object, one with the telescope direct and the other reversed.

Summary of the determination of the difference of longitude, Point Isabel and Austin, Tex.

Station— Eastern.	Station— Western.	Date of exchange of time signals.	Difference of longitude. Δλ	v	Transmission time.
		1906.	m. s.	s.	s.
Point Isabel	Austin	Mar. 29	2 07.270	+0.030	0.035
Do	do	Mar. 30	07.298	+ .002	.037
Do	do	Mar. 31	07.332	− .032	.028
Mean			2 07.300	±0.012	.033
Correction for loop closure[1]			−0.013		
Final difference			2 07.287		

[1] This difference in longitude is part of the loop involving the stations Austin, Alice, and Point Isabel, all in Texas.

At Austin the transit was mounted on the pier which was used in 1895 and 1899, reference to which may be found on pages 239 and 254 of Appendix 2 of the Report for 1897. The adjusted longitude of this Austin station is $6^h\ 30^m\ 57^s.024$ or 97° 44′ 15″.360.

At Point Isabel the transit was mounted on a concrete pier 10.60 meters east and 21.21 meters north of triangulation station Fronton. (See description on p. 400 of Appendix 5 of the Report for 1911, and p. 67 of this report.) The astronomic station is $2^m\ 07^s.287 = 31'\ 49''.305$, east of the Austin longitude station of 1895–1899–1906. The longitude of the Point Isabel astronomic station is therefore 97° 12′ 26″.055 and the longitude of triangulation station Fronton is 0″.375 greater or 97° 12′ 26″.430.

Summary of the determination of the difference of longitude, Austin and Donna, Tex.

Station— Eastern.	Station— Western.	Date of exchange of time signals.	Difference of longitude. Δλ	v	Transmission time.
		1913.	m. s.	s.	s.
Austin	Donna	May 30	1 14.320	−0.011	0.056
Do	do	May 31	14.291	+ .019	.043
Do	do	June 1	14.318	− .008	.040
Mean			1 14.310	±0.006	0.046

At Austin the transit was mounted on the longitude pier of 1911. This pier is 11.716 meters west and 0.122 meter south of the old longitude pier occupied in 1895, 1899, and 1906, reference to which may be found on pages 239 and 254 of Appendix 2 of the Report for 1897. The adjusted longitude of the pier of 1895–1899–1906 is $6^h\ 30^m\ 57^s.024$ or 97° 44′ 15″.360. The 1911 pier is $0^s.029$ west of it, making the longitude pier of 1911–1913, $6^h\ 30^m\ 57^s.053$ or 97° 44′ 15″.795.

At Donna the transit was mounted on a concrete pier 31.607 meters west and 0.034 meter north of the triangulation station Donna (see description on p. 64). The longitude station is $1^m\ 14^s.310$ or 18′ 34″.650 west of Austin longitude station of 1911–1913. The longitude of Donna longitude station is therefore 98° 02′ 50″.445 and the longitude of Donna triangulation station is 1″.138 less and therefore 98° 02′ 49″.307.

LAPLACE POINTS.

A Laplace point is a station of the triangulation at which the astronomic azimuth has been observed and the astronomic longitude has been determined.

A Laplace azimuth is an observed astronomic azimuth corrected for the prime vertical component of the deflection of the vertical. This deflection is the angle formed by the actual plumb-line direction with the normal to the reference spheroid at the point of observation.

It is possible to carry the geodetic longitudes throughout a continuous system of triangulation with very little error, but the geodetic azimuth is affected by the accidental errors of the observations of horizontal directions and also by the systematic error which seems almost always to be present in an arc of triangulation.[1] The effect on the azimuth is, in general, of such a magnitude that it is very desirable that true or Laplace azimuths be introduced into the scheme and held in the adjustment of the triangulation. This was done in the triangulation covered by this report. The Laplace azimuths are at station Alice, at the beginning of the scheme, at station Fronton, and at station Donna.

LAPLACE CORRECTIONS.

If, after a datum has been selected for the triangulation in any area, Laplace azimuths are determined and the triangulation adjusted to them, then what may be called true geodetic latitudes and longitudes can be determined for the various stations of the triangulation. These positions will be free from the effect of the deviation of the geodetic azimuths determined by the triangulation. But the Laplace azimuths in the adjustment of the triangulation in the United States have only been used in recent years. In consequence, to obtain the

[1] See pp. 64–79 of Special Publication No. 19.

value of the deflection of the vertical in the meridian at any point we need to know not only the value of the difference between the astronomic latitude and the geodetic latitude, as given directly by the triangulation, but also the effect on the geodetic latitude and longitude of the deviation of the observed azimuth of the triangulation from the true azimuth.

In the case of the ninety-eighth meridian triangulation the Laplace azimuth at station Alice only was used when that portion of the arc to the south of the thirty-ninth parallel arc was adjusted. Also no Laplace azimuths had been used in the adjustment of the triangulation along the thirty-ninth parallel. As a result, there were no latitudes and longitudes in the southern ninety-eighth meridian triangulation which were not affected by the deviation of the azimuth in the triangulation, and hence those geodetic data differ from what may be called the true North American datum latitudes and longitudes. The corrections necessary to make the geodetic data agree with the true data may be called Laplace corrections.[1]

On account of not having used all of the Laplace azimuths in the older triangulation adjustments, it is found that the Laplace corrections at Alice, Tex., are:

For latitude..... $+0''.08$
For longitude.... $-1''.42$

In the adjustment of the triangulation the Laplace azimuth was not rigidly held. In consequence, the Laplace correction to the azimuth at Alice is $+0''.04$.

DEFLECTIONS OF THE VERTICAL.

MERIDIAN DEFLECTIONS.

At Alice the Laplace correction to the geodetic latitude is $+0''.08$. A like amount should be applied to the geodetic latitude of the Rio Grande Observatory, which is 25° 27′ 17″.197 and then becomes 25° 27′ 17″.28. As the astronomic latitude of that observatory is 25° 57′ 21″.64, the value of A–G is $+4''.36$. The deflection of the vertical in the meridian is therefore to the southward.

PRIME VERTICAL DEFLECTIONS.

As the geodetic longitude at Alice requires a Laplace correction of $-1''.42$,[1] the same correction must be applied to the geodetic longitudes at Fronton and Donna before the true value of the deflection can be obtained.

[1] See p. 20, Supplementary Investigation in 1909 of the Figure of the Earth and Isostasy, 1909, J. F. Hayford.

The following table gives the principal facts regarding the prime vertical deflection at stations Fronton and Donna. The deflection is to the eastward in each case:

Prime vertical deflections from longitude determinations.

Station.	Geodetic longitude.	Astronomic longitude.	A-G.	Laplace correction to A-G.	Corrected A-G.	Cos. latitude.	Deflection of vertical A-G in prime vertical.
	° ′ ″	″	″	″	″		″
Fronton	97 12 25.35	26.43	+1.08	+1.42	+2.50	0.8982	+2.25
Donna	98 02 45.41	49.31	+3.90	+1.42	+5.32	0.8976	+4.78

At Alice there is, as mentioned above, a Laplace correction to the geodetic azimuth of +0″.04, and therefore there is a value of A-G of −0″.04.[1]

In the adjustment of a primary arc of triangulation, the Laplace azimuths are computed and equations are included in the adjustment to hold these azimuths; but as all the changes which may occur in the adjustment can not be provided for, the final azimuth may differ by a small amount from the true azimuth. If this difference is so small as to be negligible, as is generally the case, no other adjustment is made.

This is the case with the triangulation covered by this book. There should be applied Laplace corrections to the geodetic azimuth at Fronton and Donna of −0″.03. With corrections of +0″.04 at Alice and of −0″.03 at Fronton and Donna, there are necessarily errors in the geodetic azimuths at the stations between each two of these three azimuth stations. It has been found that the Laplace corrections at the intermediate azimuth stations are: At Robbins, +0″.02; at Brenner, −0″.01; at Raymond, −0″.01.

Prime vertical deflections from Azimuth determinations.

Station.	Geodetic latitude.	Geodetic longitude.	Geodetic azimuth.	To station—	Astronomic azimuth.[2]	A-G.	Laplace correction to A-G.	Corrected A-G.	−Cot latitude.	Deflection of vertical (A-G) in prime vertical.
	° ′	° ′	° ′ ″		″	″	″	″		″
Robbins	27 18.4	97 44.3	84 43 50.91	Riviera	49.56	−1.35	−0.02	−1.37	−1.9370	+2.65
Brenner	26 28.8	97 52.0	217 02 28.59	Yturria	26.99	−1.60	+0.01	−1.59	−2.0075	+3.19
Raymond	26 28.9	97 44.3	88 57 15.05	Brenner	11.90	−3.15	+0.01	−3.14	−2.0073	+6.30
Fronton	26 04.7	97 12.4	73 34 38.03	Point Isabel, south base	36.90	−1.13	+0.03	−1.10	−2.0433	+2.25
Donna	26 09.7	98 02.8	314 05 15.57	Rio	13.20	−2.37	+0.03	−2.34	−2.0358	+4.76

[1] See p. 20 of Supplemental Investigation in 1909 of the Figure of the Earth and Isostasy.
[2] The astronomic azimuths have not been corrected for variation of the pole.

The deflection of the vertical is in each case to the eastward. The values at Fronton in the above table agree exactly with the deflection from the longitude. The value at Donna is 0″.02 smaller than the value of the deflection from longitude data. The latter should be used in any work connected with the figure of the earth. Had the computations been carried to three decimal places, the deflections by azimuth and longitude would have agreed in the second place.

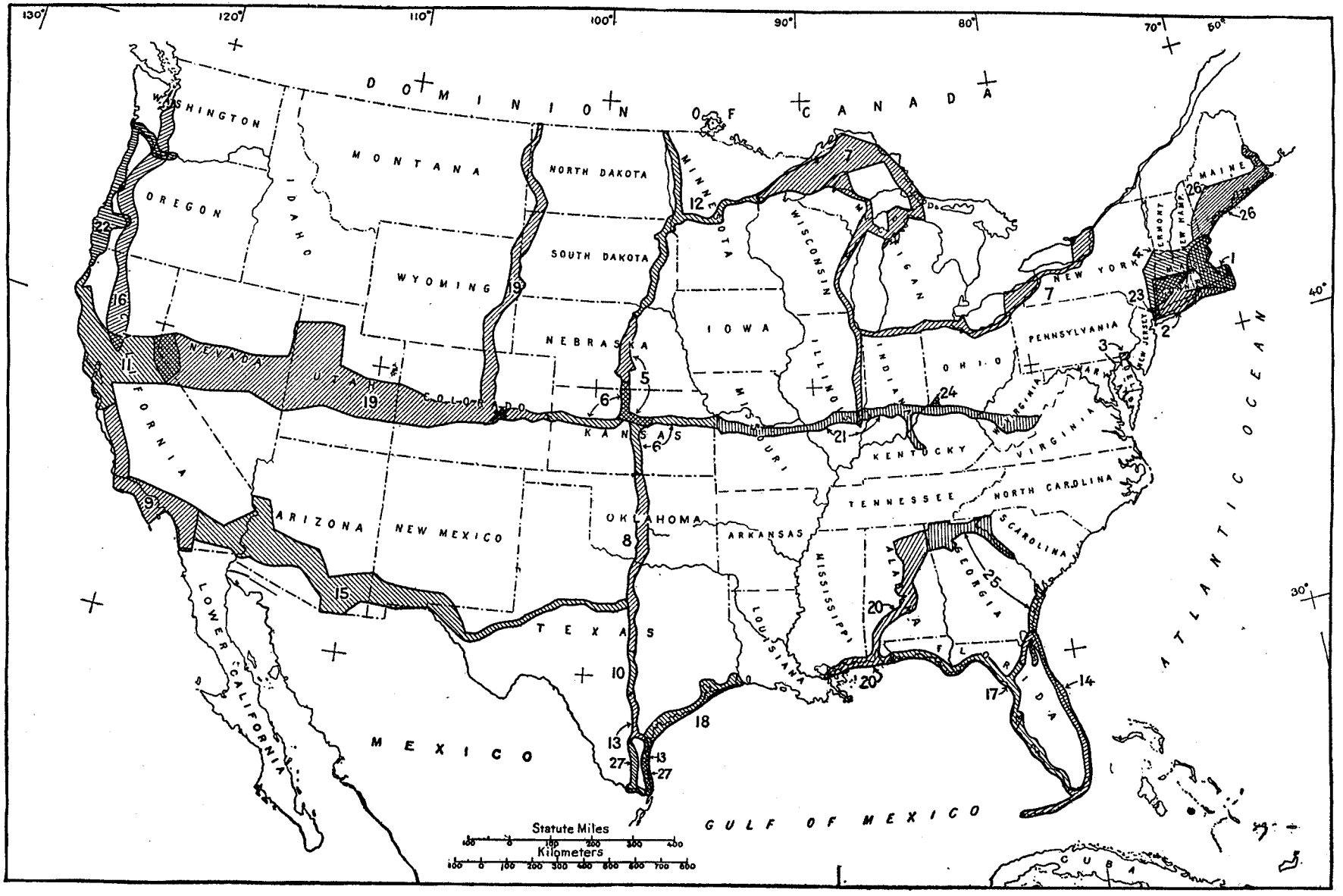

Fig. 11.—INDEX MAP SHOWING AREAS COVERED BY PUBLISHED TRIANGULATION WHICH HAS BEEN RIGIDLY COMPUTED ON THE NORTH AMERICAN DATUM.

1, Appendix 8 Report for 1885; 2, Appendix 8 Report for 1888; 3, Appendix 8 Report for 1893; 4, Appendix 10 Report for 1894; 5, Appendix 6 Report for 1901; 6, Appendix 3 Report for 1902; 7, Appendix EEE Annual Report of the Chief of Engineers, 1902; 8, Appendix 4 Report for 1903; 9, Appendix 9 Report for 1904; 10, Appendix 5 Report for 1905; 11, Appendix 5 Report for 1910; 12, Appendix 4 Report for 1911; 13, Appendix 5 Report for 1911; 14, Appendix 6 Report for 1911; 15, Special Publication No. 11; 16, Special Publication No. 13; 17, Special Publication No. 16; 18, Special Publication No. 17; 19, Special Publication No. 19; 20, Special Publication No. 24; 21, Special Publication No. 30; 22, Special Publication No. 31; 23, Report on the triangulation of Greater New York; 24, Report on a plan of sewerage for the city of Cincinnati; 25, Special Publication No. 43; 26, Special Publication No. 46; 27, this publication.

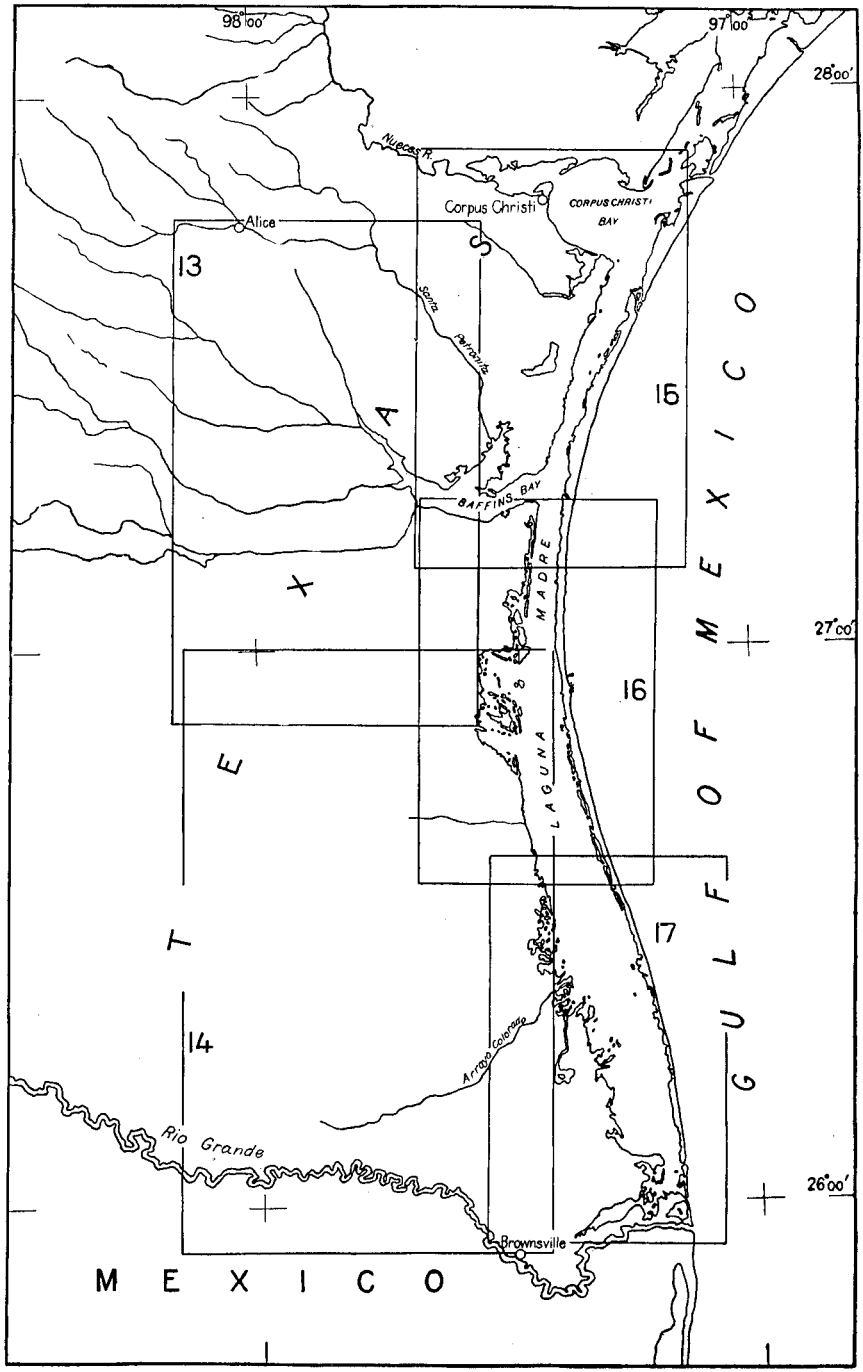

Fig. 12.—INDEX MAP SHOWING THE LIMITS OF EACH OF THE SKETCHES, FIGURES 13 TO 17.

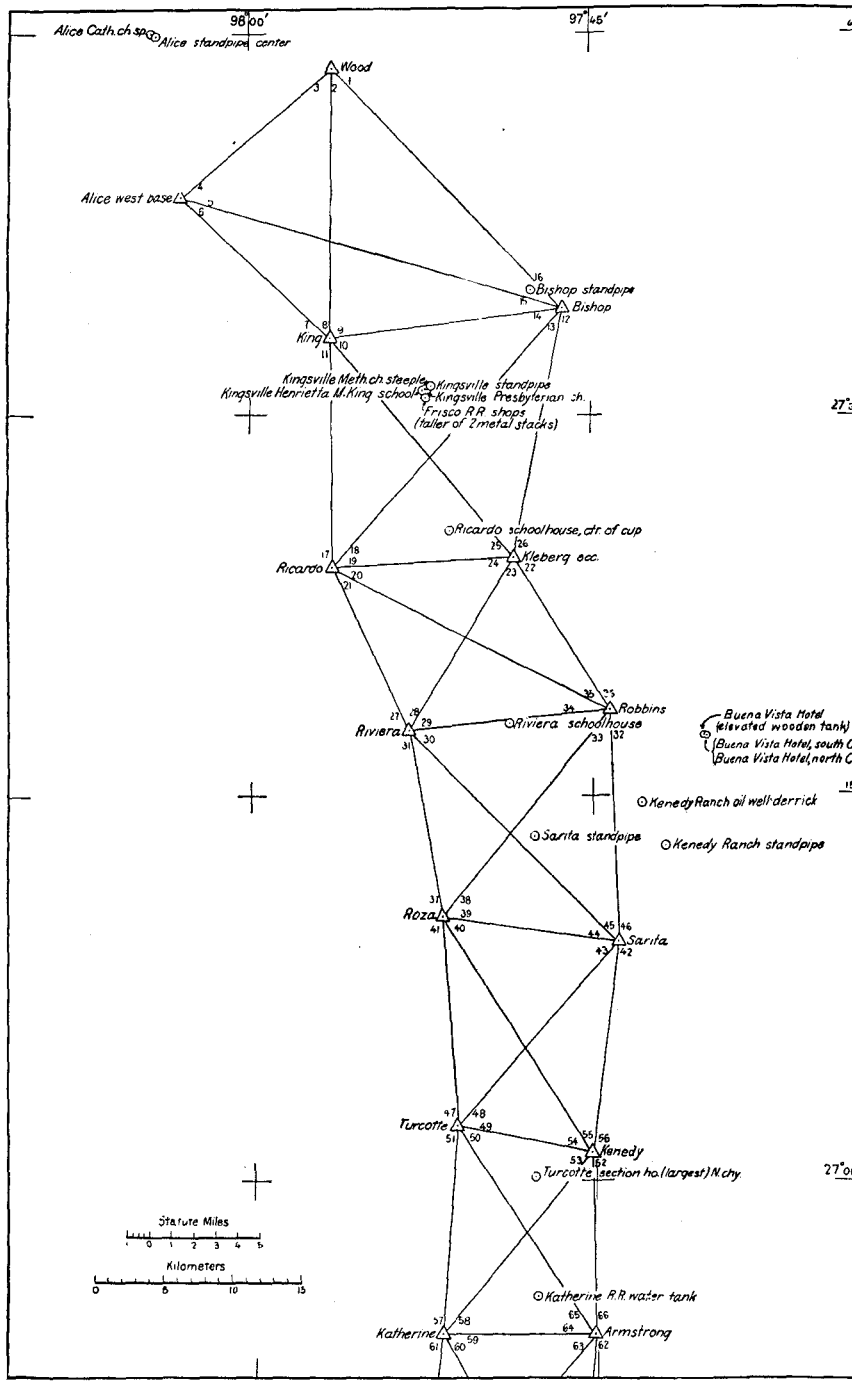

Fig. 13.—PRIMARY TRIANGULATION, ALICE BASE TO STATIONS KATHERINE AND ARMSTRONG.

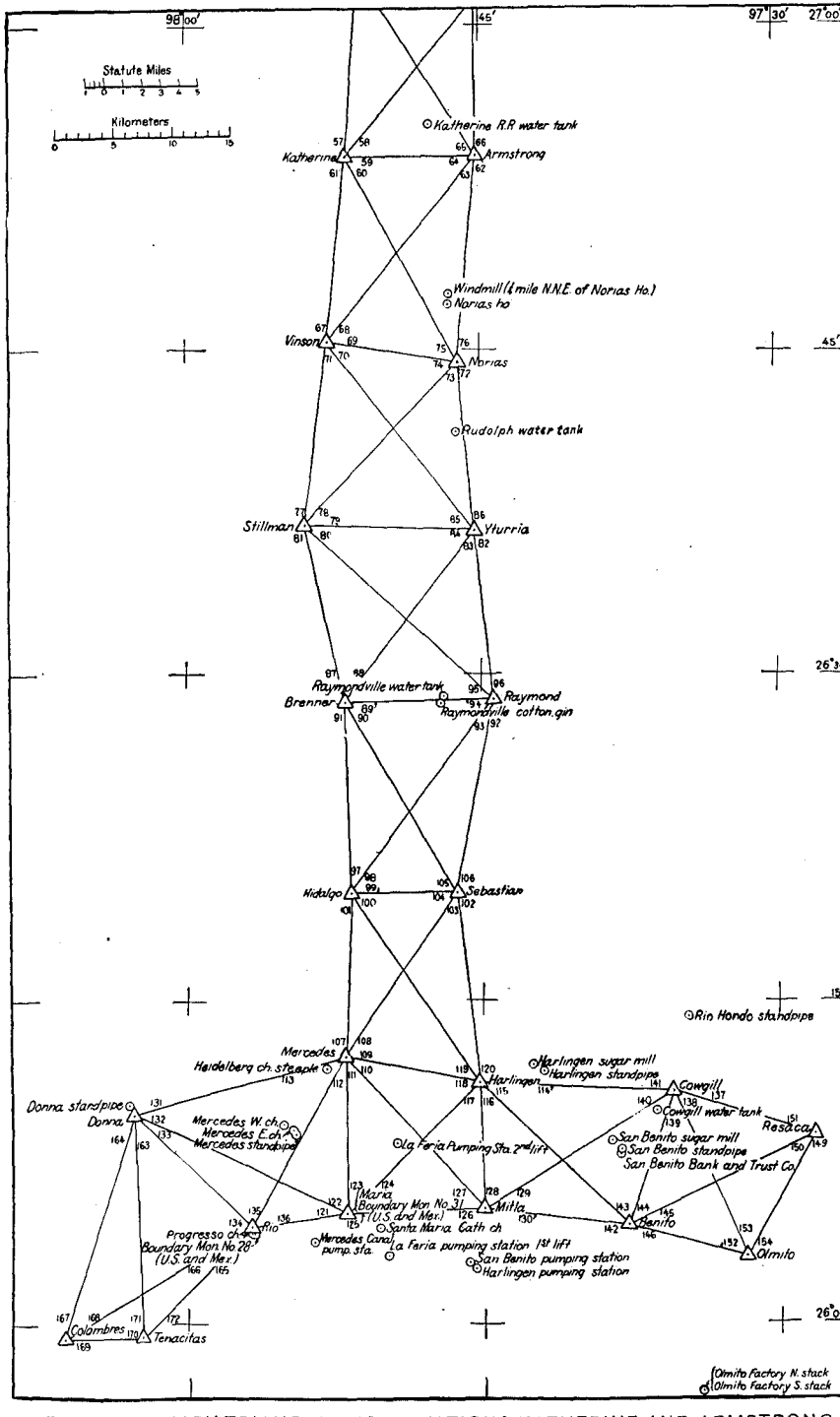

Fig. 14.—PRIMARY TRIANGULATION, STATIONS KATHERINE AND ARMSTRONG TO THE RIO GRANDE, INCLUDING THE MEXICAN CONNECTION.

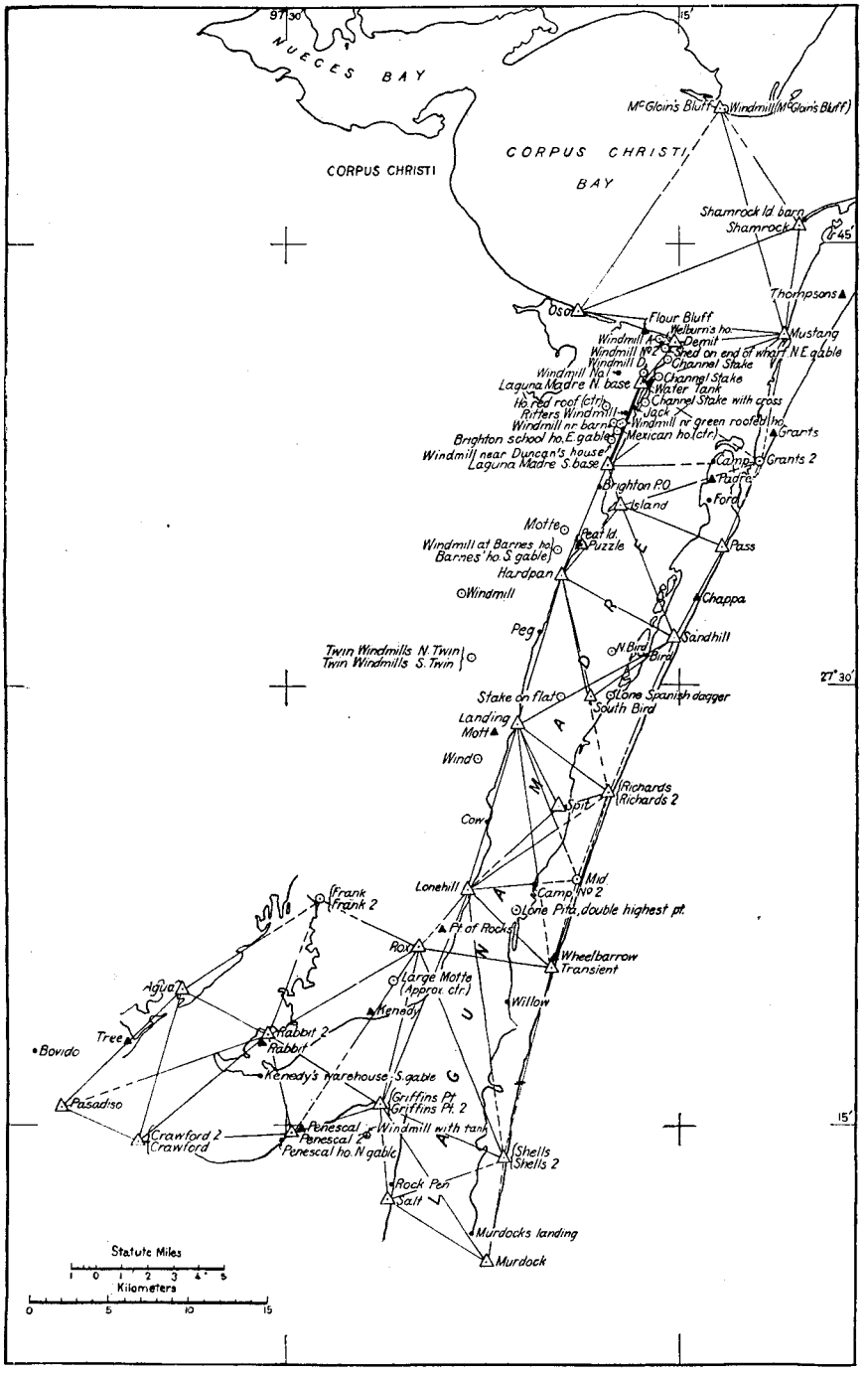

Fig. 15.—TRIANGULATION ALONG THE COAST, CORPUS CHRISTI BAY TO STATIONS SALT AND MURDOCK.

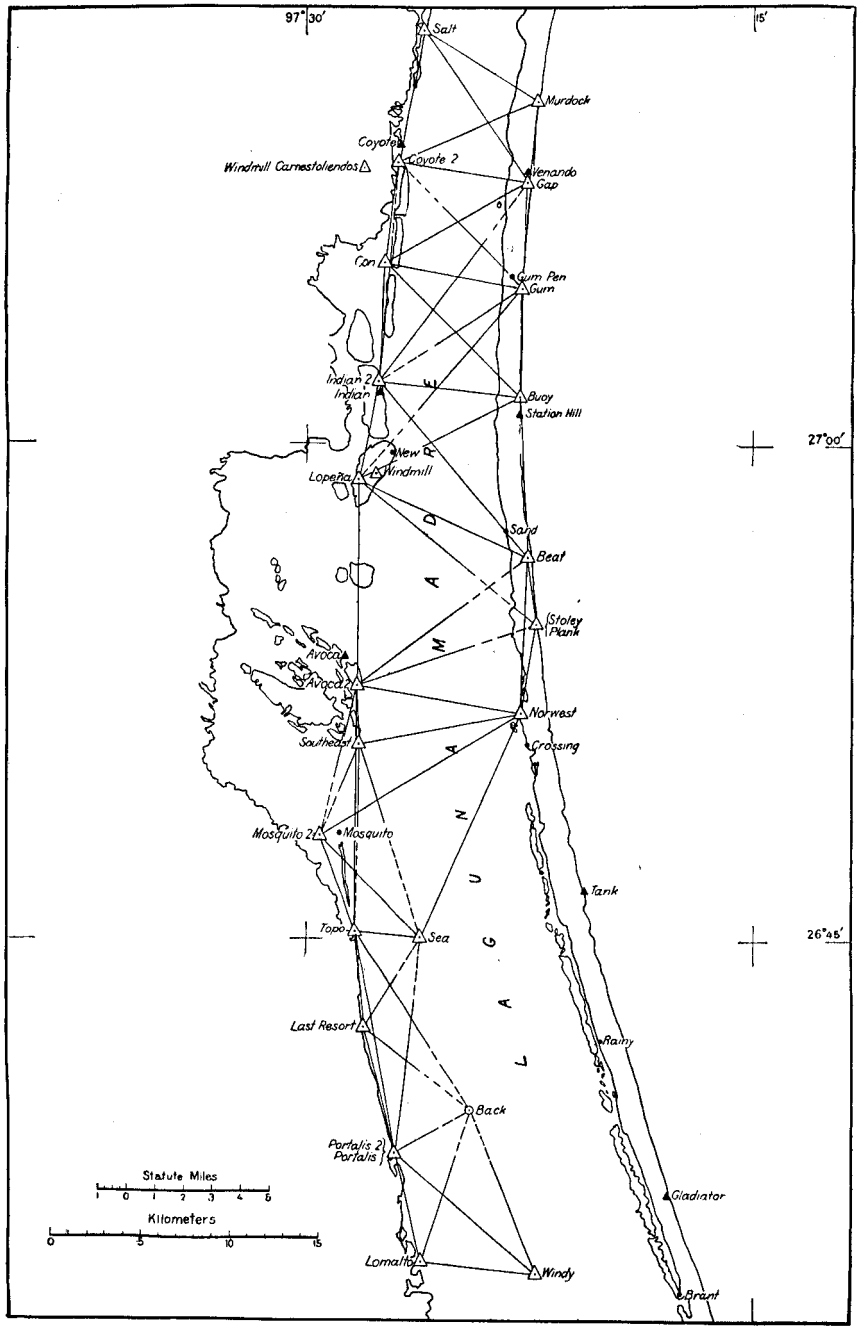

Fig. 16.—TRIANGULATION ALONG THE COAST, STATIONS SALT AND MURDOCK TO STATIONS LOMALTO AND WINDY.

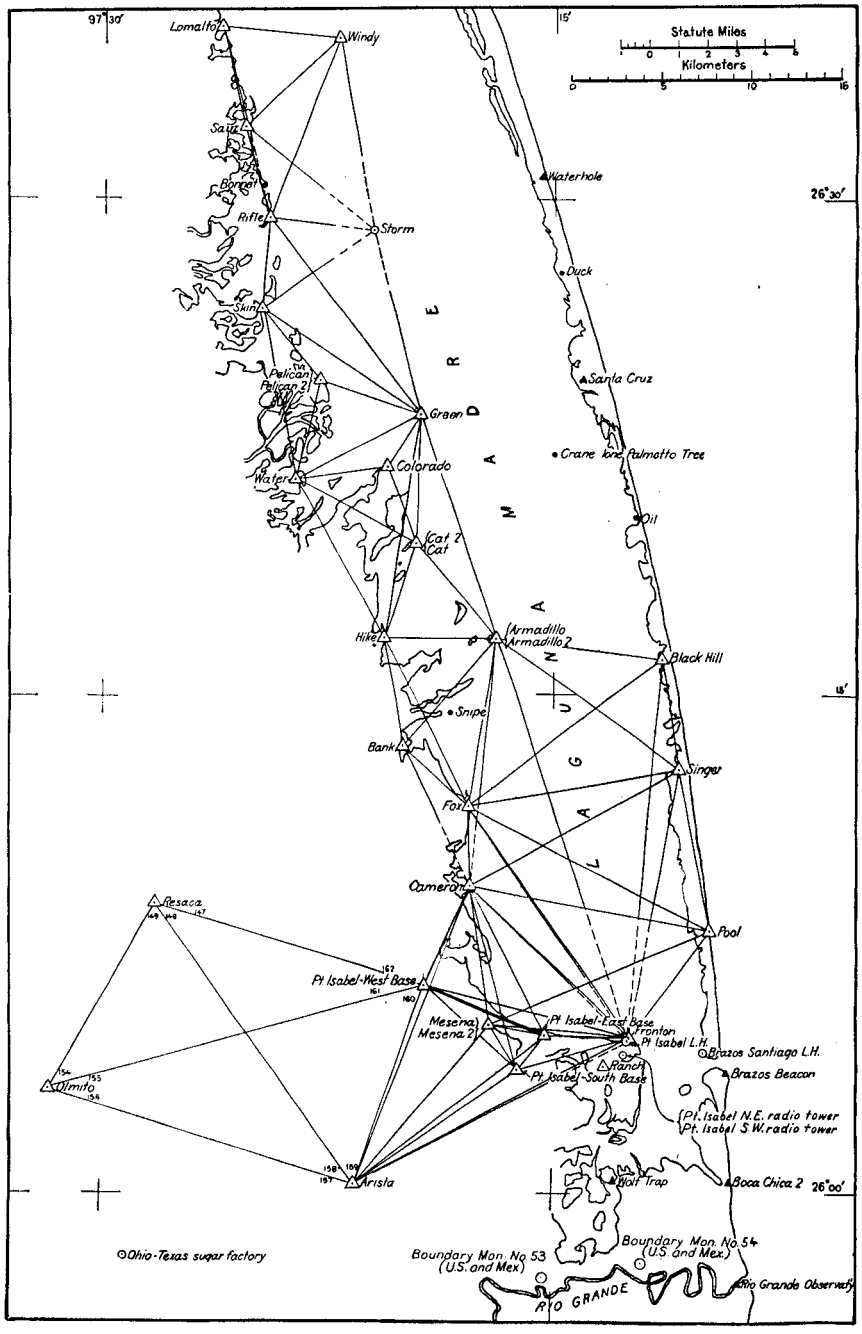

Fig. 17.—TRIANGULATION ALONG THE COAST, STATIONS LOMALTO AND WINDY TO POINT ISABEL.

INDEX.

Station.	Position.	Description.	Elevation.	Sketch.
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