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CALIFORNIA-OREGON ARC OF PRECISE TRIANGULATION

By

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Special Publication No. 84

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CALIFORNIA-OREGON ARC OF PRECISE TRIANGULATION.

By HUGH C. MITCHELL, *Mathematician, and* E. W. EICKELBERG, *Hydrographic and Geodetic Engineer.*

PART I.

GENERAL STATEMENT.

This publication contains the results for the arc of precise triangulation extending from the California-Washington arc in the vicinity of Mount Shasta in a northeasterly direction across the lower end of Oregon to a connection with the Utah-Washington arc just to the west of Boise, Idaho. The California-Washington arc was measured in the years 1903–1906, and the adjusted results of that work will be found in U. S. Coast and Geodetic Survey Special Publication No. 13, while the results of the Utah-Washington arc, measured in 1915–1916, will be found in Special Publication No. 74. The region through which this California-Oregon arc runs may be most easily identified and the approximate location of the control points which it determined most readily seen by reference to the index and other sketches at the end of this volume.

The tabulated arrangement of the data follows the general arrangement now in use in similar publications of the U. S. Coast and Geodetic Survey, and in the text relating to those tables, as well as in several general statements, the wording is practically that of the earlier publications.

The reconnaissance for this arc was made by J. S. Bilby, signalman, during the summer and fall of 1919. Mr. Eickelberg was in charge of the triangulation party, a subparty of which, under Dan. W. Taylor, signalman, did the signal building. All of the triangulation and signal building was done during the season of 1920. The office adjustment and computation of this arc was made by Mr. Mitchell, who also prepared this report.

CLASSES OF TRIANGULATION.

Triangulation is divided into different classes according to accuracy. The terms applied to these classes have recently been changed by agreement of representatives of the various Federal map-making bureaus. Four classes of triangulation are now prescribed and defined, namely, precise, primary, secondary, and tertiary. The first three of these are, respectively, equal in accuracy to the classes primary, secondary, and tertiary, as previously designated by the U. S. Coast and Geodetic Survey.

The ultimate criterion applied in classifying the different grades of triangulation is the actual error in the length of any line. This is indicated by the discrepancy between the measured length of a base line and its length as computed through the triangulation from the last preceding base. In precise triangulation such discrepancies must not exceed 1 part in 25,000, in primary triangulation 1 part in 10,000, and in secondary triangulation 1 part in 5,000. Before making the comparison between the computed and measured lengths the adjustment of the triangulation should be carried to the point where the side and angle equations have been satisfied. It is also necessary to take into consideration the maximum actual error in the measurement of the base.

To secure the accuracy indicated above, certain standards are adopted for the field work, the most important one of which relates to the closing error of the triangles or the discrepancy between the sum of the measured angles in a triangle and 180° plus the spherical excess of the triangle. In precise triangulation the average closing error of the triangles must not be greatly in excess of 1″, in primary not more than 3″, and in secondary about 5″. The shape of the figures in the triangulation scheme, the frequency of bases, the size of the instrument, and the number and kind of observations are all selected with due regard to the accuracy desired.

Under certain conditions the proportionate error in the length of a line as specified above may be found to be exceeded in any class of triangulation. Where two points are comparatively close together as compared with the size of the triangulation scheme the distance between those points may be in error in excess of that indicated by the class of triangulation of the scheme. The accuracy of the computed length of any line can be estimated by computing the ΣR_1 in accordance with the formula for the strength of figures as given in U. S. Coast and Geodetic Survey Special Publication No. 26. In any class of triangulation the subsidiary stations will be located with a less degree of accuracy than the main scheme stations.

It is obvious that in planning a scheme of triangulation it is necessary, in order to obtain the desired degree of accuracy, to select the proper size and type of instrument, predetermine the number of observations, the frequency of base lines and methods of measuring them, and the shape of the figures in the triangulation. Because of economic considerations it is the present practice of this Survey to limit the amount of work done to that required to insure that the results come within the required limits of accuracy, and it is undesirable that either time or money be spent in an attempt to go beyond that point. How well the methods have been standardized toward that end may be readily seen by noting that the average closing error for the arc of precise triangulation considered in this publication is 0″.92, while corresponding values for ten different arcs shown in the table on page 47 are within a range of 0″.63 to 1″.22.

ARRANGEMENT OF SUBJECT MATTER.

In Part I are given such data for the California-Oregon arc of precise triangulation as will ordinarily be needed for control purposes.

The final results of a system of triangulation take the form of geographic positions, which give the latitude and longitude of each point of the triangulation, the azimuths of each line, and the logarithm of the length in meters of each line, together with its length in meters and feet.

Geographic positions, with descriptions and elevations of the stations, are arranged in tabulated form in Part I of this publication. Here the engineer and surveyor will find the data which will give him control points for his local surveys. On page 9, under the heading "How to find the data desired," is a description of the use of the tables. The tabulation of the various kinds of data given in Part I is arranged in the following order: (1) The geographic positions of the triangulation points are found in the table on pages 11 to 14. Points of precise accuracy are found in a separate table from those of lower grades. (2) Following the geographic positions is a table, page 15, giving the trigonometric elevations of all points, referred to mean sea level. A note on page 15 indicates the degree of accuracy to be expected in the three different classes of elevations. Such elevations, intended primarily to furnish the approximate elevations of the stations in order that the sea-level lengths of the lines may be computed, may be used for some topographic purposes but not as elevations from which to start spirit leveling. (3) The descriptions of all marked points, with the character of the marks, are given on pages 16 to 22. (4) The lengths of the lines are given in this publication in both meters and feet, but for the convenience of those who may wish to convert other quantities from one system to the other, conversion tables are given on pages 23 to 30.

Part II of this publication is devoted to a brief description of the methods employed in making the observations and to a discussion of the errors and methods of adjustment. Tabulations of different factors in the results are given, as well as the condition equations used in making the adjustments.

An analysis of the costs of the different operations in both field and office is given for the information of the public for whose benefit the work was done.

THE NORTH AMERICAN DATUM.

All geographic positions are on the North American datum, a standard geodetic datum adopted in 1901 under the name of the United States standard datum, but in 1913 having this designation changed to North American datum. This change in name came about through the adoption of this datum as a standard for geodetic work by the Canadian and Mexican Governments, and is a recognition of the international character of the datum. It is well for the engineer who may plan an extension of work from this arc, particularly at or near its western end, to keep this identity in mind, since, though the results of the Washington-California arc are published on the United States standard datum, those results are exactly coordinate with the results in this volume which are on the North American datum.

EXPLANATION OF POSITIONS, LENGTHS, AND AZIMUTHS, AND OF THE NORTH AMERICAN DATUM.

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 U. S. 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 precise 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.

The transcontinental triangulation, the office computation of which 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 of 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 tedious 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, 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 U. S. Coast and Geodetic Survey are, first, the control of the charts published by the Survey; second, the furnishing of the geographic positions (latitudes and longitudes), of accurately determined elevations, and of distances and azimuths, to officers connected with the 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 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 U. S. Coast and Geodetic 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 files 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 of the astronomic stations so far reduced, scattered widely over the United States from Maine to Louisiana and to California, indicated that this datum approaches closely the ideal for which the algebraic sum of the station errors of each class would be zero.

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.

USE OF HORIZONTAL CONTROL DATA.

The plan or map for any extensive engineering project, whether or not map construction is the primary object, should have all of its parts properly correlated and should be on the same datum as adjacent surveys. Federal and State mapping organizations have long been aware of the necessity for having all surveys based upon a common datum, but the local engineers and surveyors in this country have too often in the past been content, and in many cases compelled, to use a local datum for their surveys. The future economic disadvantage of such a system is now becoming recognized, with the result that city and county surveys are being more generally placed upon a permanent basis by connecting them to stations on the North American datum.

One other factor must be taken into consideration by the engineer of today. As the States develop industrially they will undoubtedly follow the lead of one of the Eastern States, Massachusetts, which with splendid foresight has extended its triangulation control over the entire State for the purpose of defining property boundaries in terms of latitude and longitude. The advantage of such a system is well stated in the following extracts from the Report on the Maryland Oyster Survey:

> The difficulties of accurately locating and permanently defining the boundaries of a farmer's plantation on land, even with the aid of monuments, public roads, streams of water, and other points of reference, are often great, judging from the disputes frequently arising in connection with boundaries. * * *
>
> There is only one point on the earth's surface at the intersection of any one parallel of latitude and any one meridian of longitude, and therefore there can be no dispute as to the meaning of such a geographic definition of the location of a point, even though all the original triangulation station marks used in its determination, together with the chart on which its position was originally plotted, have been totally destroyed.
>
> In the case of the destruction of an original triangulation station mark, or any other point defined by a geographic position, a competent geodetic engineer can reestablish its exact location by means of a new system of triangulation connecting with other distant triangulation marks which have not been destroyed.

In a section of the country covered by adequate geodetic control the data are available to the engineer for any of the following operations, in addition to their possible future use as a basis for cadastral surveys:

(1) **Extensive mapping.**—The topographer needs as initial data for beginning a topographic survey the distance and direction between two points and the geographic position on the North American datum of one of them. His local triangulation, based on this

control, will prevent the accumulation of excessive errors as he carries on his mapping operations. In the event that the available precise triangulation in that region has lines of too great length to join to conveniently he can measure a base and azimuth at some place visible from a precise or a primary triangulation station and connect his base to the station by triangulation, thus obtaining proper geographic positions for his local surveys.

Instructions for secondary (formerly called tertiary) triangulation, suitable for the control of local surveys, may be found in U. S. Coast and Geodetic Survey Special Publication No. 26, which can be had at a nominal cost from the Superintendent of Documents, Government Printing Office, Washington, D. C.

(2) **Boundary lines.**—If it is desired to locate or to delimit accurately and permanently the boundaries of political subdivisions, such as States, counties, or cities, the methods indicated in paragraph (1) may be followed. Whenever possible, a line of the adjusted triangulation should be used as a basis for local surveys rather than a point, since a line gives the three essentials of position, length, and direction.

(3) **Local intensive surveys.**—The necessity for such surveys arises most frequently in connection with extensive improvements over a considerable area, or as a basis for city planning, where the needs of a city are being anticipated for a number of years. Here the requirements are somewhat different from those in the two preceding operations, for it is often necessary to extend precise or primary control in considerable detail over the entire area affected, secondary triangulation or traverse then being used to furnish additional points for the survey. In such a control survey the triangulation should invariably be started from a line of adjusted triangulation on the North American datum.

While it may be noted in the preceding paragraphs that the azimuth and length of one line and the geographic position of one end of that line constitute the essential data for the complete utilization of old work as a basis for new work, there is always grave danger in depending upon this minimum of data. There may be failure to identify the true station mark, or the mark, though genuine, may have been tampered with or otherwise disturbed in position. This will, of course, introduce an error into the new work based on these stations. It is the present practice in this Survey, unless unusual conditions render it unnecessary, to establish the integrity of the recovered points by using at least three old stations as a basis for new work, the third station serving as a check for the two stations on which the new work may actually depend.

In local surveys where the area is of limited extent it is usually desirable to use a system of plane coordinates, the origin being connected to some point of the precise or primary triangulation scheme. Tables for computing plane coordinates are found in U. S. Coast and Geodetic Survey Special Publication No. 71.

The U. S. Coast and Geodetic Survey will be glad to give advice on any problem arising out of the use of its control points or on any proposed extension of triangulation from them.

EXPLANATION OF TABLES.

ARRANGEMENT OF TABULATED DATA.

In the tables of positions the latitude and longitude of each point are given on the North American datum (see p. 3); also the length and azimuth of each line observed over, whether in one way or both ways, 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.

The distances between stations are given in both meters and feet. To facilitate further the use of the tables, a column is given of the logarithms of the lengths in meters. It must be remembered that it is the logarithm of the length in meters which is derived first in the computation, the lengths in meters given in the table being derived from the corresponding logarithms and the lengths in feet in turn being derived from the lengths in meters by the aid of the conversion tables on pages 23–30. Where further work of considerable extent is contemplated, an accumulation of error in the last two operations can be avoided by using the logarithm.

EXPLANATION OF LENGTHS.

The lengths, as explained in the discussion of the adjustments (see p. 37), depend upon the adjusted lengths of the lines Dry-Squaw of the Utah-Oregon arc of precise triangulation, and Bally-Boliver of the California-Washington arc, and upon the measured length of the Paisley base. The lengths as given in the tables are all reduced to sea level. If the actual length of a line simply reduced to the horizontal is desired—that is, its length in its actual elevation on the surface of the earth—it may be obtained by adding to the sea level length as given a correction = (length of line as given) times

$$\left[\frac{\text{mean elevation of the two ends of the line in meters}}{6\ 370\ 000}\right].$$

The maximum value of this correction does not exceed $\frac{1}{2400}$ of the length of any line of the triangulation here published. The error introduced by the use of the above approximate formula does not exceed $\frac{1}{837000}$ of the length of any portion of this triangulation.

AZIMUTH AND BACK AZIMUTH.

Because of the convergence of the meridians the azimuth and back azimuth of a line do not differ by exactly 180°, the amount of the divergence varying with the latitude and the difference of longitude of the two points. To illustrate from the tables, page 12, the azimuth from Hoffman to Crane is 244° 50′ 57″.33, while the back azimuth, or the azimuth from Crane to Hoffman, is 65° 43′ 29″.75.

The azimuths of the triangulation lines offer a very convenient and accurate means of testing the error of the magnetic needle on a surveyor's transit, and even the azimuth over such short distances as those between a station mark and its reference mark may be used for this purpose with fair accuracy, provided the distance is greater than 100 feet.

ACCURACY OF DATA INDICATED IN TABLES.

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.

HOW TO FIND THE DATA DESIRED.

Following the index at the back of this publication are four maps. The first is an index map showing all areas in the United States covered by published triangulation rigidly computed on the North American datum. The other three are detailed maps showing the scheme of triangulation plotted by latitudes and longitudes on a polyconic projection.

Having found the names of the points desired by means of these triangulation sketches the tables may then be conveniently consulted by using the index at the end of this publication. In the appropriately headed columns opposite the name of each station are given the pages on which may be found its geographic position, description, and elevation above sea level, and the number of the detailed sketch showing the scheme of observed lines from that station.

RELATED PUBLICATIONS.

Engineers and others using the data given in this report for the control of maps and surveys will find it of help to have Special Publications Nos. 5, 8, and 71 of the U. S. Coast and Geodetic Survey. They may be obtained at a nominal cost from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Special Publication No. 5 is entitled "Tables for a Polyconic Projection of Maps Based on Clarke's Reference Spheroid of 1866." This publication contains the necessary explanation of the method employed in constructing a polyconic projection, and also gives 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 from a known geographic base are available.

Special Publication No. 71 is entitled "Relation Between Plane Rectangular Coordinates and Geographic Positions." This book contains tables which will facilitate the use by engineers of plane coordinates for local surveys.

The principal lists of geographic positions published on the North American datum throughout the United States, together with descriptions of stations, are contained in the following publications of the U. S. Coast and Geodetic Survey and of other organizations:

Appendix 8 of the Report for 1888, positions in Connecticut.

Appendix 8 of the Report for 1893, positions in Pennsylvania, Delaware, and Maryland.

Appendix 6 of the Report for 1901, positions and descriptions in Kansas and Nebraska.

Appendix 4 of the Report for 1903, positions and descriptions in Kansas, Oklahoma, and Texas.

Appendix 9 of the Report for 1904, positions and descriptions in California.

Appendix 5 of the Report for 1905, positions and descriptions in Texas.

Appendix 3 of the Report for 1907, positions and descriptions in California.

Appendix 5 of the Report for 1910, positions and descriptions in California.

Appendix 4 of the Report for 1911, positions and descriptions in Nebraska, Minnesota, North Dakota, and South Dakota.

Appendix 5 of the Report for 1911, positions and descriptions in Texas.

Appendix 6 of the Report for 1911, positions and descriptions in Florida.

Special Publication No. 11, positions and descriptions in Texas, New Mexico, Arizona, and California.

Special Publication No. 13, positions and descriptions in California, Oregon, and Washington.

Special Publication No. 16, positions and descriptions in Florida.

Special Publication No. 17, positions and descriptions in Texas.

Special Publication No. 19, positions and descriptions in Colorado, Utah, Nevada, Wyoming, Montana, South Dakota, and North Dakota.

Special Publication No. 24, positions and descriptions in Alabama and Mississippi.

Special Publication No. 30, positions and descriptions in West Virginia, Ohio, Kentucky, Indiana, Illinois, and Missouri.

Special Publication No. 31, positions and descriptions in Oregon, Washington, and California.

Special Publication No. 43, positions in Georgia.

Special Publication No. 45, descriptions in Georgia.

Special Publication No. 46, positions and descriptions in Maine.

Special Publication No. 54, positions and descriptions in Texas.

Special Publication No. 62, positions and descriptions in Rhode Island.

Special Publication No. 70, positions and descriptions in Kansas.

Special Publication No. 74, positions and descriptions in Idaho, Oregon, and Washington.

Special Publication No. 76, positions and descriptions in Massachusetts.

Special Publication No. 78, positions and descriptions along the Rio Grande arc in Texas.

Special Publication No. 84, positions and descriptions in California and Oregon.

Report on triangulation of Greater New York.

Report on a plan of sewerage for the City of Cincinnati.

Apendix EEE, pages 2905-3031, Annual Report of the Chief of Engineers, U. S. Army, 1902, positions of points on and near the Great Lakes.

Professional Paper No. 144, Corps of Engineers, U. S. Army, descriptions of points on and near the Great Lakes.

Publications of the Massachusetts Commission on Waterways and Public Lands.

Various bulletins of the United States Geological Survey.

GEOGRAPHIC POSITIONS.

Station.	Latitude and longitude.	Azimuth.	Back azimuth.	To station.	Distance.		
					Log (meters).	Meters.	Feet.
Principal points.	° ′ ″	° ′ ″	° ′ ″				
Squaw, 1915	44 01 59.410	....	....	....	....	....	....
	116 24 40.335						
Dry, 1916	44 10 09.309	278 09 15.85	99 01 27.96	Squaw	5.0053347	101235.04	332138.2
	117 39 40.845						
Vale, 1920	43 58 15.246	121 00 38.37	300 41 25.15	Dry	4.6332464	42978.02	141003.7
	117 12 02.943	263 29 27.87	84 02 22.53	Squaw	4.8041795	63705.88	209008.4
Freezeout, 1920	43 37 28.063	173 39 40.72	353 36 10.85	Dry	4.7846668	60906.94	199825.5
	117 34 38.174	218 04 42.04	38 20 20.10	Vale	4.6900756	48986.41	160716.2
		243 45 49.38	64 34 16.49	Squaw	5.0179089	104209.88	341895.3
Beulah, 1920	43 52 13.065	226 12 19.57	46 30 26.21	Dry	4.6824081	48129.14	157903.7
	118 05 44.572	303 00 28.72	123 21 59.30	Freezeout	4.6980898	49898.77	163709.5
Star, 1920	43 22 32.396	169 29 02.26	349 23 47.02	Beulah	4.7474272	55901.99	183405.1
	117 58 07.642	195 34 31.35	15 47 17.04	Dry	4.9618071	91581.36	300463.2
		228 44 49.13	49 00 59.35	Freezeout	4.6235892	42032.88	137902.9
Crow, 1920	43 31 27.196	220 28 48.26	40 45 45.76	Beulah	4.7046443	50657.56	166199.0
	118 30 17.389	290 38 27.83	111 00 34.96	Star	4.6667388	46423.06	152306.3
Riddle, 1920	43 06 02.213	179 21 58.82	359 21 42.92	Crow	4.6726940	47064.56	154411.0
	118 29 54.213	200 42 57.72	20 59 35.35	Beulah	4.9614536	91506.85	300218.7
		234 25 53.78	54 47 39.85	Star	4.7223581	52766.48	173118.0
Burns, 1920	43 33 42.480	274 20 43.42	94 47 26.89	Crow	4.7195084	52421.37	171985.8
	119 09 04.961	313 49 41.66	134 16 34.80	Riddle	4.8673946	73687.63	241756.8
Jack, 1920	43 02 32.556	164 23 55.58	344 15 43.02	Burns	4.7776729	59933.95	196633.3
	118 57 06.780	259 54 35.86	80 13 10.76	Riddle	4.5740143	37498.53	123026.4
		213 58 41.82	34 17 05.23	Crow	4.8107065	64670.54	212173.3
Juniper, 1920	42 55 48.068	221 51 18.71	42 23 25.49	Burns	4.9758523	94591.54	310339.1
	119 55 57.180	260 48 56.13	81 29 03.27	Jack	4.9082048	80947.75	265576.1
Wagontire, 1920	43 20 58.724	248 15 34.53	68 46 06.37	Burns	4.8085545	64350.88	211124.5
	119 53 28.293	293 46 02.50	114 24 37.17	Jack	4.9223798	83633.40	274387.2
		4 08 41.58	184 06 59.77	Juniper	4.6694252	46711.65	153253.1
Diablo, 1920	42 57 57.245	231 52 49.89	52 20 28.51	Wagontire	4.8414639	69416.09	227744.6
	120 33 53.119	274 10 18.42	94 36 09.10	Juniper	4.7138848	51746.95	169773.1
Round, 1920	42 29 36.408	174 49 06.81	354 46 44.32	Diablo	4.7218118	52700.14	172900.4
	120 30 23.120	223 53 57.97	44 17 19.34	Juniper	4.8297140	67563.78	221665.5
Grays, 1920	42 58 43.803	88 29 47.89	268 05 36.09	Diablo	4.6838191	48285.77	158417.6
	119 58 23.276	189 09 38.36	9 13 00.16	Wagontire	4.6204551	41730.64	136911.3
		328 26 37.73	148 28 17.28	Juniper	4.8014344	63304.47	207691.4
Sharp, 1920	42 50 43.095	152 37 17.39	332 33 48.93	Diablo	4.1787171	15090.97	49511.0
	120 28 46.906	257 53 24.06	78 15 44.59	Juniper	4.6597526	45682.79	149877.6
White, 1920	42 40 29.635	23 55 37.20	203 51 12.26	Round	4.3433105	22045.02	72326.0
	120 23 51.598	160 29 48.05	340 26 27.55	Sharp	4.3028827	20085.50	65897.2
		157 08 34.42	337 01 45.56	Diablo	4.5452608	35096.26	115145.0
		233 08 03.46	53 27 01.19	Juniper	4.6763252	47459.73	155707.5
Paisley north base, 1920.	42 49 44.232	191 12 29.40	11 13 59.95	Diablo	4.1906109	15509.97	50885.6
	120 36 06.141	259 38 19.07	79 43 17.71	Sharp	4.0060090	10139.32	33265.4
		315 37 22.17	135 45 40.80	White	4.3786674	23914.84	78460.6
Paisley south base, 1920.	42 42 15.449	162 25 41.37	342 23 30.26	Paisley north base.	4.1621928	14527.568	47662.53
	120 32 53.046						
		199 38 02.72	19 40 49.87	Sharp	4.2209904	16634.10	54573.7
		284 47 08.66	104 53 15.78	White	4.1055434	12750.98	41833.8
Hart, 1920	42 27 36.393	93 37 26.11	273 06 24.37	Round	4.7999092	63082.54	206963.3
	119 44 26.199	130 02 46.37	309 29 13.80	Diablo	4.9436703	87835.54	288173.8
		163 18 19.03	343 10 30.48	Juniper	4.7367531	54544.77	178952.3
Crane, 1920	42 03 47.602	155 23 54.10	335 13 09.05	Round	4.7209501	52596.77	172561.2
	120 14 24.276	222 54 12.37	43 14 21.61	Hart	4.7806042	60348.18	197992.3

Geographic Positions—Continued.

Station.	Latitude and longitude.	Azimuth.	Back azimuth.	To station.	Distance.		
					Log (meters).	Meters.	Feet.
Principal points—Continued.	° ′ ″	° ′ ″	° ′ ″				
Drake, 1920	42 18 14.621	15 54 04.22	195 50 21.68	Crane	4.4442214	27811.31	91244.3
	120 08 52.869	125 36 21.35	305 21 51.35	Round	4.5591829	36239.50	118896.0
		242 32 28.41	62 48 57.05	Hart	4.5770918	37765.20	123901.3
Yonna, 1920	42 19 36.000	253 17 13.53	73 48 03.39	Round	4.8155573	65396.92	214556.4
	121 16 05.935	288 39 53.50	109 21 19.78	Crane	4.9534266	89831.08	294720.8
Cougar, 1920	42 18 26.504	92 32 48.16	272 06 59.96	Yonna	4.7218571	52705.64	172918.4
	120 37 46.295	206 04 44.12	26 09 42.96	Round	4.3621308	23021.35	75529.2
		309 59 44.13	130 15 25.63	Crane	4.6240471	42077.22	138048.3
Lakeview bench mark M 16, 1920.	42 11 36.988	119 47 17.68	299 36 27.90	Cougar	4.4066094	25504.06	83674.6
	120 21 39.891	325 19 12.62	145 24 04.83	Crane	4.2455740	17602.49	57750.8
Dog, 1920	42 07 08.386	199 07 00.31	19 10 33.09	Cougar	4.3453358	22148.07	72664.1
	120 43 02.984	254 10 02.29	74 24 23.44	Lakeview bench mark M16.	4.4857388	30601.23	100397.5
		278 45 12.37	99 04 24.44	Crane	4.6018637	39981.93	131174.0
Hoffman, 1920	41 36 40.923	196 26 23.54	16 37 48.50	Yonna	4.9184296	82876.15	271902.8
	121 33 10.281	224 24 38.86	45 01 41.36	Cougar	5.0365939	108791.23	356925.9
		244 50 57.33	65 43 29.75	Crane	5.0793165	120037.38	393822.6
Goosenest, 1920	41 43 12.863	229 12 44.59	49 51 02.95	Yonna	5.0161065	103778.28	340479.2
	122 13 17.633	282 01 38.19	102 28 18.56	Hoffman	4.7558057	56990.92	186977.7
Aspen, 1920	42 18 57.304	9 37 24.29	189 31 59.48	Goosenest	4.8267133	67098.58	220139.3
	122 05 12.381	268 42 38.37	89 15 42.19	Yonna	4.8291739	67479.82	221390.0
		330 19 41.86	150 41 07.12	Hoffman	4.9537830	89904.83	294962.8
Whaleback, 1920	41 31 43.181	162 16 37.73	342 13 22.30	Goosenest	4.3491031	22341.03	73297.2
	122 08 23.416	259 10 45.28	79 34 07.42	Hoffman	4.6973464	49813.43	163429.6
		61 03 27.67	240 38 04.49	Boliver	4.7872785	61274.32	201030.8
Grizzly, 1920	41 08 42.309	43 30 50.54	223 04 26.38	Bally	4.9172869	82658.39	271188.4
	121 58 39.097	100 59 43.31	280 28 01.51	Boliver	4.8354784	68466.54	224627.3
		162 22 51.37	342 16 25.83	Whaleback	4.6503987	44709.38	146684.0
		214 19 16.65	34 36 07.64	Hoffman	4.7980086	62807.09	206059.6
Eddy, 1920	41 19 12.214	10 21 30.98	190 14 45.35	Bally	4.9079455	80899.43	265417.5
	122 28 41.085	75 16 27.67	255 04 31.64	Boliver	4.4169584	26119.11	85692.4
		205 39 09.14	25 49 21.68	Goosenest	4.6931973	49339.80	161875.7
		230 34 20.95	50 47 46.99	Whaleback	4.5630682	36565.22	119964.4
		294 40 49.89	115 00 37.61	Grizzly	4.6050855	40247.20	151729.4
Bally, 1904	40 36 11.939	....	....	....	....	....	....
	122 39 00.370	....	....	....	....	....	....
Mears, 1904	41 07 29.538	16 28 16.81	196 20 20.42	Bally	4.7808671	60376.39	198084.87
	122 26 52.260	....	....	....	....	....	....
Boliver, 1904	41 15 35.575	298 11 54.84	118 25 01.56	Mears	4.4999381	31618.27	103734.27
	122 46 40.811	351 26 43.00	171 31 48.60	Bally	4.8676103	73724.24	241870.94
Supplementary points.							
Burns bench mark C 19, 1920.	43 35 08.480	319 55 20.49	140 18 12.94	Riddle	4.8465421	70233.15	230423.3
	119 03 13.703	71 25 07.11	251 21 05.04	Burns	3.9198922	8315.57	27282.0
		278 33 45.99	98 56 27.81	Crow	4.6520930	44884.21	147257.6
Iron, 1920	43 15 47.000	46 42 48.42	226 23 08.51	Juniper	4.7307610	53797.36	176500.2
	119 27 10.242	105 14 37.59	284 56 35.20	Wagontire	4.5662827	36836.86	120855.6
		300 53 24.70	121 13 58.16	Jack	4.6773274	47569.37	156067.2
Gearhart, 1920	42 29 47.051	59 49 10.04	239 33 18.84	Yonna	4.5723592	37355.90	122558.5
	120 52 35.590	270 29 36.07	90 44 36.18	Round	4.4832936	30429.41	99833.8
		315 49 58.04	135 59 57.71	Cougar	4.4658700	29232.83	95908.0
Klamath Falls bench mark A 15, 1920.	42 12 17.280	111 52 56.41	291 37 49.00	Aspen	4.5224309	33298.98	109248.4
	121 42 43.072	348 37 15.36	168 43 37.95	Hoffman	4.8275082	67221.50	220542.5
Soldier, 1920	41 04 28.839	102 45 58.9	282 29 35.6	Grizzly	4.5534056	35760.66	117324.3
	121 33 44.136	180 45 12.5	00 45 34.9	Hoffman	4.7753144	59609.36	195568.4

Geographic positions—Continued.

Station.	Latitude and longitude.	Azimuth.	Back azimuth.	To station.	Distance.		
					Log (meters).	Meters.	Feet.
Supplementary points—Contd.	° ′ ″	° ′ ″	° ′ ″				
Black Fox, 1920	41 20 48.634	18 04 57.4	198 01 30.6	Grizzly	4.3723004	23566.79	77318.7
	121 53 26.027	223 43 22.4	43 56 47.6	Hoffman	4.6098880	40727.52	133620.2
		317 33 33.9	137 46 32.5	Soldier	4.6115826	40886.75	134142.6
Turret, 1920	41 24 58.345	45 13 41.5	224 55 44.6	Soldier	4.7300830	53713.44	176224.8
	121 06 30.729	120 20 49.8	300 09 09.6	Hoffman	4.6330715	42960.71	140946.9
Dixie, 1920	40 55 03.495	109 02 13.2	288 27 21.7	Grizzly	4.8953801	78592.32	257848.3
	121 05 33.828	113 58 18.7	293 39 49.8	Soldier	4.6353351	43185.22	141683.5
Bald Mountain (U. S. G. S.) 1920.	40 54 04.268	118 25 08.7	298 01 30.9	Grizzly	4.7579749	57276.29	187914.0
	121 22 39.587	141 10 54.7	321 03 38.8	Soldier	4.3935601	24749.14	81197.8
		265 33 15.9	85 44 27.8	Dixie	4.3815790	24075.71	78988.4
Crater (U. S. G. S.) 1920.	40 41 54.672	148 42 43.9	328 28 36.4	Grizzly	4.7642013	58103.36	190627.4
	121 37 05.754	186 25 43.0	6 27 55.0	Soldier	4.6236437	42038.16	137920.2
		241 04 27.4	61 25 04.0	Dixie	4.7039978	50582.21	165951.8
Bonanza, 1920	41 04 50.033	2 24 24.7	182 23 22.7	Bally	4.7246397	53044.41	174029.9
	122 37 25.624	146 44 58.7	326 38 49.2	Bolivar	4.3770641	23826.71	78171.5
		251 31 42.6	71 38 39.0	Mears	4.1924896	15577.21	51106.2
Granite, 1920[1]	40 54 37.38	236 07 39	56 24 21	Mears	4.632381	42892.5	140723
	122 52 18.92	331 08 46	151 17 27	Bally	4.590007	38905.1	127641
Lookout Mountain, peak, 1920.	44 36 33.537	32 09 57.3	211 53 50.4	Dry	4.7610302	57680.65	189240.6
	117 16 38.608	38 48 29.3	218 14 14.0	Beulah	5.0210156	104958.02	344349.8
		312 30 39.2	133 06 58.0	Squaw	4.9740425	94198.17	309048.5
Juniper Mountain, peak, 1920.	44 12 28.090	347 58 08.3	168 05 15.6	Freezeout	4.8212232	66255.09	217373.9
	117 44 54.145	36 42 42.0	216 28 12.8	Beulah	4.6693737	46706.11	153235.0
		279 48 34.1	100 44 25.5	Squaw	5.0365430	108778.48	356884.1
		301 35 10.4	121 38 48.8	Dry	3.9122751	8171.00	26807.7
Burnt River Mountains, summit, 1920.[2]	44 14 35.92	352 00 55	172 07 51	Star	4.988254	97331.8	319329
	118 08 08.19	326 42 03	147 05 17	Freezeout	4.914262	82084.7	269306
Castle Rock (U. S. G. S. cairn) 1920.	44 01 18.411	248 21 57.1	68 43 41.5	Dry	4.6513003	44802.30	146988.9
	118 10 55.404	312 00 33.6	132 25 41.2	Freezeout	4.8175335	65695.18	215534.9
		337 35 12.8	157 38 48.5	Beulah	4.2601423	18202.97	59720.9
		346 27 29.4	166 36 20.0	Star	4.8681545	73816.68	242180.2
Kings Mountain, summit, 1920.[2]	43 48 45.45	4 33 42	184 30 15	Jack	4.933704	85842.9	281636
	118 52 05.17	339 09 09	159 24 24	Riddle	4.927241	84574.8	277476
Owyhee Mountains, summit, 1920.[2]	42 58 57.26	112 47 10	291 53 30	Star	5.060280	114891.0	376938
	116 39 42.33	134 08 36	313 30 56	Freezeout	5.012725	102973.3	337838
Placidia Butte, summit, 1920.[2]	43 28 43.11	292 27 41	113 18 07	Riddle	5.033445	108005.2	354347
	119 43 28.07	307 25 30	127 57 16	Jack	4.899128	79273.4	260083
Little Juniper, summit, 1920.	43 09 14.094	28 10 09.3	208 04 55.5	Grays	4.3434968	22054.48	72357.1
	119 50 43.785	272 37 52.8	93 33 08.2	Riddle	5.0405181	109778.71	360165.7
		279 21 37.6	99 58 15.7	Jack	4.8680523	73799.31	242123.2
		15 57 53.0	195 54 10.1	Juniper	4.4122625	25838.21	84770.9
Hampton Butte, summit, 1920.[2]	43 46 27.83	343 06 46	163 21 08	Juniper	4.990983	97945.2	321342
	120 16 51.83	344 07 38	164 20 19	Grays	4.963039	91841.4	301316
Glass Butte, summit, 1920.[2]	43 33 26.75	350 37 18	170 43 06	Juniper	4.848862	70609.4	231658
	120 04 24.56	352 44 30	172 48 38	Grays	4.811538	64794.5	212580
Paisley high school, flagpole, 1920.[2]	42 41 37.68	196 51 59	16 54 32	Sharp	4.245233	17588.7	57706
	120 32 31.64	280 00 26	100 06 18	White	4.080059	12024.3	39450
Paisley Methodist Church, spire, 1920.[2]	42 41 39.36	196 53 43	16 56 15	Sharp	4.243958	17537.1	57536
	120 32 31.35	280 15 22	100 21 15	White	4.080157	12027.0	39458

[1] No check on this position.
[2] Position checked by verticals only.

Geographic positions—Continued.

Station.	Latitude and longitude.	Azimuth.	Back azimuth.	To station.	Distance. Log (meters).	Distance. Meters.	Distance. Feet.
Supplementary points—Contd.	° ′ ″	° ′ ″	° ′ ″				
Crooks Peak, highest point, 1920.	42 21 45.447	81 19 44.2	261 00 22.7	Cougar	4.0018071	39976.72	131157.0
	120 09 01.615	252 03 59.6	72 20 34.7	Hart	4.5493052	35131.96	116246.4
		358 14 09.5	178 14 15.4	Drake	3.8134545	6508.10	21352.0
Drake Peak lookout house, 1920.	42 18 03.300	66 36 18.6	246 13 42.8	Dog	4.7033727	50509.45	165713.1
	120 09 24.958	126 44 07.2	306 29 58.9	Round	4.5546047	35851.28	117622.1
		154 36 19.2	334 26 33.9	White	4.6628968	46014.72	150966.6
		244 41 46.4	64 42 08.0	Drake	2.9100946	813.01	2667.4
Peak, first north of station Drake, 1920.	42 19 37.997	86 55 12.0	266 36 06.0	Cougar	4.5915124	39040.23	128084.5
	120 09 24.206	246 33 09.2	66 49 59.1	Hart	4.5717938	37307.30	122399.0
		344 24 36.7	164 24 57.9	Drake	3.4266388	2670.78	8762.4
Steins Mountain, highest point, 1920.[2]	42 44 05.811	184 57 37.1	4 59 23.3	Riddle	4.6103989	40775.5	133777.6
	118 32 30.119	213 03 33.6	33 27 01.7	Star	4.9300167	85117.1	279255.0
Monument Mountain (U. S. G. S. cairn), 1920.	42 28 40.475	178 16 50.8	358 16 58.3	Round	3.2372035	1726.05	5664.9
	120 30 20.855	202 02 43.1	22 07 06.5	White	4.3731745	23614.27	77474.5
		222 52 19.0	43 15 38.7	Juniper	4.8374780	68782.51	225663.9
Lakeview courthouse, finial, 1920.	42 11 22.166	75 51 59.6	255 36 58.9	Dog	4.5023064	31791.16	104301.5
	120 20 40.951	108 41 21.7	288 40 42.1	Lakeview bench mark M 16.	3.1546215	1427.65	4683.9
		119 12 48.4	299 01 19.0	Cougar	4.4298548	26906.35	88275.3
Grizzly Peak, summit, 1920.[1]	42 15 10.69	23 42 59	203 39 48	Dog	4.210869	16250.6	53316
	120 38 18.46	186 57 03	6 57 25	Cougar	3.784367	6086.5	19969
Fishhole Mountain, tallest tree, 1920.[1]	42 15 15.53	246 42 44	66 49 27	Cougar	4.174311	14938.6	49011
	120 47 45.40	336 38 58	156 42 08	Dog	4.213993	16367.9	53700
Crater (or Magee) lookout house, 1920.[1]	40 41 23.66	149 11 58	328 57 51	Grizzly	4.770265	58920.3	193308
	121 37 05.97	240 08 15	60 28 51	Dixie	4.708048	51056.1	167507
Mount McLaughlin (or Mount Pitt) lookout house, 1920.	42 26 41.774	354 28 37.1	174 32 22.6	Goosenest	4.9077638	80865.59	265300.5
	122 18 54.332	278 18 43.9	99 01 04.2	Yonna	4.9405045	87197.60	286080.8
		307 14 09.0	127 23 23.0	Aspen	4.3736055	23642.61	77567.5
Weed Lumber Co., east chimney, 1920.[2]	41 26 07.16	34 11 42	214 07 35	Eddy	4.189494	15470.1	50755
	122 22 27.86	201 53 23	21 59 28	Goosenest	4.532944	34114.8	111925
Weed Lumber Co., west chimney, 1920.[2]	41 26 07.45	34 09 24	214 05 17	Eddy	4.189604	15474.0	50768
	122 22 28.14	201 54 19	22 00 24	Goosenest	4.532806	34108.7	111905
Boliver lookout house, 1920.	41 15 33.496	212 48 10.2	32 48 11.4	Boliver	1.8825615	76.31	250.4
	122 46 48.587	254 57 46.0	75 09 43.2	Eddy	4.4178968	26175.61	85877.8
		351 24 20.7	171 29 27.5	Bally	4.8672729	73666.98	241689.1
Bonanza lookout house, 1920.	41 04 49.737	146 44 17.7	326 38 07.9	Boliver	4.3773208	23840.80	78217.7
	122 37 25.124	204 34 44.7	224 40 29.5	Eddy	4.4664033	29268.69	96025.7
		2 25 12.0	182 24 09.7	Bally	4.7245088	53035.76	174001.5
Burney (U. S. G. S.), 1920.[2]	40 48 25.34	141 58 10	321 44 23	Grizzly	4.678834	47735.6	156609
	121 37 38.63	254 35 04	74 56 04	Dixie	4.669522	46722.1	153287
Beatties Butte, summit, 1920.	42 23 10.696	103 48 54.3	283 32 20.1	Hart	4.5305827	34640.38	113649.3
	119 19 52.585	140 59 34.2	320 35 07.4	Juniper	4.8920166	77986.00	255859.1
		202 58 02.0	23 13 28.5	Jack	4.8988916	79230.35	259941.6
		220 23 43.9	40 57 39.0	Riddle	5.0196502	104628.55	343268.9
Drakes Peak (U. S. G. S. cairn), 1920.	42 18 01.828	100 50 50.4	280 40 49.8	Drake	3.3220663	2099.3	6887.5
	120 07 22.856	192 31 42.2	12 39 25.7	Juniper	4.8554027	71680.8	235172.8
		240 29 43.6	60 45 11.5	Hart	4.5570994	36140.9	118572.3

[1] No check on this position.
[2] Position checked by verticals only.

TABLE OF ELEVATIONS.

Station.	Point to which elevation refers.	Elevation above mean sea level.	
		Meters.	*Feet.*
Class 1.			
Burns bench mark C 19.	Station mark	1264.6099	4148.97
Lakeview bench mark M 16.	.....do......	1443.0557	4734.43
Klamath Falls bench mark A 15.	.....do......	1274.5704	4181.65
Class 2.			
Squaw..........	.....do......	1800.15	5906.0
Dry..........	.....do......	1978.10	6489.8
Vale..........	.....do......	965.08	3166.3
Beulah..........	.....do......	1776.58	5828.7
Freezeout..........	.....do......	1671.68	5484.5
Star..........	.....do......	1841.68	6042.2
Crow..........	.....do......	1796.04	5892.5
Riddle..........	.....do......	1937.40	6356.3
Burns..........	.....do......	1609.12	5279.3
Jack..........	.....do......	1709.49	5608.6
Grays..........	.....do......	1881.59	6173.2
Wagontire..........	.....do......	1982.47	6504.2
Paisley south base.	.....do......	1354.39	4443.5
Paisley north base.	.....do......	1345.13	4413.1
Sharp..........	.....do......	1748.99	5738.1
Diablo..........	.....do......	1873.14	6145.5
White..........	.....do......	1891.92	6207.1
Juniper..........	.....do......	2035.82	6679.2
Hart..........	.....do......	2444.37	8019.6
Drake..........	.....do......	2535.34	8318.0
Round..........	.....do......	2278.87	7476.6
Dog..........	.....do......	2113.96	6935.6
Crane..........	.....do......	2574.52	8446.6
Cougar..........	.....do......	2415.63	7925.3
Yonna..........	.....do......	2202.64	7226.5
Aspen..........	.....do......	2502.53	8210.4
Hoffman..........	.....do......	2416.38	7927.7
Goosenest..........	.....do......	2526.48	8289.0
Bally..........	.....do......	1892.4	6208.6
Boliver..........	.....do......	2451.5	8043.0
Mears..........	.....do......	2174.1	7132.9
Whaleback..........	.....do......	2601.73	8535.8
Grizzly..........	.....do......	1905.90	6253.2
Eddy..........	.....do......	2753.44	9033.6
Class 3.			
Lookout Mountain.	Ground.....	2172.4	7127
Juniper Mountain.	.....do......	1973.7	6475
Burnt River Mountains.	Summit.....	2381.9	7815
Class 3—Con.			
Castle Rock (U. S. G. S.).	Cairn, middle point.	2087.0	6847
Owyhee Mountains.	Summit.....	2571.9	8438
Kings Mountain.	Ground.....	2045.4	6711
Placidia Butte..	.....do......	1680.5	5513
Iron..........	.....do......	1636.0	5367
Steins Mountain.	.....do......	2851.0	9354
Beatties Butte..	.....do......	2412.8	7916
Little Juniper Mountain.	.....do......	1872.5	6143
Glass Butte.....	.....do......	1947.6	6390
Hampton Butte.	.....do......	1930.4	6333
Crooks Peak....	.....do......	2387.9	7834
Paisley high school.	Finial.......	1345.7	4415
Paisley Methodist Church.	Cupola......	1348.6	4425
Drakes Peak (U. S. G. S.).	Cairn, top...	2560.9	8402
Drakes Peak, lookout house.	Top of house.	2505.0	8218
Peak, first north of Drakes Peak.	Ground.....	2482.3	8144
Monument Mountain.	Top of cairn.	2224.1	7297
Gearhart........	Ground.....	2549.2	8364
Mount McLaughlin lookout house.	Top of house.	2898.6	9510
Weed Lumber Co., east chimney.	Top.........	1128.3	3702
Weed Lumber Co., west chimney.	.....do......	1127.3	3698
Black Fox......	Station mark	1984.4	6510
Turret..........	.....do......	1871.1	6139
Soldier..........	.....do......	1688.5	5540
Dixie..........	.....do......	1852.0	6076
Bald Mountain (U. S. G. S.).	Ground.....	1701.3	5582
Burney (U. S. G. S.).	Cairn, top...	2399.2	7871
Boliver lookout house.	Top of house.	2472.6	8112
Crater (U. S. G. S.).	Ground.....	2645.3	8679
Bonanza lookout house.	Top of house.	2124.9	6971
Granite[1]........	Ground.....	2467	8094

[1] No check on this elevation.

NOTE.—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, the elevations of which 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 ±1.5 meters; and, third, the intersection stations the elevations of which are fixed by measurement of vertical angles which are not reciprocal, the stations not being occupied, and subject to probable errors which may be as great as ±3 meters. In the third class are also a few supplementary stations the elevations of which were partly determined by reciprocal observations.

DESCRIPTIONS 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 specifically stated, the surface and underground marks 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 Director, Coast and Geodetic Survey, Washington, D. C.

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. 1. 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 17 mm. in diameter and 80 mm. long, with several grooves cut around it to give a secure anchorage in concrete.

The standard disk reference mark, shown in figure No. 1, 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.

Surface 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 bedrock (*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.

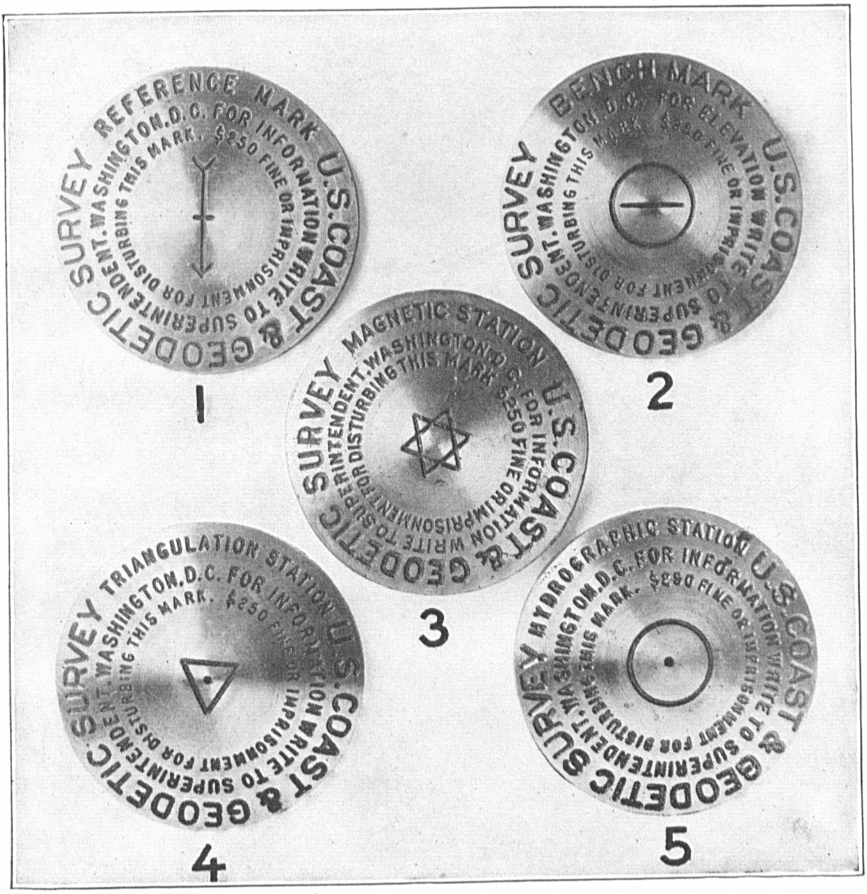

FIG. 1.—STANDARD MARKS OF THE U. S. COAST AND GEODETIC SURVEY.

1. Reference mark.
2. Bench mark.
3. Magnetic station mark.
4. Triangulation station mark.
5. Hydrographic station mark.

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.

Underground marks.

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.

Reference marks.

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.

Witness marks.

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.

ADDITIONAL NOTES FOR THIS PUBLICATION.

Note 16.—A ⅜-inch copper bolt 3 inches long cemented into a drill hole in the rock, while directly above it and in the same hole is cemented an old-type station mark, a disk and shank of brass cast in one piece, and having a raised flange around its edge, with a polished center surrounded by the raised letters "U. S. C. & G. S." A cross in the top of the bolt and another in the polished center of the disk marks the station.

Note 17.—The reference mark is a punch or drill hole in the top of a ⅜-inch copper bolt, cemented or leaded into a drill hole in a rock with the top of the bolt flush with the surface of the rock.

PRINCIPAL POINTS.

Dry (Malheur County, Oreg., C. V. Hodgson, 1916; 1920).—About 22 miles northwest of Vale, 8 miles southwest of Brogan, 6 miles southeast of Juniper Mountain, and 6 miles southwest of Charles Pritchard's ranch, on the highest point of the west end of a bald ridge. The station was marked as described in note 5, with a reference mark, as described in note 12d, 22.25 meters from the station in azimuth 132° 59′. The

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For notes in regard to marking of stations see p. 16.

cairn, 7 feet in diameter and 10 feet high, marking the U. S. Geological Survey station Dry Ridge is 3.70 meters from the station in azimuth 30° 47′.

Squaw (Canyon-Boise Counties, Idaho, C. V. Hodgson, 1915; 1920).—On or near the line between Canyon and Boise Counties, about 11 miles north and 6 miles east of Emmett, about 5 miles east of Van Deusen ranch, 2½ miles E. 10° N. from H. M. Shearer's house, on the highest and most northerly butte of Squaw Mountain, and about one-quarter mile south from Cold Springs, well known to the ranchers of the vicinity. The station was marked as described in note 5, the bowlder projecting 4 inches above the surface of the ground. The reference mark, as described in note 12d, is at the same elevation as the station and 18 inches above the ground. It is 5.56 meters from the station in azimuth 156° 39′.

Vale (Malheur County, Oreg., E. W. Eickelberg, 1920).—About 2 miles east by south from the town of Vale, 0.6 mile south from the Vale-Ontario road, and on the highest point of a prominent rocky butte, the highest in the immediate vicinity. The station was marked as described in note 2, while two reference marks, as described in note 12a, were set as follows: 17 meters from the station in azimuth 303° 29′ and 6.45 meters from the station in azimuth 195° 47′. A U. S. Geological Survey cairn is 4.12 meters from the station in azimuth 137° 41′.

Freezeout (Malheur County, Oreg., E. W. Eickelberg, 1920).—About 40 miles southwest from the town of Vale, about 15 miles south from Harper, about 4 miles south from the main Vale-Skull Spring-Crane road, 2 miles north from an old dim road leading from the main Vale-Skull Spring road at a point 3 miles east of Coyote Wells via Buckboard Springs to the McKnight sheep ranch on the Vale-Watson road. Station bears north from the road at a point 5½ miles east of Buckboard Springs, where it leads through a narrow gap in the rock, but is not visible from the road. The U. S. Geological Survey cairn "Grass," on or near the highest point of a ridge known as Freezeout Hills is 4.5 meters from the station in azimuth 348° 01′. The station was marked as described in note 4, while two reference marks, as described in note 12c, were set as follows: 14.23 meters from the station in azimuth 222° 48′ and 5.60 meters from the station in azimuth 306° 03′.

Beulah (Malheur County, Oreg., E. W. Eickelberg, 1920).—About 5 miles southeast from Beulah post office, and about 12 miles north from Juntura, on highest point in vicinity. Station is on hill directly behind one which appears as highest one from Beulah. The station was marked as described in note 2, while two reference marks, as described in note 12a were set as follows: 17.01 meters from station in azimuth 153° 42′ and 6.12 meters from station in azimuth 359° 56′.

Star (Malheur County, Oreg., E. W. Eickelberg, 1920).—About 15 miles southeast from Riverside, about 2 miles east of the Riverside-Crowley road, about 3 miles southwest from the Star ranch and 2 miles east by south from the ranch house formerly owned by Sam A. Armstrong, and on the southerly end and highest point of Star Mountain. The station was marked as described in note 2, while two reference marks, as described in note 12a, were set as follows: 9.83 meters from station in azimuth 83° 23′ and 10.48 meters from station in azimuth 244° 26′.

Crow (Harney County, Oreg., E. W. Eickelberg, 1920).—About 9.5 miles northeast of Crane, about 30 miles east of Burns, and 5 miles by road and trail east of the Crow Camp ranch, and on the highest point of Crow Camp Mountain. The station was marked as described in note 2, while two reference marks, as described in note 12a, were set as follows: 13.19 meters from station in azimuth 311° 26′, and 12.95 meters from station in azimuth 57° 57′. U. S. Geological Survey cairn "Crow" is 3.90 meters from station in azimuth 173° 58′.

Riddle (Harney County, Oreg., E. W. Eickelberg, 1920).—About 26 miles southeast from Narrows, about 24 miles south from Crane, 6 miles east from Smith post office (locally known as Coon Town), 4 miles north of James Paul ranch, and on the eastern end and highest point of Riddle Mountain. The station was marked as described in note 2, while two reference marks, as described in note 12a, were set as follows: 16.55 meters from station in azimuth 122° 41′ and 4.75 meters from station in azimuth 272° 22′.

Burns (Harney County, Oreg., E. W. Eickelberg, 1920).—About 7 miles west from Burns, 4.4 miles north (by wood road) from the Burns-Bend highway, and on the highest point of one of the Sage Hen Hills. The station is about 2 miles farther west and to the left of the hill which appears to be the highest when looking from Burns. The station was marked as described in note 2, while two reference marks, as described in note 12a, were set as follows: 6.18 meters from station in azimuth 354° 41′ and 8.42 meters from station in azimuth 162° 00′.

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Jack (Harney County, Oreg., E. W. Eickelberg, 1920).—About 40 miles south from Burns, about 16 miles south from Narrows, and 4 miles west from the Narrows-"P" Ranch-Denio road, on the westerly and higher of two prominent hills known locally as the Jackass Buttes. The station was marked as described in note 2, while a reference mark, as described in note 12c, was set 13.65 meters from station in azimuth 329° 23′.

Juniper (Harney County, Oreg., E. W. Eickelberg, 1920).—About 60 miles northeast from Lakeview, about 20 miles south from Butte, and 5 miles east from Alkali Lake, on the highest point of Big Juniper Butte. The station was marked as described in note 2, while two reference marks, as described in note 12a, were set in the following azimuths from the station: 7° 12′ and 118° 35′.

Wagontire (Lake-Harney Counties, Oreg., E. W. Eickelberg, 1920).— About 4 miles west of the Burns-Butte road, on Wagontire Mountain, and about 100 meters north of its highest point. This highest point has several massive rocks on it. The station was marked by a standard disk station mark set in the center of a flat rock about 6 by 10 feet in size and about 1 foot above the level of the ground. Two reference marks, as described in note 12a, were set as follows: 13.43 meters from station in azimuth 353° 43′ and 15.22 meters from station in azimuth 123° 15′.

Diablo (Lake County, Oreg., E. W. Eickelberg, 1920).—About 20 miles north of Paisley and about 7 miles east of the north end of Summer Lake, on Diablo Mountain, and about 50 meters south of its highest point. The station was marked as described in note 2, while two reference marks, as described in note 12a, were set as follows: 14.16 meters from station in azimuth 1° 19′ and 22.50 meters from station in azimuth 147° 56′.

Round (Lake County, Oreg., E. W. Eickelberg, 1920).—About 19 miles south from Paisley, 30 miles north from Lakeview, about one-half mile south from Round Pass, on the highest point of Round Mountain, and about 6 meters southeast of a Forest Service lookout house under construction (in 1920). The station was marked as described in note 1c, while reference marks, triangles cut in the west sides of two pine trees, were 29.12 meters from the station in azimuth 202° 26′ and 29.26 meters from station in azimuth 234° 40′.

Grays (Lake County, Oreg., E. W. Eickelberg, 1920).—About 60 miles northeast from Lakeview, about 20 miles south from Butte, 3 miles east from Alkali Lake, and on the highest point of Grays Butte. The station was marked as described in note 2, while a reference mark, as described in note 12a, was set in azimuth 207° 22′ from the station.

Sharp (Malheur County, Oreg., E. W. Eickelberg, 1920).—About 10 miles N. 17° E. from Paisley, about 2½ miles west from a wagon road leading from the Paisley-Butte and Burns road at a point 10 miles from Paisley, and on the highest point of Sharp Butte or Sharp Top. The station bears west from the road at a point 13.8 miles from Paisley, but is not visible from the road. It was marked as described in note 2, while a reference mark, as described in note 12a, was set 6.24 meters from the station in azimuth 195° 48′.

White (Lake County, Oreg., E. W. Eickelberg, 1920).—About 7 miles east of Paisley, about 3 miles northeast of the ZX white ranch house, and on the highest point of Coglan Buttes. The station was marked as described in note 2, and a reference mark, as described in note 12a, was set 23.53 meters from the station in azimuth 240° 20′.

Paisley north base (Lake County, Oreg., E. W. Eickelberg, 1920).—About 10 miles north of Paisley, 600 meters west of the Paisley-Hoy ranch road at the south base of the southerly of two rocky buttes, the only ones in the vicinity. The station was marked as described in note 4, and a reference mark, as described in note 12c, was set 43.56 meters from the station in azimuth 159° 51′.

Paisley south base (Lake County, Oreg., E. W. Eickelberg, 1920).—About three-fourths mile north of Paisley, at the junction of the Paisley-Silver Lake and the Paisley-Butte and Burns wagon roads, about 20 feet east of a corner fence post at the southeast corner of road crossing and 6 feet north of the east and west line fence. The station was marked by a standard disk station mark set in a concrete block 12 inches square and 22 inches high, and by an underground mark, a standard disk set in concrete 18 inches below the surface, with 2 inches of earth between it and the surface mark. A standard disk reference mark in a concrete block similar to the one just described was placed 7.97 meters from the station in azimuth 71° 14′.

Hart (Lake County, Oreg., E. W. Eickelberg, 1920).—About 9 miles northeast of Plush post office, 7 miles by road and trail south from Lyons sheep ranch, and three-fourths mile west from a dim road leading from the Lyons sheep ranch to Old Post,

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For notes in regard to marking of stations see p. 16.

on highest point of Hart Mountain, a well-known ridge lying east of Warner Lake. The station was marked as described in note 4, while reference marks, as described in note 12c, were set as follows: 11.48 meters from station in azimuth 122° 04′ and 29.55 meters from station in azimuth 303° 10′.

Crane (Lake County, Oreg., E. W. Eickelberg, 1920).—About 8 miles southeast from Lakeview, on the highest point of Crane Peak. The station was marked as described in note 2, while two reference marks, as described in note 12a, were set as follows: 19.8 meters from station in azimuth 176° 44′ and 9.9 meters from station in azimuth 323° 57′.

Drake (Lake County, Oreg., E. W. Eickelberg, 1920).—About 14 miles northeast from Lakeview, 3 miles northeast from Bulls Prairie ranger station, five-eighths mile northeast from the Forest Service lookout on Drakes Peak, and on a round bald mountain about 1½ miles northwest from Drakes Peak. The station was marked as described in note 4, while a reference mark, as described in note 12c, was set 22.01 meters from the station in azimuth 216° 15′.

Yonna (Klamath County, Oreg., E. W. Eickelberg, 1920).—About 12 miles northeast from Bonanza, on the top of Yonna Butte, and about 70 meters east from its highest point. The station was marked as described in note 2, while two reference marks, as described in note 12a, were set as follows: 1.73 meters from station in azimuth 354° 23′ and 4.99 meters from station in azimuth 140° 26′.

Cougar (Lake County, Oreg., E. W. Eickelberg, 1920).—About 18 miles northwest from Lakeview, 5 miles by road and trail southwest from Thomas Creek ranger station, 3¾ miles by trail from road leading from Lakeview to Thomas Creek ranger station via Mesman Creek, and 10 meters southeast from Forest Service lookout "Cougar Peak." The station was marked as described in note 4, while two reference marks, as described in note 12c, were set as follows: 11.42 meters from station in azimuth 89° 58′ and 5.44 meters from station in azimuth 6° 05′.

Lakeview bench mark M 16 (Lake County, Oreg., E. W. Eickelberg, 1920).—On the west edge of the town of Lakeview, on the south side (in fence line) of the Lakeview-Klamath Falls wagon road, and about 300 yards west from the N. C. O. Railroad crossing. The station was marked as described in note 1c, while a reference mark, as described in note 11c, was set 18.45 meters from the station in azimuth 186° 29′.

Dog (Lake County, Oreg., E. W. Eickelberg, 1920).—About 22 miles south by west from Lakeview, 2½ miles by trail north by west from Dog Lake ranger station, and 5 meters northeast from a Forest Service lookout which occupies the highest point on Dog Mountain. The station was marked as described in note 2, and two reference marks, as described in note 12a, were set as follows: 3.30 meters from station in azimuth 0° 14′ and 4.58 meters from station in azimuth 182° 53′.

Hoffman (Siskiyou County, Calif., E. W. Eickelberg, 1920).—About 32 miles northeast from McCloud, about 21 miles east by south from Bray, 4 miles northeast from Medicine Lake ranger station, and on the highest point of Big Hoffman Mountain. The station was marked as described in note 2, while two reference marks, as described in note 12a, were set as follows: 11.51 meters from station in azimuth 107° 23′ and 11.67 meters from station in azimuth 329° 38′.

Goosenest (Siskiyou County, Calif., E. W. Eickelberg, 1920).—About 20 miles east from Montague, Calif., on the highest point of Goosenest Mountain, and at the edge of an old crater. The station was marked as described in note 2. There are two reference marks; one, as described in note 12a, was set 31.12 meters from the station in azimuth 343° 15′, and the other, an arrow cut in native rock, is 16.05 meters from the station in azimuth 171° 29′.

Whaleback (Siskiyou County, Calif., E. W. Eickelberg, 1920).—About 15 miles east from Weed, Calif., on the highest point of Black Crater Mountain. The station is on the southeast edge of an old crater and is surrounded by a heavy growth of timber. It was marked as described in note 2, while two reference marks, as described in note 12a, were set as follows: 7.31 meters from station in azimuth 188° 59′ and 8.78 meters from station in azimuth 266° 13′.

Grizzly (Shasta County, Calif., E. W. Eickelberg, 1920).—On top of Grizzly Peak, 12 miles (3 by road and 9 by trail) from Henderson, Calif., and about 30 meters northeast of a lookout house. The station was marked as described in note 2, and two reference marks, as described in note 12a, were set as follows: 26.58 meters from station in azimuth 382° 19′ and 19.13 meters from station in azimuth 230° 01′.

Eddy (Siskiyou County, Calif., E. W. Eickelberg, 1920).—On top of Mount Eddy, about 15 miles by road and trail from Sisson, Calif., a little below the highest point on the mountain, and about 18 meters east from a new lookout house. The station

For notes in regard to marking of stations see p. 16.

is marked by a standard disk station mark, while two reference marks, as described in note 12a, were set as follows: 30.02 meters from the station in azimuth 298° 43′ and 14.32 meters from the station in azimuth 97° 45′.

Aspen (Klamath County, Oreg., E. W. Eickelberg, 1920).—Located 18 miles west from Klamath Falls, Oreg., on the highest point of Aspen Butte. The station was marked as described in note 2, and two reference marks, as described in note 12a, were set as follows: 5.31 meters from station in azimuth 338° 14′ and 6.56 meters from station in azimuth 110° 54′.

Boliver (Siskiyou County, Calif., O. B. French, 1904; 1920).—On the north side of a large group of bowlders about 60 yards northeast of the highest part of the summit of Mount Scott, known locally as Old Craggy or Boliver; this is the high peak about 5 miles in a southerly direction from Callahan. The station was marked as described in note 16, while reference marks, as described in note 17, were set as follows: 6.57 meters from station in azimuth 272° 41′ and 9.88 meters from station in azimuth 107° 47′.

Bally (Shasta County, Calif., O. B. French, 1904; 1920).—On the northernmost of the two main peaks of the summit of Bally Mountain, a prominent and well-known mountain about 15 miles by road west of Redding. The station was marked as described in note 16, the mark being in the top of a rock on the north side of the most prominent group of rocks on the peak and 5 or 6 feet below the top of the group. Two reference marks, as described in note 17, were set as follows: 4.29 meters from station in azimuth 247° 07′ and 10.62 meters from station in azimuth 154° 49′.

Mears (Shasta County, Calif., O. B. French, 1904; 1920).—About 4 or 5 miles west by south from Castella, and about southwest from Castle Crags, on the northern summit of the highest rocky peaks in the region known locally as Gray Rocks. The station is about 20 feet below the highest part of the peak and near the bluff on the south and east sides, with a ledge about 10 feet higher some 10 feet distant to the southeast. The peak was approached from the south and the 30-foot bluff near the station surmounted by the use of ladders. In 1920 there was a wagon road from Castella, up Castle Creek, crossing Trinity Mountains divide 3 miles north of the station and 14 miles by road from Castella. This road follows on down the headwaters of the Trinity River, passing within about 2 miles of the station. The station was marked as described in note 16. Two reference marks, as described in note 17, were set as follows: One in a bowlder near the trail to the station, 7.92 meters from the station in azimuth 70° 50′; the other in a low bowlder east of a high pointed rock, 17.77 meters from the station in azimuth 143° 03′.

SUPPLEMENTARY POINTS.

Burns bench mark C 19 (Harney County, Oreg., E. W. Eickelberg, 1920).—In the town of Burns, Oreg., 50 meters (164 feet) south of the south end of the main street, at the southeast corner of an old barn and on the east side of a fence running south, on the property of C. H. Voegtly. The station was marked by a standard bench-mark disk in the top of a concrete post, the station having been set by a precise level party in 1919.

Iron (Harney County, Oreg., E. W. Eickelberg, 1920).—About 2½ miles west of the Burns-Lakeview (via Plush) road. Reached from Burns by following this road to a point where Iron Mountain bears about due west, then take road leading to ranch house, pass to south of house, and follow around south side of valley along foothills to small and dilapidated schoolhouse; station is on Iron Mountain and about three-fourths mile west of schoolhouse. It was marked as described in note 2.

Gearhart (Klamath County, Oreg., E. W. Eickelberg, 1920).—On the summit of Mount Gearhart, about 10 miles northeast of Bly. The station was marked as described in note 2.

Klamath Falls bench mark A 15 (Klamath County, Oreg., E. W. Eickelberg, 1920).—About 4.4 miles east of the White Pelican Hotel at Klamath Falls, 1.3 miles east of steel bridge over irrigation canal, in the southwest corner of a field, 30 meters (98 feet) northwest of a house owned by Mrs. John A. Short, and 2 meters (7 feet) east of the Klamath Falls-Olene (or Merrill) road. Station was marked by a standard bench-mark disk set in top of a concrete post, having been established by a precise level party.

Soldier (Shasta County, Calif., E. W. Eickelberg, 1920).—About 7 miles northwest from Falls River Mills, 2½ miles west from Glenburn, and 3 miles northeast from Cayton, on Soldier Mountain, 5 meters west from Forest Service lookout *Soldier*. The station was marked as described in note 2, and two reference marks, as described in note 12a, were set as follows: 7.36 meters (inclined) from the station in azimuth 315° 21′ and 15.40 meters (inclined) from the station in azimuth 115° 09′.

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Black Fox (Siskiyou County, Calif., E. W. Eickelberg, 1920).—A Forest Service lookout point, 15 miles northeast of McCloud, Calif., on highest point of Black Fox Mountain. Station marked as described in note 2.

Turret (Modoc County, Calif., E. W. Eickelberg, 1920).—About 20 miles north of Bieber, 13 miles north of Lookout post office, and 4 miles by trail southeast of Happy Camp ranger station, on the highest point of Turret Mountain, and 9 meters west from Forest Service lookout *Happy Camp*. The station was marked as described in note 2, while reference marks were set as follows: No. 1 is a standard disk reference mark cemented in drill hole in the concrete foundation of the lookout house, 9.05 meters from station in azimuth 273° 54′; No. 2, a disk as described in note 12a, is 8.10 meters from station in azimuth 106° 44′.

Dixie (Lassen County, Calif., E. W. Eickelberg, 1920).—About 25 miles southeast of Burnt River Mills, 2¼ miles north of the Cox and Clark ranch in Dixie Valley, on highest point of first range of lava rock hills lying north of Dixie Valley and visible from the Clark and Cox ranch house. The station was marked by a standard U. S. C. & G. S. disk station mark set in solid rock, while a standard U. S. Geological Survey disk was set in rock 2.68 meters from the station in azimuth 310° 09′.

Bald Mountain (U. S. G. S.) (Shasta County, Calif., E. W. Eickelberg, 1920).—About 8 miles south by east from Fall River Mills, 1¼ miles southeast of the Saint Johns ranch (W. S. Bernard), and one-half mile east of road leading southward from Saint Johns ranch. The station was marked by a U. S. Geological Survey bronze disk cemented in drill hole in solid rock.

Crater (U. S. G. S.) (Shasta County, Calif., E. W. Eickelberg, 1920).—About 13 miles south from Burney, 16 miles northeast from Whitemore, 5 miles by trail northeast from Cow Creek ranger station, three-fourths mile northeast of Forest Service lookout *Magee Peak*, on the northern and highest point of a volcanic mountain known locally as Magee Peak. The station was marked by a standard U. S. Geological Survey disk, while standard C. & G. S. station and reference disks were cemented in drill holes in solid rock but their positions not determined.

Bonanza (Trinity County, Calif., E. W. Eickelberg, 1920).—About 10 miles north of Trinity Center, a short distance from Bonanza King mine, and 25 yards north of Bonanza King lookout. The station was marked as described in note 2.

Granite (Trinity County, Calif., E. W. Eickelberg, 1920).—Ten miles west of Trinity Center, on Granite Peak, and 150 yards northeast of lookout house. The station was marked as described in note 2.

Burney (U. S. G. S.) (Shasta County, Calif., E. W. Eickelberg, 1920).—About 5½ miles south by east from Burney, 4 miles east of Dry Lake on the Burney-Whitemore (Tamarack) wagon road, 2 miles north of old road leading from Hat Creek to Burney Springs, on highest point of prominent volcanic mountain known as Burney Butte. The station was marked by a U. S. Geological Survey bronze disk set in a bowlder under a cairn having a 7-foot base and height of 8 feet.

For notes in regard to marking of stations see p. 16.

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	24.68886	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	2	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

PART II.

GENERAL STATEMENT.

The remaining pages of this publication are devoted to a description of field methods, tabulations of cost data for the various operations, and to a discussion of errors and methods of adjustment. The condition equations and other data used in making the adjustments are also included.

While these may be of little interest to the engineer who desires only the geographic positions of control points in some particular area, there are a number of reasons why they should be published. The methods employed in the field work are of interest and value to local organizations carrying on detailed triangulation. Cost data for all public work should be published for the information of those interested and as an evidence that the work is being performed economically. For the information of those using the data the size of the errors in the observations and the distribution of the discrepancies in the adjustment should be evident in the published results. Finally, the condition equations and other adjustment data should be published in order that future work may be started with certainty at any point without recourse to the original data; publication of complete results is the best insurance against loss of original records by fire or otherwise. In any future reprints of the data for this arc of triangulation only the preceding portions of this publication need be printed.

The methods employed in the field will be described very briefly first, with the cost factors for the various operations.

RECONNAISSANCE.

The reconnaissance for the California-Oregon arc of precise triangulation was made by Signalman J. S. Bilby in the summer and fall of 1919. Mr. Bilby reached Redding, Calif., on August 20 of that year, and after completing arrangements for the work, which included the purchase of a half-ton motor truck, commenced actual work on the reconnaissance for the Mount Shasta region on September 1. He completed the reconnaissance to a connection with the Utah-Oregon arc near Nyssa, Oreg., on October 19. One of the objects of the work in the vicinity of Mount Shasta was to provide control points for the engineers of the Forest Service. As the reconnaissance was extended it provided points also in Klamath, Modoc, and Fremont National Forests. No towers were required on this work, and the stands for the instrument were constructed by a building party under the direction of and just ahead of the observing party. The following statement gives the principal statistics for this reconnaissance:

Length of main scheme of reconnaissance, in statute miles	550
Area in square miles	22 000
New points selected (main schemes 37 and supplementary 22)	59
Total cost of reconnaissance	$989
Cost per mile of progress	$1.80
Cost per square mile	$0.04
Cost per station selected	$16.76

SIGNAL BUILDING.

A subsidiary party under Dan W. Taylor, signalman, preceded the observers and constructed stands for the support of the instrument at the stations which were to be occupied. One of the six trucks provided for the use of the observing party was assigned to the building party. This work was completed on September 1, 1920. In all 50 stands were built, at an average cost per stand of $37.95.

HORIZONTAL ANGLE OBSERVATIONS.

The observing party under Mr. Eickelberg commenced work at Redding, Calif., on June 11, 1920, and closed the field work at Vale, Oreg., on October 22 following. During this time 40 stations were occupied, 1 base line was measured, and 7 azimuths were observed. A double observing party was used for about two-thirds of the season. Part of the observing was done by the chief of party and the rest by E. O. Heaton, hydrographic and geodetic engineer, and W. Mussetter, extra observer.

The double observing party made it necessary for each light keeper to show two lights, one to each observer. In order to be able to have both lights properly centered, each light keeper was furnished with a stand made in the form of a box with two opposite sides missing. One light could be mounted inside of this stand and the other on top of it.

Seven light keepers were employed and assigned singly to stations, Each had his own camp outfit, which with instruments and provisions varied from 400 to 600 pounds in weight. Each light keeper was given a schedule of the stations which he was to occupy and those to which he was to show a light. He was trained in the visual use of the continental Morse code for signaling with the signal lamps and heliotropes, in order that the observer could keep in close touch with him and inform him of the observer's requirements. One truck was used in moving the light keepers from station to station. Detailed "Instructions to light keepers" are given in Special Publication No. 65.

The party commenced work with only three light keepers and was able to function only through the assistance of employees of the U. S. Forest Service and by using truck drivers as light keepers. At the first four stations, where packing averaged 10 miles, animals were used, but thereafter back packing was resorted to on account of the saving in time. It was possible at many of the stations to drive the trucks quite close to the station. In many instances they were driven several miles beyond the point where people of the neighborhood said it was possible for them to go, and in two cases, at stations Wagontire and Grays, the mountain was climbed with the trucks.

Unusual difficulties encountered in the work were severe dust storms while crossing the Great Sandy Desert and a great deal of smoke and haze from extensive forest fires; also, it was very difficult to secure competent men for light keepers and truck drivers. The season was very successful, however, both in regard to the accuracy obtained and the low cost per mile of progress. (See pp. 36 and 46.)

FIG. 2.—TRUCKS TRAVELING IN CREEK TO AVOID IMPASSABLE ROAD.

FIG. 3.—BACK PACKING INSTRUMENTAL OUTFIT.

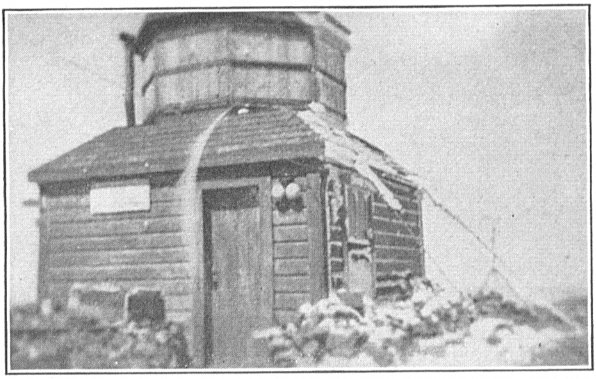

FIG. 4.—U. S. FORESTRY SERVICE LOOKOUT HOUSE ON MOUNT EDDY, CALIF.

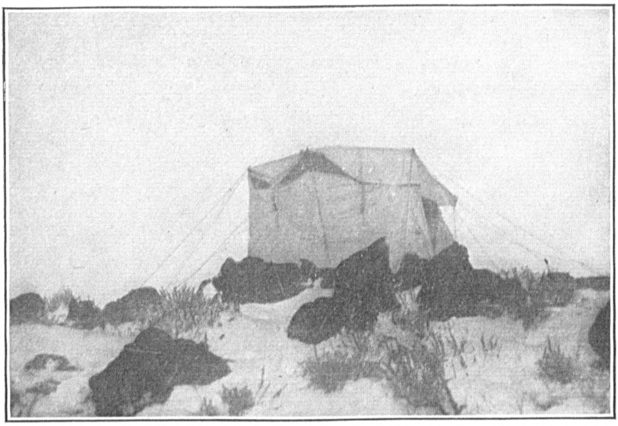

FIG. 5.—OBSERVING TENT AT STATION SQUAW ON OCT. 20, 1920.

INSTRUCTIONS GOVERNING THE OBSERVATIONS.

The instructions for the observation of horizontal angles on precise triangulation are given in detail in U. S. Coast and Geodetic Survey Special Publication No. 19 and will not be repeated here. In brief, such instruments and methods are used as will insure that the maximum closing error of a triangle is not greater than 3″, with an average of about 1″. The frequency of bases, strength of figures, and accuracy of angle measures must be such that the measured length of a base will not differ by more than 1 part in 25,000 from the length as computed through the triangulation from the preceding base.

The general instructions for precise triangulation as given in Special Publication No. 19 were amended for this arc in the following particulars:

All observations for horizontal angles between precise stations were to be made at night, unless to do so would materially delay the party. In order to minimize the effect of temperature on the instrument, the circle was shifted approximately 195° in azimuth between each two positions, thus making the alternate settings 180° from those shown in the table in page 35 of Special Publication No. 19.

An effort was made to make all observations for elevations between the hours of 1 and 4 in the afternoon, the period of greatest constancy in refraction, but the instructions permitted some of the observations of vertical angles to be made at night, provided a portion of the observations had been made during daylight, and providing also that those stations which had been observed upon during the day were reobserved at night, along with the remaining stations.

The reconnaissance called for a Laplace azimuth at Lakeview, Oreg. When it was found, however, that the agreement between the fixed lines at either end of the arc as determined by a preliminary computation through the triangulation was satisfactory, instructions were given to proceed with the final computations without waiting for the longitude observations at the proposed Laplace station.

INSTRUMENTS AND METHODS.

The precise measures for horizontal directions were made partly with a standard 12-inch direction theodolite such as has been in use in the Survey for a number of years and partly with one of the two Wanschaff 8-inch direction theodolites which were very generously loaned to the Survey during the war by Prof. Harold Jacoby, head of the department of astronomy of Columbia University, in order that certain urgent work could be done for the War Department. A part of the vertical angles were measured with an ordinary vertical circle instrument and a part with the vertical circle on the Wanschaff theodolite.

STATEMENT OF COSTS.

The following statement gives a brief summary of the cost of the observing, including the azimuth observations, with analysis that may serve as a basis for comparison with work of a similar character on other arcs:

Total expenses (including depreciation of trucks and salary of observer, plus annual leave earned, but excluding cost of base)	$18 088.00
Linear miles of progress through scheme	550
Cost per mile of progress	$32.89

Number of square miles covered	$22 000
Cost per square mile	$0.82
Number of stations occupied in main scheme	36
Number of stations occupied in supplemental scheme	4
Cost per station occupied (two supplemental equals one precise)	$476.00
Number of points whose geographic positions were determined	72
Cost per point determined	$251.22

BASE MEASUREMENT.

One base of precise accuracy was measured on the California-Oregon arc; it is just north of the town of Paisley, Oreg., and is 14.53 kilometers (9.03 miles) in length. It was measured according to the standard instructions given in Special Publication No. 19, using the 50-meter invar tapes, which for a number of years have been kept solely for precise base measurement. A statement of the accuracy obtained will be found on page 35 of this publication.

The total cost of measuring this base line was $811.12, which includes labor, expressage, salary of chief of party, lumber, running expenses and depreciation of truck, etc., but no charges for the standardization of the tapes. This gives a unit cost for the base line of $55.82 per kilometer or $89.82 per mile.

STANDARDIZATION OF TAPES.

The Paisley base line was measured with invar base tapes Nos. 516, 517, and 521. These tapes were standardized at the Bureau of Standards in July, 1920, and used on the base line in the following October. A post-season standardization was made in February, 1921, but as the tapes had not been sent directly in from the Paisley base line for standardization but had been used by another party to measure another base line (in Oklahoma) and had, therefore, possibly been subjected to conditions which might have produced changes between the time of the measurement of the Paisley base line and the post-season standardization, it was deemed advisable to use only the values from the July, 1920, standardization in computing this base line. These values are as follows, the tapes being supported at the 0, 25, and 50 meter points:

$$T_{516} = 50.008496 \text{ meters } \pm 0.026 \text{ mm. at } 26^\circ.6 \text{ C.}$$
$$T_{517} = 50.009564 \text{ meters } \pm 0.019 \text{ mm. at } 26^\circ.3 \text{ C.}$$
$$T_{521} = 50.009248 \text{ meters } \pm 0.031 \text{ mm. at } 26^\circ.2 \text{ C.}$$

REDUCTION TO SEA LEVEL.

The formula used for reducing the measured base line to its length at sea level is—

$$C = -S\frac{h}{r} + S\frac{h^2}{r^2} - S\frac{h^3}{r^3}, \text{ etc.}$$

where C is the sea-level correction for a section of measured length S, and of mean elevation h above sea level, r being the radius of the earth's curvature for the given section. This correction was computed for the Paisley base line section by section, and applied separately for each section, instead of being computed for and applied to the base line as a whole, as is sometimes done.

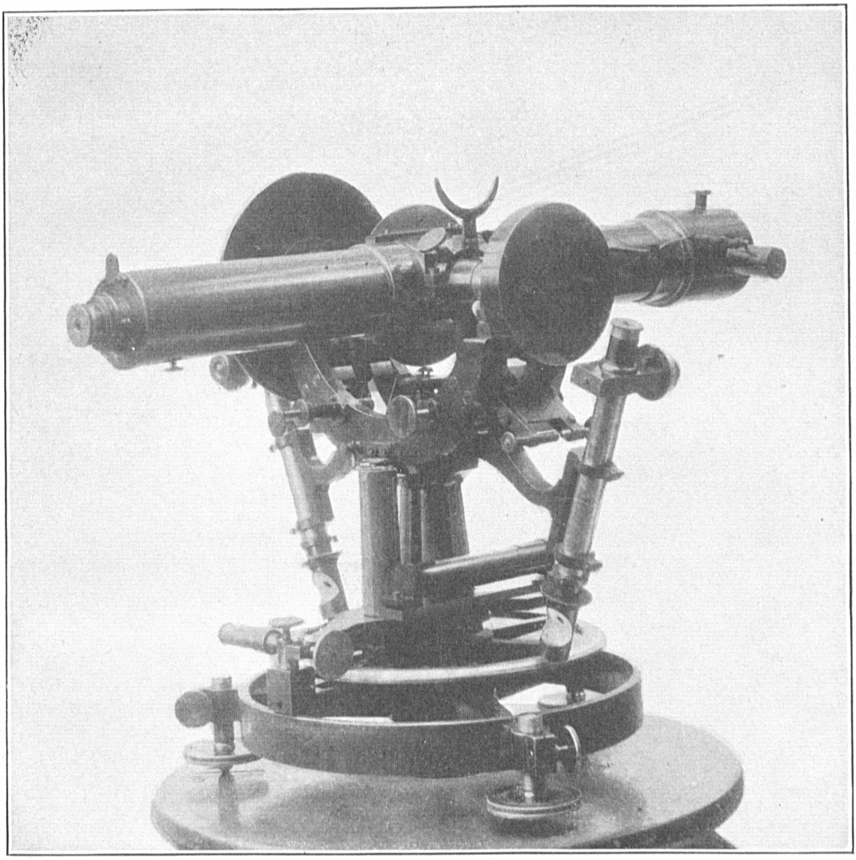

FIG. 6.—WANSCHAFF 8-INCH THEODOLITE.

COMPUTATION OF PAISLEY (OREG.) BASE LINE.

Section.	Date.	Dir. of meas.	Tape No.	Uncorrected length.		Temp.	Corrections.		
				Tape lengths.	Meters.		Temp.	Tape.	Set-up. Set-back.
	1920.					°C.	*Meters.*	*Meters.*	*Meters.*
Paisley north base—104	Oct. 13	F	516	101	5050	6.63	−0.0359	+0.8581	−1.2700 (Oct. 13 and ..do..)
	..do....	F	521	1	50	9.7	− .0003	+ .0092	
	Oct. 14	B	517	102	5100	11.23	− .0246	+ .9755	−1.3795
104—200	Oct. 13	F	516	96	4800	11.09	− .0265	+ .8154	+ .2868
	Oct. 14	B	521	96	4800	7.44	− .0369	+ .8878	+ .2405
	Oct. 15	B	521	96	4800	4.91	− .0435	+ .8878	+ .2396
200—Paisley south base	Oct. 12	F	521	92½	4625	5.47	− .0392	+ .8554	+6.1447
	..do....	B	517	92½	4625	4.96	− .0315	+ .8847	+6.1331 − .0154*

Section.	Corrections—Cont'd.		Reduced length.	Mean by tapes.	Adopted length.	(v)	(vv)
	Inclination.	Sea level.					
	Meters.	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*mm.*	*mm.*
Paisley north base—104	−1.1417	−1.0618	5097.3486	....	5097.3582	+9.6	92.16
	−1.1417	−1.0618	5097.3679	....		−9.7.	94.09
104—200	− .0526	− .9980	4800.0251	....	4800.0326	+7.5	56.25
	− .0526	− .9980	4800.0468	4800.0401 (4800.0468 and 4800.0333)		−7.4	54.76
	− .0526	− .9980	4800.0333				
200—Paisley south base	− .8077	− .9730	4630.1648	....	4630.1775	+12.7	161.29
	− .8077	− .9730	4630.1922	....		−12.7	101.29

Total length of base line 14 527.5683

Mean elevation of base line above sea level = 1330 meters.

The probable error of this base line from errors of measuring and probably including certain systematic errors of the standardizations of the tapes is ±11.9 mm., which corresponds to an error of 1 part in 1 220 000.

*Correction for catenary.

ASTRONOMIC WORK.

There were no astronomic latitudes or longitudes observed along this arc. The reconnaissance provided for a Laplace station at Lakeview, Oreg., and an astronomic azimuth was observed there, but it was later decided not to complete the station by determining its astronomic longitude. Azimuths were observed at eight stations of this arc, but the azimuth at one of these stations, Grizzly, was rejected when the final computations were made. These azimuths are inserted here that the data along this arc may be complete in one publication.

The dates of occupation of the various stations and the probable errors of the determined azimuths are as follows:

Program of occupation of azimuth stations.

Station.	Date of occupation.	Number of positions.	Probable error of result.
			″
Beulah, Oreg.	Oct. 7, 1920	12	±0.45
Riddle, Oreg.	Sept. 29, 1920	14	± .38
Burns, Oreg.	Sept. 27, 1920	15	± .31
Juniper, Oreg.	Sept. 18, 1920	14	± .58
Lakeview bench mark M 10, Oreg.	Oct. 28, 30, 1920.	18	± .58
Yonna, Oreg.	Aug. 5, 1920	12	± .39
Goosenest, Calif.	July 14, 1920	12	± .46

In the following table are given the astronomic azimuths resulting from these observations, the geodetic azimuths of the same lines, and the resulting deflection of the vertical reduced to the prime vertical.

Deflections in prime vertical.

Station.	Geodetic latitude.	Geodetic longitude.	Geodetic azimuth.	To station—	Astronomic azimuth (seconds only).	A-G.	$-\cot\phi'$[1]	A-G (P. V.).
	° ′ ″	° ′ ″	° ′ ″		″	″		″
Beulah, Oreg.	43 52 13.065	118 05 44.572	349 23 47.02	Star	33.63	−13.39	−1.0403	+13.93
Riddle, Oreg.	43 06 02.213	118 29 54.213	179 21 58.82	Crow	52.75	− 6.07	−1.0686	+ 6.49
Burns, Oreg.	43 33 42.480	119 09 04.961	344 15 43.02	Jack	40.20	− 2.82	−1.0515	+ 2.97
Juniper, Oreg.	42 55 48.968	119 55 57.180	221 51 18.71	Burns	13.17	− 5.74	−1.0749	+ 6.17
Lakeview bench mark M 16, Oreg.	42 11 36.988	120 21 39.891	119 47 17.68	Cougar	01.26	−16.42	−1.1031	+18.11
Yonna, Oreg.	42 19 36.000	121 16 05.935	272 06 59.96	Cougar	55.10	− 4.86	−1.0979	+ 5.34
Goosenest, Calif.	41 31 12.863	122 13 17.633	25 49 21.68	Eddy	12.52	− 9.16	−1.1216	+10.27

[1] ϕ' is the geodetic latitude.

ANALYSIS OF COSTS, FIELD AND OFFICE.

For the purpose of showing unit costs in a condensed form, and also of comparing the relative cost of the various operations connected with the determination of geodetic control points, there follows a tabulation of these factors:

Kind of operation.	Total cost.	Cost per point determined (72).	Cost per mile of progress (550).	Cost per square mile (22 000).
	Dollars.	*Dollars.*	*Dollars.*	*Dollars.*
Reconnaissance	989	13.74	1.80	0.04
Signal building	1898	26.36	3.45	0.09
Triangulation and azimuth observations	18 088	251.22	32.89	0.82
Base measurement	811	11.26	1.47	0.04
Total, field	21 786	302.58	39.61	0.99
Office computation	1265	17.57	2.30	0.06
Compiling and publishing (estimated)	1000	13.89	1.82	0.04
Total, office	2265	31.46	4.12	0.10
Field and office	24 051	334.04	43.73	1.09

Different arcs of triangulation show a great divergence in the cost per point determined and the cost per square mile, both of which are largely dependent upon the length of lines in the scheme. The cost per mile of progress through the middle of the scheme, however, is relatively constant and furnishes a good basis of comparison or of estimation of costs. The cost per mile of progress for various arcs are given below. These costs include the signal building but do not include the cost of reconnaissance and base measurements.

Ninety-eighth meridian arc (after 1901)	$63
Texas-California arc	32
One hundred and fourth meridian arc	39
Utah-Washington arc	30
California-Washington arc (see above)	36

STATEMENT OF ADJUSTMENTS.

After all observed directions and the measured base line had been reduced to sea level, the entire arc was adjusted by the method of least squares, using one set of equations. The discrepancies which it was necessary to eliminate were distributed in the following classes:

	Equations.
Closure of triangles	51
Discrepancies in triangle sides	19
Length discrepancies	2
Discrepancy in latitude	1
Discrepancy in longitude	1
Discrepancy in azimuth	1

making a total of 75 equations. These equations will be found in detail on pages 41 and 42, while the results of their solution are given on page 43.

DISCREPANCIES IN LENGTH, AZIMUTH, AND POSITION.

In examining the least-squares adjustment for criterions of the accuracy of this triangulation, we find that after the angle and side equations were satisfied the length discrepancy developed between the Paisley base and the line Dry-Squaw of the Utah-Washington arc of precise triangulation was 93 in the seventh place of logarithms or 1 part in 46 800, and the discrepancy between the same base and the line Bally-Boliver of the California-Washington arc of precise triangulation was 72 in the seventh place of logarithms or 1 part in 145 700. The measured length of the base is shorter than its length computed from the line Dry-Squaw and longer than its length computed from the line Bally-Boliver.

No Laplace azimuths were observed, though one had been proposed in the reconnaissance. It was omitted, partly from economic considerations, and partly because the preliminary computation of the triangulation seemed to justify so doing. After all equations relating to angles, sides, and lengths (but not latitude and longitude) had been satisfied the discrepancy remaining between the azimuth of the line Bally-Boliver as fixed by the adjustment of the California-Washington arc of precise triangulation and as brought through the California-Oregon triangulation from the fixed line Dry-Squaw was 2''.62, the azimuth carried through from the line Dry-Squaw being too small.

The discrepancy which the latitude equation was required to eliminate was 0''.238, equal to 7.34 meters or 24.1 feet; the longitude discrepancy was 0''.189, equal to 4.40 meters or 14.4 feet. It will thus be seen that the total discrepancy in position which remained for the latitude and longitude equations to eliminate, after all conditions in angles, sides, lengths, and azimuth had been satisfied, was only about 28 feet. The geodetic position of station Boliver as computed through the triangulation from station Dry was too large in latitude and too small in longitude.

HORIZONTAL DIRECTIONS AND ELEVATIONS OF TELESCOPE ABOVE THE STATION MARKS.

Wherever either the instrument or the object observed was not directly over the center of the station mark the observed direction was reduced to center. All observed directions on this arc of precise triangulation were given equal or unit weight, and all were reduced to sea level, using the following formula:

Reduction to sea level (expressed in seconds of arc) $= \frac{e^2 h \sin 2\alpha \cos^2 \phi}{2\rho \sin 1''}$

where $e^2 = \frac{(a^2 - b^2)}{a^2}$, a is the earth's equatorial radius and b is the polar semi-diameter, h is the height above sea level of the station observed, ρ is the radius of curvature of the earth in a plane normal to the meridian, ϕ is the latitude of the station occupied, and α is the azimuth of the direction reckoned from the south around through the west. This computation is facilitated by computing a part of the formula, $\frac{e^2 \cos^2 \phi}{2\rho \sin 1''}$, for every alternate degree of latitude within the range of the triangulation being considered, and interpolating from the table thus formed for the values at the separate stations.

In the following table are given for all precise triangulation stations of the California-Oregon arc the lists of observed directions reduced to sea level, the numbers assigned those directions in the least-squares adjustment, the adjusted directions, and the elevations of the telescope of the theodolite above the station marks. Directions of a secondary character, from or to stations not included in the principal least-squares adjustment, may be obtained from the azimuths listed with the table of geographic positions (see p.11).

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

Station occupied and elevation of telescope above station mark.	Number of direction.	Object observed.	Observed direction reduced to sea level.	Final seconds after figure adjustment.
			° ′ ″	″
Dry, 1.45 meters	7	Freezeout	0 00 00.00	59.93
	8	Star	22 11 06.18	06.12
	9	Beulah	52 54 10.52	15.29
	6a	Squaw	284 33 04.19	04.93
	6	Vale	307 05 13.61	14.23
Squaw, 1.41 meters	2	Vale	0 00 00.00	59.63
	2a	Dry	14 59 04.91	05.06
	1	Freezeout	340 31 53.37	53.59
Vale, 1.41 meters	4	Freezeout	0 00 00.00	59.84
	5	Dry	82 40 18.60	18.11
	3	Squaw	225 09 06.97	07.61
Freezeout, 1.27 meters	10	Star	0 00 00.00	00.18
	11	Beulah	74 21 00.22	00.12
	12	Dry	124 38 41.57	41.55
	13	Vale	169 03 42.58	42.87
	14	Squaw	194 44 50.55	50.20
Beulah, 1.49 meters	15	Dry	0 00 00.00	00.67
	16	Freezeout	76 48 09.70	09.81
	17	Star	123 11 27.60	28.11
	18	Riddle	154 47 17.31	16.43
	19	Crow	174 33 27.25	26.84
Star, 1.40 meters	20	Riddle	0 00 00.00	00.34
	21	Crow	56 12 55.97	55.46
	22	Beulah	114 41 22.96	22.76
	23	Dry	140 46 51.32	51.86
	24	Freezeout	173 57 09.80	09.64

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

Station occupied and elevation of telescope above station mark.	Number of direction.	Object observed.	Observed direction reduced to sea level. °	′	″	Final seconds after figure adjustment. ″
Crow, 1.34 meters	29	Burns	0	00	00.00	00.16
	.....	Burns bench mark C 19	4	09	01.15	01.09
	25	Beulah	125	41	21.38	21.54
	26	Star	195	51	01.07	01.11
	27	Riddle	264	34	15.73	16.20
	28	Jack	290	29	39.36	38.51
Riddle, 1.27 meters	30	Jack	0	00	00.00	00.55
	31	Burns	54	03	25.06	24.60
	.....	Burns bench mark C 19	60	05	02.70	02.74
	32	Crow	99	08	48.92	48.62
	33	Beulah	120	29	47.61	47.52
	34	Star	154	12	43.29	43.58
Jack, 1.28 meters	40	Juniper	0	00	00.00	59.90
	41	Wagontire	32	55	33.87	33.80
	42	Burns	82	54	52.20	52.21
	43	Crow	132	29	37.96	38.45
	44	Riddle	178	25	32.83	32.49
Burns, 1.38 meters	37	Jack	0	00	00.00	00.16
	38	Juniper	58	07	42.44	42.64
	39	Wagontire	84	30	23.71	23.52
	.....	Burns bench mark C 19	267	05	22.20	22.79
	35	Crow	290	05	01.22	00.57
	36	Riddle	329	33	58.35	58.82
Wagontire, 1.40 meters	47	Juniper	0	00	00.00	00.38
	48	Grays	5	04	16.99	16.96
	49	Diablo	48	11	47.41	47.31
	45	Burns	244	06	53.80	53.34
	46	Jack	289	37	21.09	21.31
Grays, 1.28 meters	61	Wagontire	0	00	00.00	59.77
	59	Juniper	139	16	59.07	59.14
	60	Diablo	259	20	09.13	09.29
Diablo, 1.33 meters	64	Juniper	00	00	00.00	59.33
	65	Hart	35	18	52.72	54.71
	66	Sharp	58	23	29.97	29.84
	67	White	62	51	26.32	26.47
	68	Round	80	36	25.41	25.23
	69	Paisley north base	97	03	41.11	40.86
	62	Wagontire	317	42	31.33	30.80
	63	Grays	353	55	17.30	17.00
Juniper, 1.26 meters	50	Hart	0	00	00.00	59.40
	51	Round	61	06	47.66	48.26
	52	White	70	16	30.00	30.10
	53	Sharp	95	05	13.78	13.51
	54	Diablo	111	25	37.78	38.02
	55	Grays	165	17	46.31	46.20
	56	Wagontire	200	56	28.72	28.69
	57	Burns	238	40	47.67	47.63
	58	Jack	277	38	24.93	25.05
Sharp, 1.30 meters	73	Diablo	0	00	00.00	00.11
	74	Juniper	105	16	06.88	06.78
	70	White	187	49	10.31	10.27
	71	Paisley south base	227	03	32.48	32.59
	72	Paisley north base	287	06	00.51	00.43
Paisley north base, 1.29 meters	75	Diablo	0	00	00.00	59.96
	76	Sharp	68	25	49.77	49.63
	77	White	124	24	52.62	52.73
	78	Paisley south base	151	11	00.74	00.82
Paisley south base, 1.30 meters	79	Paisley north base	0	00	00.00	59.88
	80	Sharp	37	12	20.98	21.23
	81	White	122	21	27.30	27.17
White, 1.41 meters	85	Diablo	0	00	00.00	59.93
	86	Sharp	3	21	13.92	13.56
	87	Juniper	75	59	28.72	28.97
	82	Round	226	47	02.64	02.72
	83	Paisley south base	307	44	40.82	41.29
	84	Paisley north base	338	37	06.68	00.30

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

Station occupied and elevation of telescope above station mark.	Number of direction.	Object observed.	Observed direction reduced to sea level. °	′	″	Final seconds after figure adjustment. ″
Hart, 1.28 meters	88	Crane	0	00	00.00	00.06
	89	Drake	19	34	34.83	35.50
	90	Round	50	23	05.01	04.56
	91	Diablo	86	48	24.94	24.82
	92	Juniper	120	03	57.62	57.48
Round, 1.38 meters	99	Hart	0	00	00.00	59.64
	100	Drake	32	15	26.90	26.61
	101	Crane	62	06	44.22	44.31
	102	Cougar	113	03	18.17	18.22
	103	Yonna	160	41	38.35	38.65
	96	Diablo	261	42	42.02	42.08
	97	White	290	44	47.94	47.53
	98	Juniper	310	47	32.68	33.24
Drake, 1.28 meters	93	Crane	0	00	00.00	00.25
	94	Round	109	42	17.03	17.38
	95	Hart	226	38	25.02	24.43
Crane, 1.36 meters	107	Cougar	0	00	00.00	00.09
	108	Lakeview bench mark M 16	15	08	39.29	39.28
	109	Round	25	08	28.34	28.56
	110	Drake	65	34	56.33	56.14
	111	Hart	92	38	46.96	46.81
	104	Hoffman	295	28	04.79	04.21
	105	Dog	328	48	58.95	58.90
	106	Yonna	339	05	53.54	54.23
Lakeview bench mark M 16, 1.27 meters	115	Crane	0	00	00.00	59.84
	116	Dog	109	05	10.82	10.06
	117	Cougar	154	28	04.57	04.90
Dog, 1.66 meters	112	Cougar	0	00	00.00	59.80
	113	Lakeview bench mark M 16	55	03	01.43	01.78
	114	Crane	79	38	12.00	11.86
Cougar, 1.57 meters	.....	Drake	0	00	......	59.10
	118	Lakeview bench mark M 16	29	14	26.43	25.77
	119	Crane	39	37	41.86	42.00
	120	Dog	108	48	30.81	30.96
	121	Hoffman	134	39	38.85	39.23
	122	Yonna	182	10	45.73	46.03
	123	Round	295	42	42.28	41.99
Yonna, 1.48 meters	125	Cougar	0	00	00.00	59.34
	126	Crane	16	32	53.44	52.88
	127	Hoffman	104	30	47.47	47.94
	128	Goosenest	137	44	00.78	01.32
	129	Aspen	177	08	41.12	41.56
	124	Round	341	10	13.13	12.91
Hoffman, 1.16 meters	.....	Soldier	0	00	00.00	00.00
	130	Grizzly	33	50	29.43	30.33
	131	Whaleback	78	48	31.06	30.11
	132	Goosenest	101	42	40.75	41.25
	133	Aspen	149	55	29.87	29.80
	134	Yonna	195	40	46.47	46.23
	135	Cougar	223	39	02.53	01.54
	136	Crane	244	05	19.16	20.01
Aspen, 1.12 meters	137	Yonna	0	00	00.00	59.42
	138	Hoffman	61	37	02.55	02.91
	139	Goosenest	100	54	45.13	45.34
Goosenest, 1.35 meters	142	Hoffman	0	00	00.00	00.44
	143	Whaleback	60	11	44.68	44.55
	144	Eddy	103	47	42.90	43.03
	140	Aspen	267	30	22.14	21.73
	141	Yonna	307	11	07.77	06.84
Whaleback, 1.15 meters	145	Hoffman	0	00	00.00	59.60
	146	Grizzly	83	05	39.94	40.15
	147	Eddy	151	37	00.86	01.30
	148	Boliver	161	52	41.77	41.88
	149	Goosenest	263	05	52.42	52.05

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

Station occupied and elevation of telescope above station mark.	Number of direction.	Object observed.	Observed direction reduced to sea level.	Final seconds after figure adjustment.
			° ′ ″	″
Grizzly, 1.35 meters	150	Bally	0 00 00.00	00.12
	151	Bolivar	57 28 51.07	52.80
	152	Eddy	71 29 47.40	47.19
	153	Whaleback	118 52 01.71	00.96
	154	Hoffman	170 48 26.30	26.23
Eddy, 1.37 meters	159	Whaleback	0 00 00.00	59.22
	155	Grizzly	64 06 28.13	28.16
	156	Bally	139 47 08.62	09.25
	157	Bolivar	204 42 05.47	05.94
	158	Goosenest	335 04 47.76	47.41
Bally, 1.43 meters	163a	Bolivar	0 00 00.00	59.87
	163	Eddy	18 42 56.44	56.62
	164	Grizzly	51 32 37.71	37.65
Bolivar, 2.41 meters	160	Whaleback	0 00 00.00	58.76
	161	Eddy	14 26 26.56	25.91
	162	Grizzly	39 49 55.71	55.78
	162a	Bally	110 48 35.51	37.33

CONDITION EQUATIONS.

No.

1. 0 = − 1.53 −(2)+(2a)+(3)−(5)+(6)−(6a).
2. 0 = + 0.71 −(4)+(5)−(6)+(7)−(12)+(13).
3. 0 = + 2.02 −(1)+(2)−(3)+(4)−(13)+(14).
4. 0 = − 3.68 +5.96(1)−13.83(2)+7.87(2a)−6.66(6)+5.07(6a)+1.59(7)+2.15(12)−6.53(13)+4.38(14).
5. 0 = + 1.64 −(7)+(9)−(11)+(12)−(15)+(16).

6. 0 = + 0.59 −(8)+(9)−(15)+(17)−(22)+(23).
7. 0 = − 0.16 −(10)+(11)−(16)+(17)−(22)+(24).
8. 0 = − 8.25 −5.17(7)+8.72(8)−3.55(9)−0.59(10)+2.34(11)−1.75(12)−0.50(15)+2.50(16)−2.00(17) −4.30(22)+7.52(23)−3.22(24).
9. 0 = + 0.72 −(17)+(19)−(21)+(22)−(25)+(26).
10. 0 = − 0.99 −(18)+(19)−(25)+(27)−(32)+(33).

11. 0 = − 0.16 −(20)+(21)−(26)+(27)−(32)+(34).
12. 0 = + 9.60 −3.43(17)+9.29(18)−5.86(19)−1.41(20)+2.71(21)−1.30(22)−0.76(25)+1.58(26)−0.82(27) −5.39(32)+8.54(33)−3.16(34).
13. 0 = − 0.97 −(27)+(29)−(31)+(32)−(35)+(36).
14. 0 = − 2.30 −(28)+(29)−(35)+(37)−(42)+(43).
15. 0 = + 1.67 −(30)+(31)−(36)+(37)−(42)+(44).

16. 0 = − 1.65 −3.22(27)+3.02(28)+0.20(29)−2.56(35)+6.14(36)−3.58(37)+0.20(42)+2.04(43)−2.24(44).
17. 0 = − 0.41 −(37)+(39)−(41)+(42)−(45)+(46).
18. 0 = − 0.44 −(38)+(39)−(45)+(47)−(56)+(57).
19. 0 = − 0.34 −(40)+(41)−(46)+(47)−(56)+(58).
20. 0 = + 1.44 +0.20(37)−4.25(38)+4.05(39)+3.25(40)−5.02(41)+1.77(42)+2.22(56)−2.72(57)+0.50(58).

21. 0 = + 0.03 −(47)+(48)−(55)+(56)+(59)−(61).
22. 0 = + 0.33 −(48)+(49)−(60)+(61)−(62)+(63).
23. 0 = + 0.53 −(54)+(55)−(59)+(60)−(63)+(64).
24. 0 = + 0.442−2.373(47)+2.598(48)−0.225(49)−0.153(54)+0.440(55)−0.293(56)−0.288(62)+2.265(63) −1.977(64).
25. 0 = − 0.84 −(53)+(54)−(64)+(66)−(73)+(74).

26. 0 = − 0.31 −(52)+(53)+(70)−(74)−(86)+(87).
27. 0 = − 0.13 −(66)+(67)−(70)+(73)−(85)+(86).
28. 0 = + 2.322− 0.456(52)+1.174(53)−0.718(54)−0.129(64)+2.825(66)−2.696(67)−3.593(85)+3.648(86) −0.065(87).
29. 0 = + 0.03 −(68)+(69)−(72)+(73)−(75)+(76).
30. 0 = − 0.22 −(70)+(72)−(76)+(77)−(84)+(86).

31. 0 = − 2.000−2.696(66)+3.006(67)−0.310(69)+0.034(70)+0.031(72)−0.065(73)−0.083(75)+0.225(76) −0.142(77)−0.538(84)+4.131(85)−3.593(86).
32. 0 = − 0.39 −(71)+(72)−(76)+(78)−(79)+(80).
33. 0 = + 0.89 −(77)+(78)−(79)+(81)−(83)+(84).
34. 0 = + 0.97 −2.57(70)+3.79(71)−1.22(72)−0.26(76)+4.17(77)−3.91(78)−2.08(83)+3.52(84)−1.44(86).
35. 0 = + 8.65 −3.07(1)+3.07(2a)−1.59(7)+1.59(9)−0.59(10)+0.59(11)+0.76(12)−0.76(14)+0.50(15) −0.50(16)−1.68(17)+1.68(19)−1.41(20)+1.41(21)+1.25(22)−1.25(24)+0.76(25)−0.76(26) +0.34(30)+1.13(32)−1.47(34)−1.19(28)+1.19(29)+0.77(35)−0.97(37)+0.20(39)−3.25(40) +3.25(41)+2.03(43)−2.03(44)+2.07(45)−2.07(46)−1.88(47)+1.88(49)−2.41(52)+2.41(54) +0.50(56)−0.50(58)+2.31(62)−2.31(64)−3.10(67)+3.10(69)−1.44(75)+1.44(77)−1.33(79) +1.33(81)−3.52(84)+0.53(85)−0.53(87).

No.

36. 0=+ 0.94 −(67)+(68)−(82)+(85)−(96)+(97).

37. 0=− 0.29 −(51)+(52)+(82)−(87)−(97)+(98).

38. 0=−11.07 +13.06(51)−15.47(52)+2.41(54)+1.08(64)−7.66(67)+6.58(68)+3.79(96)−9.56(97)+5.77(98).

39. 0=+ 2.26 −(65)+(68)−(90)+(91)−(96)+(99).

40. 0=− 0.59 −(50)+(51)−(90)+(92)−(98)+(99).

41. 0=−10.63 −2.62(64)+2.97(65)−0.35(68)−0.78(90)+3.21(91)−2.43(92)−1.82(96)+3.63(98)−1.81(99).

42. 0=+ 1.98 −(89)+(90)−(94)+(95)−(99)+(100).

43. 0=− 0.07 −(93)+(94)−(100)+(101)−(109)+(110).

44. 0=− 1.48 −(88)+(89)+(93)−(95)−(110)+(111).

45. 0=−5.23−5.92(88)+9.45(89)−3.53(90)−3.33(99)+7.00(100)−3.67(101)−2.47(109)+6.59(110) −4.12(111).

46. 0=−0.52−(101)+(102)−(107)+(109)+(119)−(123).

47. 0=+0.78−(102)+(103)−(122)+(123)−(124)+(125).

48. 0=+0.35−(106)+(107)−(119)+(122)−(125)+(126).

49. 0=+7.88−1.71(101)+3.63(102)−1.92(103)−5.52(106)+1.00(107)−4.49(109)−6.17(124)+13.25(125) −7.08(126).

50. 0=−0.21−(105)+(107)−(112)+(114)−(119)+(120).

51. 0=+0.44−(105)+(108)−(113)+(114)−(115)+(116).

52. 0=−1.20−(107)+(108)−(115)+(117)−(118)+(119).

53. 0=−12.75−2.01(105)+7.78(107)−5.77(108)−1.47(112)+6.07(113)−4.60(114)−11.10(118)+11.48(119) −0.38(120).

54. 0=−0.31−(121)+(122)−(125)+(127)−(134)+(135).

55. 0=−2.74−(104)+(107)−(119)+(121)−(135)+(136).

56. 0=+6.48−2.20(104)+7.72(106)−5.52(107)+0.19(119)+1.74(121)−1.93(122)−7.08(125)+7.16(126) −0.08(127)−3.96(134)+9.61(135)−5.65(136).

57. 0=−0.74−(127)+(129)−(133)+(134)−(137)+(138).

58. 0=−0.18−(128)+(129)−(137)+(139)−(140)+(141).

59. 0=−0.69−(127)+(128)−(132)+(134)−(141)+(142)

60. 0=+0.56−2.57(127)+3.22(128)−0.65(129)−1.13(137)+3.70(138)−2.57(139)+0.09(140)+1.59(141) −1.68(142).

61. 0=−0.85−(131)+(132)−(142)+(143)+(145)−(149).

62. 0=+0.09−(143)+(144)−(147)+(149)−(158)+(159).

63. 0=−0.50−(146)+(147)−(152)+(153)+(155)−(159).

64. 0=+0.55−(130)+(131)−(145)+(146)−(153)+(154).

65. 0=+19.32−2.11(130)+7.09(131)−4.98(132)−1.21(142)+3.42(143)−2.21(144)−1.94(152)+3.59(153) −1.65(154)−1.02(155)−4.53(158)+5.55(159).

66. 0=+0.46−(146)+(148)−151)+(153)−(160)+(162).

67. 0=−0.03−(151)+(152)−(155)+(157)−(161)+(162).

68. 0=− 2.72+0.82(146)−12.45(147)+11.63(148)+8.43(151)−10.37(152)+1.94(153)+8.17(160)−12.61(161) +4.44(162).

69. 0=− 2.62−(156)+(157)−(161)+(162a)+(163)−(163a).

70. 0=− 2.63−(150)+(151)−(162)+(162a)−(163a)+(164).

71. 0=−15.79−0.71(150)+8.43(151)−7.72(152)−4.68(161)+0.24(162a)+4.44(162)+9.47(163)−6.21(163a) −3.26(164).

72. 0=+1.86−1.16(50)+1.16(51)+2.41(52)−2.41(54)−0.35(64)+3.10(67)+0.35(68)−3.10(69)+1.44(75) −1.44(77)+1.33(79)−1.33(81)+3.52(83)−3.52(84)−0.53(85)+0.53(87)−1.74(88)+2.52(90) −0.78(92)+1.82(96)−1.82(98)+0.31(101)−0.31(103)−2.20(104)+2.20(106)+0.87(109)−0.87(111) +2.96(124)−2.96(126)−3.22(127)+3.22(128)−2.11(130)+2.11(131)+1.87(134)−1.87(136) +1.59(141)−2.80(142)+1.21(143)−0.82(146)+0.82(147)+0.25(145)−0.25(149)−0.71(150) +0.71(152)+1.65(153)−1.65(154)−1.02(155)+1.02(159)−0.99(156)+0.99(157)−0.24(161) +0.24(162a)+3.26(163)−3.26(164).

Azimuth equation.

73. 0=(−0.30+0.32)−(6a)+(9)−(15)+(19)−(25)+(29)−(35)+(38)+(51)−(57)−(98)+(101)+(104)−(109) +(130)−(136)+(151)−(154)−(162)+(162a).

Latitude equation.

74. 0=−13.4631+10.2376(1)−10.2376(2a)−2.6989(7)+2.6989(9)+5.3861(10)−5.3861(11)+3.5464(12) −3.5464(14)−5.6585(15)+5.6585(16)−2.4479(17)+2.4479(19)+5.9880(20)−5.9880(21) +2.5026(22)−2.5026(24)−5.5493(25)+5.5493(26)−4.3008(27)+4.3008(29)+5.5654(30) −5.5654(31)+2.0752(32)−2.0752(34)−6.9030(35)+6.9030(36)+1.5422(38)−1.5422(39) +3.8196(40)−0.0815(42)−3.7381(44)−1.0892(45)+0.8629(47)+0.8263(49)+3.0267(50) −3.0267(51)−0.1389(57)+0.1389(58)−5.0339(62)+3.6691(64)+2.3648(68)+3.4559(88) −1.8665(90)−1.5894(92)−4.5428(96)+4.5428(98)−2.5730(101)+2.5739(103)+2.8546(104) −2.8546(106)+1.5213(109)−1.5213(111)−3.8497(124)+3.8497(126)−0.4915(127)+0.4915(128) +0.9501(130)−0.9501(131)+0.2442(134)−0.2442(136)−1.5065(141)+0.5911(142)+0.9154(143) +1.1157(145)−0.7933(146)+0.7933(148)−1.1157(149)+0.3441(153)−0.3441(154)−0.5905(160) +0.5905(162).

Longitude equation.

75. 0=+34.5988−4.5578(1)+4.5578(2a)−8.9297(7)+8.9297(9)+2.7166(10)−2.7166(11)+7.2137(12)−7.2137(14) −2.4183(15)+2.4183(16)−8.4018(17)+8.4018(19)+0.1782(20)−0.1782(21)+7.8908(22) −7.8908(24)−1.3498(25)+1.3498(26)−2.5692(27)+2.5692(29)+0.5331(30)−0.5331(31) +7.5654(32)−7.5654(34)+3.4831(35)−3.4831(36)−10.0506(38)+10.0506(39)+3.2840(40) +0.1284(42)−3.4133(44)−4.5431(45)−1.4708(47)+6.0139(49)+0.4805(50)−0.4805(51) +9.5245(57)−9.5245(58)+1.1575(62)−4.5492(64)+3.3017(68)−0.3106(88)+3.4400(90) −3.1294(92)+0.3204(96)−0.3204(98)−0.8606(101)+0.8606(103)−0.2169(104)+0.2169(106) +3.2549(109)−3.2549(111)+3.1729(124)−3.1729(126)−2.9551(127)+2.9551(128)−0.3595(130) +0.3595(131)+3.4814(134)−3.4814(136)+0.5877(141)−2.0632(142)+1.4755(143)+0.7762(145) −0.0088(146)+0.0088(148)−0.7762(149)+1.0828(153)−1.0828(154)+1.4073(160)−1.4073(162).

COMPUTED CORRECTIONS TO OBSERVED DIRECTIONS.

A least-squares solution of the preceding condition equations resulted in the following corrections to the observed directions:

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	+0.221	41	−0.070	86	−0.364	126	−0.564
2	− .370	42	+ .013	87	+ .253	127	+ .470
2a	+ .149	43	+ .491	88	+ .058	128	+ .536
3	+ .643	44	− .336	89	+ .664	129	+ .437
4	− .156	45	− .460	90	− .455	130	+ .900
5	− .487	46	+ .220	91	− .121	131	− .945
6	+ .619	47	+ .376	92	− .146	132	+ .502
6a	+ .737	48	− .033	93	+ .245	133	− .069
7	− .069	49	− .103	94	+ .345	134	− .211
8	− .000	50	− .604	95	− .590	135	− .991
9	−1.227	51	+ .590	96	+ .060	136	+ .845
10	+ .178	52	+ .104	97	− .407	137	− .580
11	− .096	53	− .271	98	+ .557	138	+ .366
12	− .022	54	+ .236	99	− .365	139	+ .214
13	+ .285	55	− .114	100	− .200	140	− .413
14	− .350	56	− .032	101	+ .000	141	− .927
15	+ .067	57	− .039	102	+ .054	142	+ .440
16	+ .112	58	+ .122	103	+ .302	143	− .129
17	+ .507	59	+ .068	104	− .585	144	+1.029
18	− .877	60	+ .164	105	− .055	145	− .399
19	− .409	61	− .231	106	+ .604	146	+ .213
20	+ .344	62	− .529	107	+ .086	147	+ .445
21	− .514	63	− .394	108	− .008	148	+ .111
22	− .200	64	− .671	109	+ .216	149	− .370
23	+ .535	65	+1.092	110	− .193	150	+ .115
24	− .163	66	− .126	111	− .155	151	+ .919
25	+ .163	67	+ .152	112	− .202	152	− .211
26	+ .046	68	− .177	113	+ .846	153	− .753
27	+ .473	69	− .246	114	− .144	154	− .070
28	− .853	70	− .040	115	− .166	155	+ .028
29	+ .164	71	+ .114	116	− .161	156	+ .634
30	+ .554	72	− .082	117	+ .329	157	+ .470
31	− .462	73	+ .110	118	− .682	158	− .340
32	− .208	74	− .102	119	+ .137	159	− .782
33	− .087	75	− .040	120	+ .147	160	−1.244
34	+ .203	76	− .141	121	+ .374	161	− .649
35	− .647	77	+ .106	122	+ .298	162	+ .070
36	+ .468	78	+ .075	123	− .289	162a	+1.824
37	+ .161	79	− .121	124	− .210	163	+ .184
38	+ .202	80	+ .249	125	− .660	163a	− .128
39	− .188	81	− .129			164	− .055
40	− .098	82	+ .078				
		83	+ .472				
		84	− .370				
		85	− .066				

The maximum correction to an observed direction is $+1''.99$.

The probable error of an observed direction is given by the formula:

$$d = 0.674\sqrt{\frac{\Sigma v^2}{c}}$$

in which Σv^2 is the sum of the squares of the corrections to directions and c is the number of conditions. The probable error of an observed direction resulting from the figure adjustment for this arc of precise triangulation is $\pm 0''.26$.

CORRECTIONS TO ANGLES AND CLOSURES OF TRIANGLES.

The correction to each angle is the algebraic difference 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 precise 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.
	"	"	° ' "	"
Vale	+1.13		142 28 49.50	
Dry	−0.12	+1.53	22 32 09.30	4.23
Squaw	+0.52		14 59 05.43	
Freezeout	+0.31		44 25 01.32	
Dry	−0.69	−0.71	52 54 45.70	5.29
Vale	−0.33		82 40 18.27	
Freezeout	−0.32		70 06 08.66	
Dry	−0.81	−1.20	75 26 55.00	15.13
Squaw	−0.07		34 27 11.47	
Freezeout	−0.63		25 41 07.34	
Vale	−0.80	−2.02	134 50 52.23	5.61
Squaw	−0.59		19 28 06.04	
Star	−0.70		33 10 17.78	
Dry	+0.01	−0.89	22 11 06.19	5.34
Freezeout	−0.20		124 38 41.37	
Beulah	−0.55		76 48 09.15	
Dry	−1.16	−1.64	52 54 15.36	5.93
Freezeout	+0.07		50 17 41.42	
Beulah	+0.16		123 11 27.44	
Dry	−1.17	−0.59	30 43 09.17	5.71
Star	+0.74		26 05 29.10	
Beulah	+0.39		46 23 18.29	
Freezeout	−0.27	+0.16	74 20 59.95	5.12
Star	+0.04		59 15 46.88	
Riddle	+0.38		33 42 56.06	
Beulah	−1.39	−1.55	31 35 48.32	6.80
Star	−0.54		114 41 22.42	
Crow	−0.12		70 09 39.57	
Beulah	−0.91	−0.72	51 21 58.74	5.61
Star	+0.31		58 28 27.30	
Crow	+0.31		138 52 54.66	
Beulah	+0.47	+0.99	19 46 10.41	3.97
Riddle	+0.21		21 20 58.90	
Crow	+0.43		68 43 15.00	
Star	−0.86	+0.16	56 12 55.11	5.16
Riddle	+0.59		55 03 54.96	
Jack	−0.83		45 55 54.04	
Crow	−1.32	−3.00	34 55 22.31	4.42
Riddle	−0.85		99 08 48.07	
Burns	+1.12		39 28 58.25	
Crow	−0.31	+0.97	95 25 43.96	6.23
Riddle	+0.16		45 05 24.02	
Burns	+0.81		69 54 59.50	
Crow	+1.01	+2.30	60 30 21.65	7.48
Jack	+0.48		49 34 46.24	
Burns	−0.30		30 26 01.35	
Riddle	−1.02	−1.67	54 03 24.04	5.67
Jack	−0.35		95 30 40.28	
Juniper	+0.16		38 57 37.42	
Burns	+0.04	+0.31	58 07 42.48	12.21
Jack	+0.11		82 54 52.31	
Wagontire	+0.68		45 30 27.97	
Burns	−0.35	+0.41	84 30 23.36	9.74
Jack	+0.08		49 59 18.41	
Wagontire	+0.84		115 53 07.04	
Burns	−0.39	+0.44	26 22 40.88	6.86
Juniper	−0.01		37 44 18.94	
Wagontire	+0.16		70 22 39.07	
Jack	+0.03	+0.34	32 55 33.90	9.33
Juniper	+0.15		76 41 56.36	
Grays	+0.30		139 16 59.37	
Wagontire	−0.41	−0.03	5 04 18.58	0.44
Juniper	+0.08		35 38 42.49	
Diablo	+0.14		36 12 46.20	
Wagontire	−0.07	−0.33	43 07 28.35	5.02
Grays	−0.40		100 39 50.47	
Diablo	−0.14		42 17 28.53	
Wagontire	−0.48	−0.89	48 11 46.93	6.13
Juniper	−0.27		89 30 50.07	
Diablo	−0.28		6 04 42.33	
Grays	+0.10	−0.53	120 03 10.10	0.07
Juniper	−0.35		53 52 08.18	
White	+0.32		75 59 29.04	
Diablo	+0.82	+1.28	62 51 27.14	4.09
Juniper	+0.13		41 09 07.91	
Round	+0.50		49 04 51.16	
Diablo	+0.49	+0.03	80 36 25.90	6.82
Juniper	−0.36		50 18 49.76	
Round	−0.47		29 02 05.45	
Diablo	−0.33	−0.94	17 44 58.76	1.43
White	−0.14		133 12 57.22	
Round	+0.96		20 02 45.70	
White	−0.17	+0.29	150 47 33.75	1.29
Juniper	−0.50		9 09 41.84	

Table of triangles—Continued.

Station.	Correction to angles from figure adjustment.	Error of closure of triangle.	Corrected spherical angles.	Spherical excess.
	"	"	° ′ "	"
Sharp	−0.21	+0.84	105 16 06.67	1.69
Diablo	+0.54		58 23 30.51	
Juniper	+0.51		16 20 24.51	
Sharp	+0.06	+0.31	82 33 03.49	2.31
Juniper	−0.37		24 48 43.41	
White	+0.62		72 38 15.41	
Sharp	+0.15	+0.13	172 10 49.84	0.10
White	−0.30		3 21 13.63	
Diablo	+0.28		4 27 56.63	
Paisley north base.	+0.15	+0.06	124 24 52.77	0.78
Diablo	−0.40		34 12 14.30	
White	+0.31		21 22 53.62	
Paisley north base.	−0.10	−0.03	68 25 49.67	0.37
Diablo	−0.12		38 40 11.02	
Sharp	+0.19		72 53 59.68	
Paisley north base.	+0.25	+0.22	55 59 03.10	0.51
Sharp	−0.04		99 16 50.16	
White	+0.01		24 44 07.25	
Paisley south base.	+0.37	+0.30	37 12 21.35	0.37
Paisley north base.	+0.22		82 45 11.19	
Sharp	−0.20		60 02 27.83	
Paisley south base.	−0.01	−0 89	122 21 27.20	0.40
Paisley north base.	−0.03		26 46 08.00	
White	−0.85		30 52 25.02	
Paisley south base.	−0.38	−1.06	85 09 05.94	0.54
Sharp	+0.15		39 14 22.33	
White	−0.83		55 36 32.27	
Hart	+0.33	−2.26	36 25 20.26	8.34
Round	−0.42		98 17 17.56	
Diablo	−2.17		45 17 30.52	
Hart	+0.31	+0.59	69 40 52.92	8.18
Round	−0.92		49 12 26.40	
Juniper	+1.20		61 06 48.86	
Hart	−0.02	+3.48	33 15 32.66	6.66
Diablo	+2.66		35 18 55.38	
Juniper	+0.84		111 25 38.62	
Drake	−0.94	−1.98	116 56 07.05	3.00
Round	+0.08		32 15 26.98	
Hart	−1.12		30 48 29.06	
Crane	−0.37	−0.43	67 30 18.27	7.44
Round	+0.45		62 06 44.67	
Hart	−0.51		50 23 04.50	
Crane	−0.41	+0.07	40 26 27.58	2.41
Round	+0.38		29 51 17.70	
Drake	+0.10		109 42 17.13	
Crane	+0.04	+1.48	27 03 50.09	1.94
Drake	+0.83		133 21 35.82	
Hart	+0.61		19 34 35.43	
Cougar	+0.43	+0.52	103 55 00.01	2.39
Round	−0.04		50 56 33.91	
Crane	+0.13		25 08 28.47	

Station.	Correction to angles from figure adjustment.	Error of closure of triangle.	Corrected spherical angles.	Spherical excess.
	"	"	° ′ "	"
Yonna	−0.34	−0.61	35 22 39.97	8.63
Round	+0.21		98 34 54.34	
Crane	−0.48		46 02 34.32	
Yonna	−0.44	−0.78	18 49 46.43	2.82
Round	+0.25		47 38 20.43	
Cougar	−0.59		113 31 55.96	
Yonna	+0.10	−0.35	16 32 53.54	3.42
Cougar	+0.16		142 33 04.03	
Crane	−0.61		20 54 05.85	
Dog	+0.06	+0.21	79 38 12.06	2.21
Cougar	+0.01		69 10 48.96	
Crane	+0.14		31 11 01.19	
Lakeview bench mark M 16.	0.00	−0.44	109 05 10.82	1.29
Crane	+0.05		46 19 40.39	
Dog	−0.49		24 35 10.08	
Lakeview bench mark M 16.	+0.49	+1.20	154 28 05.06	0.49
Crane	−0.09		15 08 39.20	
Cougar	+0.80		10 23 16.23	
Lakeview bench mark M 16.	+0.49	+1.85	45 22 54.24	1.41
Dog	+0.55		55 03 01.98	
Cougar	+0.81		79 34 05.19	
Hoffman	−0.75	+0.31	27 58 15.32	10.72
Yonna	+1.13		104 30 48.60	
Cougar	−0.07		47 31 06.80	
Hoffman	+1.09	+3.40	48 24 33.78	18.87
Yonna	+1.03		87 57 55.06	
Crane	+1.28		43 37 50.03	
Hoffman	+1.84	+2.74	20 26 18.46	11.57
Cougar	+0.24		95 01 57.23	
Crane	+0.67		64 31 55.88	
Aspen	+0.94	+0.74	61 37 03.49	13.54
Yonna	−0.03		72 37 53.62	
Hoffman	−0.17		45 45 16.43	
Goosenest	−0.51	+0.18	39 40 45.12	11.28
Aspen	+0.79		100 54 45.92	
Yonna	−0.10		39 24 40.24	
Goosenest	+0.85	+0.13	92 20 38.71	0.69
Aspen	−0.15		39 17 42.43	
Hoffman	−0.57		48 12 48.55	
Goosenest	+1.37	+0.69	52 48 53.60	11.95
Yonna	+0.07		33 13 13.37	
Hoffman	−0.74		93 58 04.98	
Whaleback	−0.03	+0.85	96 54 07.55	2.80
Goosenest	−0.57		60 11 44.11	
Hoffman	+1.45		22 54 11.14	
Eddy	−0.43	−0.09	24 55 11.81	1.93
Goosenest	+1.16		43 35 59.38	
Whaleback	−0.82		111 28 50.74	
Grizzly	−0.54	+0.50	47 22 13.77	3.86
Eddy	+0.81		64 06 28.94	
Whaleback	+0.23		68 31 21.15	

Table of triangles—Continued.

Station.	Correction to angles from figure adjustment.	Error of closure of triangle.	Corrected spherical angles.	Spherical excess.	Station.	Correction to angles from figure adjustment.	Error of closure of triangle.	Corrected spherical angles.	Spherical excess.
	″	″	° ′ ″	″		″	″	° ′ ″	″
Grizzly......	+0.68	−0.55	51 56 25.27	5.61	Bally........	+0.31	+2.62	18 42 56.75	4.86
Whaleback..	+0.61		83 05 40.55		Boliver......	+2.47		96 22 11.42	
Hoffman....	−1.84		44 57 59.79		Eddy........	−0.16		64 54 56.69	
Boliver......	+1.31	−0.46	39 49 57.02	6.82	Bally........	+0.07	+2.63	51 32 37.79	12.11
Whaleback..	−0.10		78 47 01.73		Boliver......	+1.75		70 58 41.55	
Grizzly......	−1.67		61 23 08.07		Grizzly......	+0.80		57 28 52.77	
Boliver......	+0.59	−0.99	14 26 27.15	1.01	Bally........	−0.24	+0.04	32 49 41.03	9.20
Whaleback..	−0.33		10 15 40.58		Eddy........	+0.61		75 40 41.10	
Eddy........	−1.25		155 17 53.28		Grizzly......	−0.33		71 29 47.07	
Boliver......	+0.72	+0.03	25 23 29.87	1.95					
Eddy........	+0.44		140 35 37.78						
Grizzly......	−1.13		14 00 54.30						

ACCURACY OF OBSERVATIONS.

The maximum correction to any angle is +2″.66, to the angle at Diable between Juniper and Hart. The average closing error, taken without regard to sign, for the 69 closed triangles of this arc is 0″.92, while the maximum closing error is 3″.40. The general instructions for precise triangulation require that the average closing error shall not be over 1″.00, while the maximum closing error shall seldom exceed 3″.00. In this triangulation only two triangles have closing errors in excess of this.

The following table gives statistics for closures of triangles and related errors for this arc of precise triangulation. The mean error of an angle was computed from the formula:

$$a=\sqrt{\frac{\Sigma\Delta^2}{3n}}$$

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.

STATISTICS SHOWING ACCURACY OF TRIANGULATION.

Total number of triangles..	69
Number of triangles with plus closures...........................	40
Number of triangles with minus closures..........................	29
Average closure of triangle......................................	0″.92
Maximum closure of triangle......................................	3.40
Mean error of an angle...	±0.72
Probable error of an observed direction..........................	±0.26

For purposes of comparison a table showing the closing errors of a number of other arcs of precise triangulation is given below:

	Average closing error.
Ninety-eighth meridian arc, Alice, Tex., to Colombres, Mexico	0."63
Texas-California arc	0. 90
Ninety-eighth meridian arc	0. 92
California-Oregon arc (in this publication)	0. 92
One hundred and fourth meridian arc	0. 99
Rio Grande arc	1. 01
Transcontinental arc	1. 06
Utah-Washington arc	1. 12
Eastern oblique arc	1. 19
California-Washington arc	1. 22

It will be noted from the above that the arc of precise triangulation considered in this publication, when judged by the criterion of average closure of triangles, ranks high as compared with other arcs of the same order, tying for third place in a comparison of 10 arcs. If we apply the more rigid test for accuracy, which is indicated by the probable error, *d*, of an observed direction, we find that the value given on page 46 of this publication, namely ±0."26, would be placed with the sixth and seventh values in a table of 66 sections of triangulation arranged in order of accuracy. This table is shown on pages 79 and 80 of Special Publication No. 19.

COMPUTATION, ADJUSTMENT, AND ACCURACY OF THE ELEVATIONS.

In the main scheme of the triangulation vertical angles were measured at both ends of most of the lines; these are called *reciprocal* observations. For nearly all lines to intersection points *nonreciprocal* observations were made; that is, the vertical angles were measured at the occupied point on the intersection point, but not in the reverse direction.

In computing the difference of elevation between two points where corresponding reciprocal observations were made, the observed double zenith distances were first reduced to the zenith distances of the line connecting the two station marks, and then the difference of elevation of the station marks was computed by the formula:

$$h_2 - h_1 = s\left(1+\frac{h_1}{\rho}\right)\tan\left(\frac{\zeta_2-\zeta_1}{2}\right)\left[1+\frac{s}{2\rho}\tan\left(\frac{\zeta_2-\zeta_1}{2}\right)\right]\left[1+\frac{s^2}{12\rho^2}\right].$$

In this formula (h_2-h_1) is the difference of elevation, ζ_2 and ζ the reduced zenith distances at the stations, s the length and ρ the mean radius of curvature of the line connecting the stations. This formula will be found reduced to an easily handled working form with prepared tables on pages 207 et seq. of U. S. Coast and Geodetic Survey Special Publication No. 28, Application of Least Squares to Triangulation.

The least-squares adjustment of the main scheme of vertical angles involved 27 new stations and 7 stations whose elevations, determined in previous seasons by spirit leveling or by vertical angles, were already known and were held as fixed. There were formed 76 observation equations, requiring the solution of 29 normal equations. From this computation was derived the probable error of ±1.26 meters for a difference of elevation over a line of length 31.7 kilometers (19.7 miles), this being the length of line corresponding to an observation of weight unity. The probable error for any adjusted difference of elevation may be determined by assuming it and the probable error of an observation of weight unity to be in the same proportion as the lengths of the lines involved.

In computing the difference of elevation determined by a nonreciprocal observation, the observed zenith distance was either reduced to the zenith distance at the station mark or else correction for height of instrument above mark was applied to the derived difference of elevation. The formula used for computing the difference of elevation is:

$$h_2-h_1=sAR\frac{\cos\left[\zeta_1-(\frac{1}{2}-m)\frac{s}{\rho\sin 1''}\right]}{\sin\left[\zeta_1-(\frac{1}{2}-m)\frac{s}{\rho\sin 1''}-\frac{1}{2}\frac{s}{\rho\sin 1''}\right]}$$

where $A=1+\frac{h_1}{\rho}$, the correction for elevation of the known station, R is the reduction factor from arc to chord, and m is the coefficient of refraction derived from the computation of the reciprocal observations at the same station. The other symbols have the same meaning as in the formula for reciprocal observations given above. A more complete explanation of this formula together with a working form and tables is given in Special Publication No. 28 referred to above.

The datum for all the elevations is mean sea level. The stations are in three classes: First, those fixed by direct connection with precise level elevations, the elevations of which 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 meter to ±1.5 meters; and, third, the supplementary and intersection points whose elevations, with a few exceptions, were determined by nonreciprocal zenith distance observations from stations of the main scheme. The few exceptions are where reciprocal observations were made along lines connecting main scheme stations with occupied supplementary stations. These elevations are of varying degrees of accuracy, some of them being subject to probable errors as great as ±3 meters. They are here given to the public because they are probably the best values available for the elevations of the points named, many of which are mountain peaks, and because they are undoubtedly of sufficient accuracy for general geographic and mapping purposes.

The table of elevations is given in Part I. (See p. 15.)

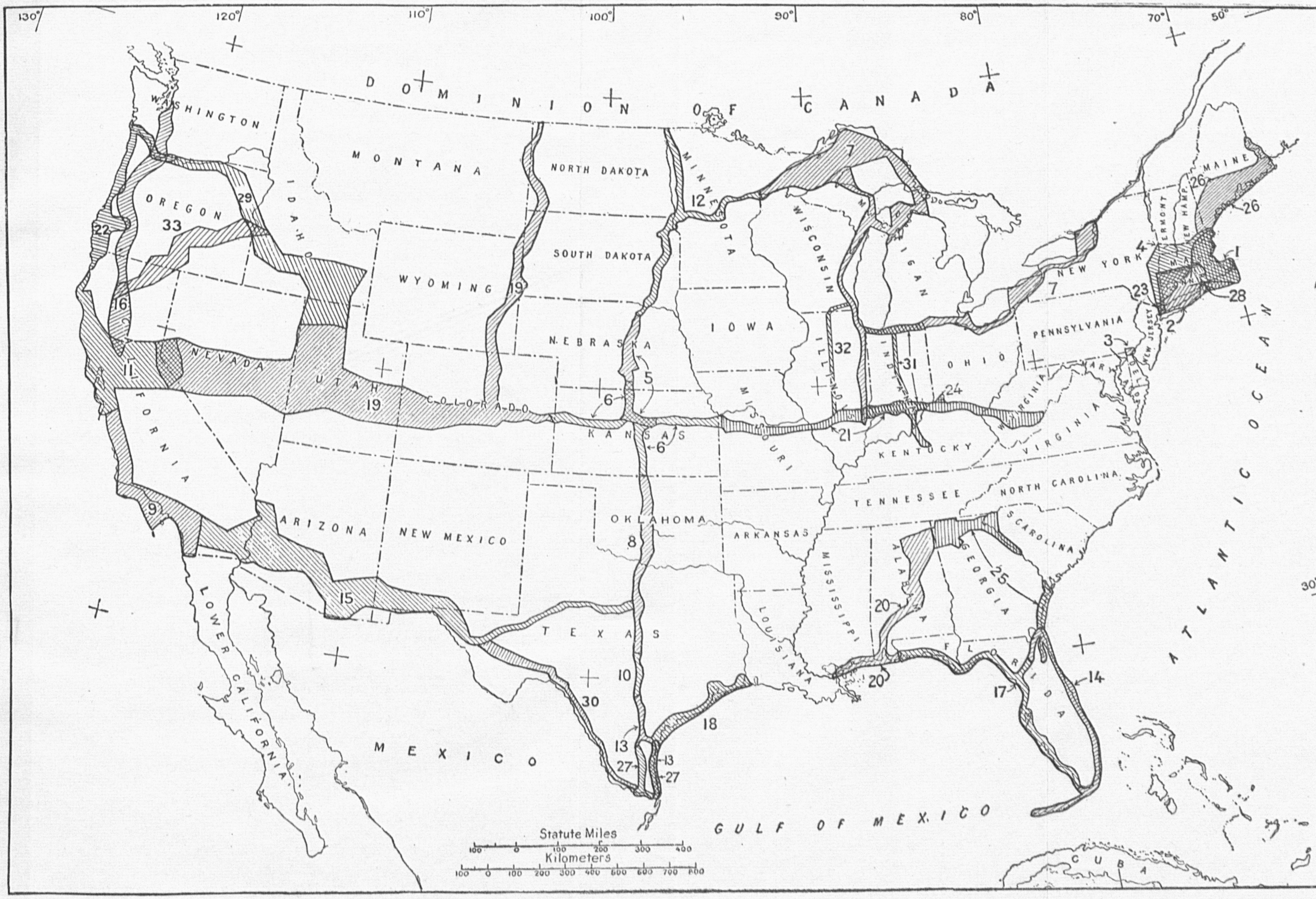

FIG. 7. INDEX MAP SHOWING AREAS IN THE UNITED STATES COVERED BY PUBLISHED TRIANGULATION AND TRAVERSE WHICH HAVE BEEN RIGIDLY COMPUTED ON THE NORTH AMERICAN DATUM.

1. Appendix 8, Report for 1885 (superseded by Special Publication No. 76).
2. Appendix 8, Report for 1888.
3. Appendix 8, Report for 1893.
4. Appendix 10, Report for 1894 (superseded by Special Publication No. 76).
5. Appendix 6, Report for 1901.
6. Special Publication No. 70.
7. Appendix EEE, Annual Report of the Chief of Engineers, 1902.
8. Appendix 4, Report for 1903 (superseded by S. P. No. 88).
9. Appendix 9, Report for 1904.
10. Appendix 5, Report for 1905 (superseded by S. P. No. 88).
11. Appendix 5, Report for 1910.
12. Appendix 4, Report for 1911.
13. Appendix 5, Report for 1911 (superseded by S. P. No. 88).
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. Special Publication No. 54.
28. Special Publication No. 62.
29. Special Publication No. 74.
30. Special Publication No. 78.
31. Special Publication No. 79.
32. Special Publication No. 86.
33. Special Publication No. 84.

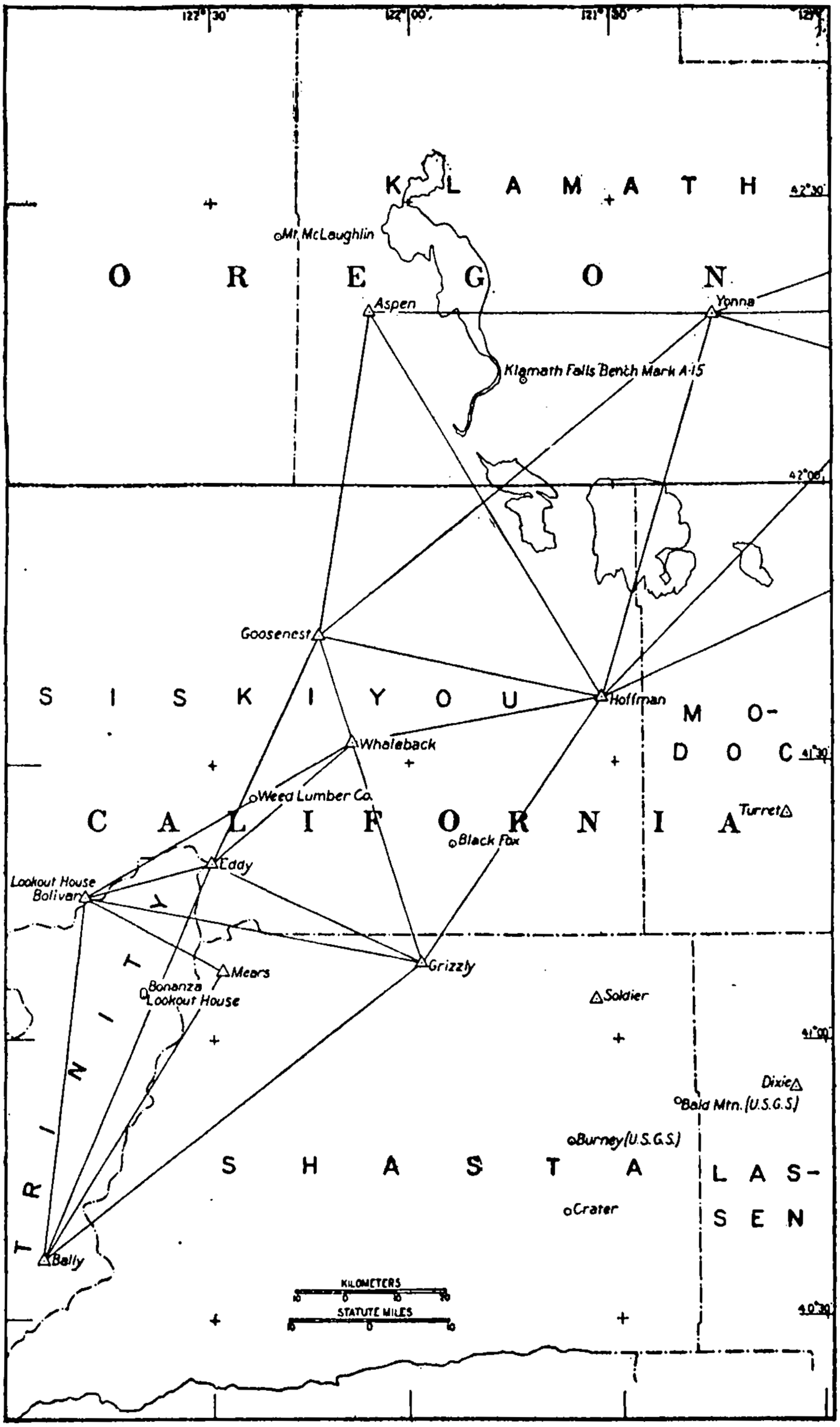

FIG. 8.—Triangulation, vicinity of Redding, Calif., to vicinity of Klamath Falls, Oreg.

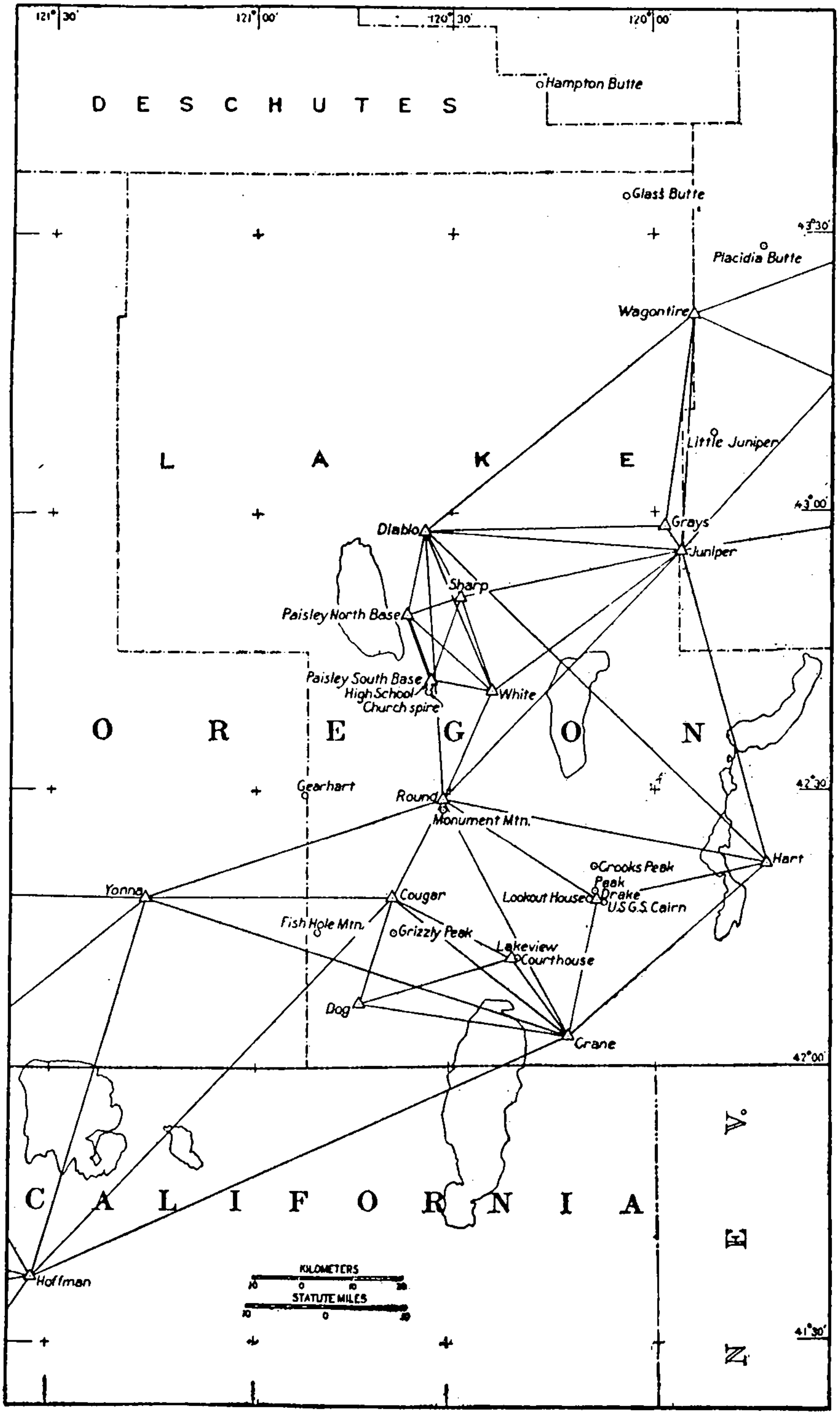

FIG. 9.—Triangulation, vicinity of Klamath Falls, Oreg., to vicinity of Alkali Lake, Oreg.

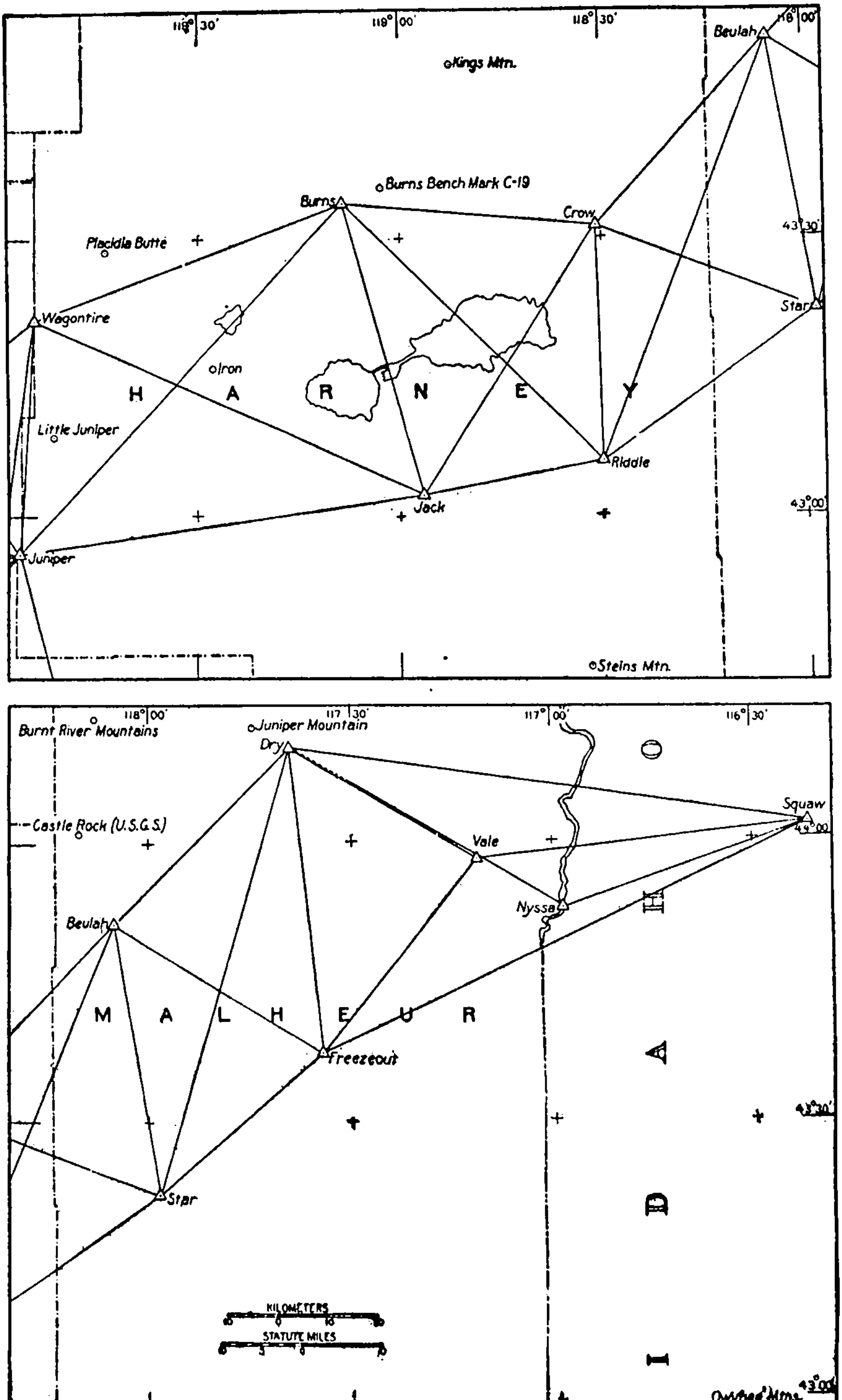

FIG. 10.—Triangulation, vicinity of Alkali Lake, Oreg., to Idaho-Oregon State line.

INDEX TO POSITIONS, DESCRIPTIONS, ELEVATIONS, AND SKETCHES.

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