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UTAH-WASHINGTON ARC OF PRECISE TRIANGULATION

BY

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Special Publication No. 74

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UTAH-WASHINGTON ARC OF PRECISE TRIANGULATION.

By C. V. Hodgson, *Assistant Chief, Division of Geodesy, U. S. Coast and Geodetic Survey.*

PART I.

GENERAL STATEMENT.

This publication gives the results for the arc of precise triangulation which extends from the vicinity of Great Salt Lake, Utah, northward into Idaho, and then westward and northwestward to the Columbia River and to a junction near Portland, Oreg., with the California-Washington arc of adjusted precise triangulation. The region through which this arc runs and the approximate location of the control points in the scheme can be most readily seen by referring to the index sketch at the back of this publication.

The tabulated arrangement of data follows the general plan adopted by the U. S. Coast and Geodetic Survey some years ago. No attempt has been made to secure originality in language in the explanation of the tables. On the contrary, in some paragraphs the language is identical with that found in previous publications of this Bureau, and it was not considered necessary to indicate such paragraphs as quotations.

The writer made all of the observations for the triangulation and azimuth along this arc, the latitude and longitude observations were made by J. E. McGrath and W. B. Fairfield, hydrographic and geodetic engineers, and the office computations and adjustments of the triangulation were made by the members of the division of geodesy at the Washington office of the U. S. Coast and Geodetic Survey. The compilation of the tabulated data and the discussion of methods of adjustment were made by W. F. Reynolds, chief computer.

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—viz, 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 one part in 25 000, in primary triangulation one part in 10 000, and in secondary triangulation one part in 5000. 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 measured sum of the 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.

ARRANGEMENT OF SUBJECT MATTER.

In Part I are given such data for the Utah-Washington 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 12, 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 tables on pages 14 to 21. Points of precise accuracy are found in a separate table from those of lower grades. (2) Following the geographic positions is a table, page 22, giving the trigonometric elevations of all points, referred to mean sea level. A note on page 22 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 23 to 32. (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 33 to 40.

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.

Concerning the actual use of the table of geographic positions, it is necessary to explain the "North American datum," which serves as the basis for all the geodetic values in this report.

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

Owing to the international character of the datum adopted by the three countries, the Superintendent of the U. S. Coast and Geodetic Survey changed its designation from the "United States standard datum" to 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 he 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 astronomical 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 to-day. 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 its 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 of one of them, in latitude and longitude, on the North American datum. 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 the preceding paragraph 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 the modern "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.

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. 7); 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 this table being derived from the corresponding logarithm and the lengths in feet in turn derived from the lengths in meters by the aid of the conversion tables on pages 33–40. 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. 11), depend upon the adjusted lengths of the lines Ogden-Pilot of the thirty-ninth parallel triangulation, and Larch-Red of the California-Washington arc, and upon the measured length of the Stanfield 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 $\frac{1}{2000}$ 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 $\frac{1}{670\,000}$ 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 14, the azimuth from Oxford to Putnam is 177° 53′ 29″.64, while the back azimuth, or the azimuth from Putnam to Oxford, is 357° 52′ 11″.08.

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. Following that is an index map showing the triangulation stations in the area covered by this publication. The other two are detailed maps showing the scheme of triangulation plotted by latitudes and longitudes on a polyconic projection.

The second index map shows all the territory covered by this arc of triangulation, together with county boundaries and the names and approximate location of all points determined. From this can be obtained the names of all points in any portion of the area.

Having thus found the names of the points desired, 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 are known.

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 publication: of the U. S. Coast and Geodetic Survey and of other organizationss

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.
Report on triangulation of Greater New York.
Report on a plan of sewerage for the City of Cincinnati.
Appendix EEE, pages 2905–3031, Annual Report of the Chief of Engineeres, 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).	Distance. Meters.	Distance. Feet.
Principal points.	° ′ ″	° ′ ″	° ′ ″				
Cache, 1897	42 11 09.402	305 52 42.13	127 03 42.35	Ogden Peak	5.2652158	184168.69	604226.8
	113 39 37.544	15 09 35.58	194 53 00.41	Pilot Peak	5.1268066	133908.02	439329.9
Oxford, 1897	42 16 11.766	351 20 05.13	171 28 42.32	Ogden Peak	5.0797571	120159.22	394222.4
	112 05 49.972	50 36 14.43	229 17 18.29	Pilot Peak	5.3333520	215452.72	706864.4
		86 23 27.06	265 20 24.74	Cache	5.1118964	129388.72	424502.8
Big Butte, 1915	43 23 47.288	328 32 55.09	149 10 38.23	Oxford	5.1649605	146204.41	479672.3
	113 01 18.580	21 27 03.65	201 01 01.81	Cache	5.1591658	144266.61	473314.7
Big Butte reference mark, 1915.[1]	43 23 47.262	107 05 04	287 05 04	Big Butte	0.43457	2.72	8.9
	113 01 18.464						
Putnam, 1915	42 54 49.648	357 52 11.08	177 53 29.64	Oxford	4.8547348	71570.62	234811.3
	112 07 46.056	57 46 47.58	236 44 40.34	Cache	5.1746207	149492.96	490461.5
		126 45 38.56	306 09 01.23	Big Butte	4.9554074	90241.73	296068.1
MiddleButte, 1915	43 29 27.969	322 10 21.84	142 35 20.57	Putnam	4.9083289	80970.89	265652.0
	112 44 15.303	65 32 29.72	245 20 46.07	Big Butte	4.4030996	25298.78	83001.1
Middle Butte reference mark, 1915.[1]	43 29 27.950	261 53 55	81 53 55	Middle Butte	0.62428	4.21	13.8
	112 44 15.489						
Caribou, 1915	43 05 37.440	34 25 16.52	214 53 17.54	Oxford	5.0489275	111925.10	367207.6
	111 18 39.407	73 36 19.32	253 02 49.55	Putnam	4.8430413	69669.27	228573.3
		111 21 35.72	290 22 53.81	Middle Butte	5.0931008	123908.40	406522.8
Caribou reference mark, 1915.[1]	43 05 37.142	192 37 09	12 37 09	Caribou	0.97451	9.43	30.9
	111 18 39.498						
Kimama, 1915	42 50 49.583	230 57 51.23	51 36 13.35	Big Butte	4.9893370	97574.64	320126.1
	113 57 26.397	341 31 18.81	161 43 21.16	Cache	4.8886841	77389.88	253903.3
Kimama reference mark, 1915.[1]	42 50 49.267	174 39	354 39	Kimama	0.99078	9.79	32.1
	113 57 26.357						
Picabo, 1915	43 16 50.968	261 38 48.04	82 25 25.71	Big Butte	4.9671629	92717.74	304191.5
	114 09 14.915	341 26 36.62	161 46 42.79	Cache	5.1077858	128169.82	420503.8
		341 31 43.90	161 39 47.69	Kimama	4.7056934	50780.08	166601.0
Picabo reference mark, 1915.[1]	43 16 50.783	166 13	346 13	Picabo	0.76938	5.88	19.3
	114 09 14.853						
Flat, 1915	42 43 48.702	199 03 28.85	19 14 08.44	Picabo	4.8112545	64752.19	212441.1
	114 24 52.624	250 42 09.32	71 00 47.60	Kimama	4.5977603	39605.94	129940.5
		314 00 19.56	134 30 52.42	Cache	4.9376267	86621.70	284191.4
Flat reference mark, 1915.[1]	42 43 48.783	315 33	135 33	Flat	0.54531	3.51	11.5
	114 24 52.732						

[1] No check on this position.

GEOGRAPHIC POSITIONS—Continued.

Station.	Latitude and longitude.	Azimuth.	Back azimuth.	To station.	Distance.		
					Log (meters).	Meters.	Feet.
Principal points—Continued.	° ′ ″	° ′ ″	° ′ ″				
Green, 1915	43 12 51.263	262 53 06.37	83 24 15.06	Picabo	4.7921968	61972.19	203320.4
	114 54 42.307	322 48 22.59	143 08 42.53	Flat	4.8283508	67352.05	220970.8
Green reference mark, 1915.[1]	43 12 51.286	298 05	118 05	Green	0.18752	1.54	5.1
	114 54 42.367						
Camas, 1915	43 14 57.954	267 38 19.00	88 30 55.68	Picabo	5.0167434	103930.60	340979.0
	115 26 00.591	275 05 29.47	95 26 56.00	Green	4.6290466	42564.41	139646.7
		304 25 07.81	125 06 48.93	Flat	5.0049816	101153.66	331868.3
Camas reference mark, 1915.[1]	43 14 58.181	327 10	147 10	Camas	0.92117	8.34	27.4
	115 26 00.791						
Blue, 1915	42 41 15.461	176 12 11.16	356 10 06.01	Camas	4.7962256	62549.75	205215.3
	115 22 56.985	213 07 54.47	33 27 09.18	Green	4.8450189	69987.24	229616.5
		266 15 33.18	86 54 56.55	Flat	4.9000168	79435.89	260615.9
Blue reference mark, 1915.[1]	42 41 15.301	215 16 26	35 16 26	Blue	0.78032	6.03	19.8
	115 22 57.138						
Mountain Home, 1915.	43 07 44.382	237 33 38.75	57 44 18.99	Camas	4.3980229	25004.77	82036.5
	115 41 36.050	332 31 17.89	152 43 59.79	Blue	4.7420413	55213.00	181144.7
Mountain Home reference mark, 1915.[1]	43 07 43.952	244 02 53	64 02 54	Mountain Home.	1.48130	30.29	99.4
	115 41 37.255						
Silver, 1915	42 58 51.394	252 54 20.34	73 44 30.34	Camas	5.0167672	103936.29	340997.6
	116 39 24.485	257 50 12.71	78 29 40.65	Mountain Home.	4.9041598	80197.31	263114.0
		286 55 56.66	107 47 55.70	Blue	5.0380822	109164.70	358151.2
Silver reference mark, 1915.[1]	42 58 51.046	157 13 56	337 13 56	Silver	1.06558	11.63	38.2
	116 39 24.286						
Shafer, 1915	43 46 19.294	317 24 57.73	137 52 00.39	Camas	4.8952679	78572.02	257781.7
	116 05 17.387	334 18 35.90	154 47 35.98	Blue	5.1252052	133415.17	437712.9
		27 51 57.78	207 28 31.81	Silver	4.9966744	99237.18	325580.6
Shafer reference mark, 1915.[1]	43 46 19.164	244 02 32	64 02 32	Shafer	0.96142	9.15	30.0
	116 05 17.755						
Squaw, 1915	44 01 59.410	318 04 36.08	138 18 02.52	Shafer	4.5902705	38928.76	127718.8
	116 24 40.335	9 43 36.70	189 33 27.99	Silver	5.0740070	118578.80	389037.3
Squaw reference mark, 1915.[1]	44 01 59.575	336 39 23	156 39 23	Squaw	0.74507	5.56	18.2
	116 24 40.434						
Nyssa, 1915	43 52 25.950	248 36 41.83	69 00 22.89	Squaw	4.6898679	48962.99	160639.4
	116 58 47.747	278 39 18.12	99 16 21.10	Shafer	4.8610937	72626.27	238274.7
		345 06 47.73	165 20 07.42	Silver	5.0111344	102596.93	336603.4
Nyssa, reference mark, 1915.[1]	43 52 26.212	326 53 59	146 53 59	Nyssa	0.98498	9.66	31.7
	116 58 47.983						
Iron, 1915	44 33 03.614	319 14 36.26	139 40 26.44	Squaw	4.8791878	75716.02	248411.6
	117 01 40.174	357 04 14.68	177 06 14.93	Nyssa	4.8770066	75336.70	247167.2
Iron reference mark, 1915.[1]	44 33 03.993	47 32 11	227 32 11	Iron	1.23830	17.31	56.8
	117 01 39.595						
Dry, 1916	44 10 09.309	229 45 06.82	50 11 41.41	Iron	4.8192525	65955.73	216389.8
	117 39 40.845	278 09 15.85	99 01 27.96	Squaw	5.0053347	101235.94	332138.2
		300 45 22.79	121 13 47.55	Nyssa	4.8043779	63734.99	209103.9
Dry reference mark, 1916.[1]	44 10 09.800	312 58 49	132 58 50	Dry	1.34733	22.25	73.0
	117 39 41.578						
Beaver, 1916	44 35 59.517	274 54 15.51	95 26 04.63	Iron	4.7800329	60260.53	197704.8
	117 47 00.282	348 27 58.42	168 33 05.79	Dry	4.6886683	48827.93	160196.3
Beaver reference mark, 1916.[1]	44 35 59.593	81 47 19	261 47 18	Beaver	1.21696	16.48	54.1
	117 46 59.542						

[1] No check on this position.

GEOGRAPHIC POSITIONS—Continued.

Station.	Latitude and longitude.	Azimuth.	Back azimuth.	To station.	Distance. Log (meters).	Distance. Meters.	Distance. Feet.
Principal points—Continued.	° ′ ″	° ′ ″	° ′ ″				
Maxwell, 1916	44 51 43.633	291 58 41.90	112 43 28.78	Iron	4.9586077	90909.17	298257.8
	118 05 19.532	320 11 59.64	140 24 53.27	Beaver	4.5783373	37873.66	124257.2
		336 02 01.22	156 20 00.02	Dry	4.9250985	84158.60	276110.3
Maxwell reference mark, 1916.[1]	44 51 43.899	326 37 15	146 37 15	Maxwell	0.99211	9.82	32.2
	118 05 19.778						
Medical, 1916	45 04 48.927	326 31 26.13	146 52 05.60	Iron	4.8473944	70371.11	230875.9
	117 30 58.690	21 40 43.54	201 29 25.48	Beaver	4.7589019	57410.58	188354.5
		61 58 33.56	241 34 17.05	Maxwell	4.7097375	51255.15	168159.6
Medical reference mark, 1916.[1]	45 04 47.987	242 11 06	62 11 07	Medical	1.79386	62.21	204.1
	117 31 01.206						
Fanny, 1916	45 18 30.006	326 29 16.58	146 38 20.58	Medical	4.4825066	30374.32	99653.1
	117 43 45.426	3 07 27.90	183 05 10.22	Beaver	4.8967901	78847.89	258686.8
		29 50 32.37	209 35 15.93	Maxwell	4.7566127	57096.92	187325.5
Fanny reference mark, 1916.[1]	45 18 29.833	229 12 01	49 12 01	Fanny	0.91355	8.195	26.89
	117 43 45.711						
Powder, 1916	44 55 47.749	218 39 10.64	38 57 26.98	Fanny	4.7321040	53963.99	177046.9
	118 09 32.651	323 35 01.81	143 38 00.47	Maxwell	3.9713318	9361.21	30712.6
Powder reference mark, 1916.[1]	44 55 47.827	299 56 19	119 56 19	Powder	0.68215	4.81	15.8
	118 09 32.841						
Emily, 1916	45 26 06.888	296 08 32.42	116 24 06.93	Fanny	4.5033172	31865.24	104544.5
	118 05 38.527	359 37 29.46	179 37 42.93	Maxwell	4.8041057	63695.06	208972.9
		5 13 26.09	185 10 40.01	Powder	4.7512039	56390.23	185006.9
Emily reference mark, 1916.[1]	45 26 07.422	54 32 19	234 32 18	Emily	1.45347	28.41	93.2
	118 05 37.462						
La Grande, 1916	45 19 49.467	180 05 15.10	0 05 15.68	Emily	4.0663876	11651.65	38227.1
	118 05 39.346	274 46 10.50	95 01 44.74	Fanny	4.4582264	28722.77	94234.6
La Grande reference mark No. 1, 1916.[1]	45 19 49.190	99 53 24	279 53 23	La Grande	1.69714	49.79	163.4
	118 05 37.094						
La Grande reference mark No. 2, 1916.[1]	45 19 51.907	329 58 15	149 58 17	La Grande	1.93952	87.00	285.4
	118 05 41.345						
La Grande reference mark No. 3, 1916.[1]	45 19 49.439	94 46 11	274 46 11	La Grande	1.02263	10.535	34.56
	118 05 38.864						
Birch, 1916	45 24 13.236	264 56 51.25	85 19 21.73	Emily	4.6167119	41372.51	135736.3
	118 37 14.546	325 15 20.13	145 34 58.70	Powder	4.8058181	63946.69	209798.4
Birch reference mark, 1916.[1]	45 24 13.452	350 31 29	170 31 29	Birch	0.83059	6.77	22.2
	118 37 14.597						
Big Hill, 1916	45 35 59.885	298 08 04.40	118 26 42.53	Emily	4.5869058	38628.32	126733.1
	118 31 45.699	338 32 55.12	158 48 42.09	Powder	4.9027393	79935.43	262254.8
		18 09 13.05	198 05 18.49	Birch	4.3608675	22954.48	75309.8
Big Hill reference mark, 1916.[1]	45 36 01.784	10 24 13	190 24 13	Big Hill	1.77539	59.62	195.6
	118 31 45.202						
Alkali (U.S.G.S.), 1916.	45 32 04.100	260 17 00.07	80 40 49.68	Big Hill	4.6436598	44020.99	144425.5
	119 05 07.743	291 37 57.64	111 57 50.42	Birch	4.5926882	39146.07	128431.7
Alkali reference mark, 1916.[1]	45 32 04.097	91 43	271 43	Alkali	0.49969	3.16	10.4
	119 05 07.597						
Laurila, 1916	45 49 14.589	305 54 05.79	126 12 41.04	Big Hill	4.6199825	41685.26	136762.4
	118 57 43.700	329 59 46.65	150 14 25.03	Birch	4.7280138	53458.14	175387.2
		16 51 08.21	196 45 50.53	Alkali	4.5215896	33234.53	109037.0
Job, 1916	45 38 45.095	233 57 25.12	54 12 13.69	Laurila	4.5202003	33128.39	108688.7
	119 18 24.543	305 33 09.25	125 42 38.45	Alkali	4.3273666	21250.38	69719.0

[1] No check on this position.

GEOGRAPHIC POSITIONS—Continued.

Station.	Latitude and longitude.	Azimuth.	Back azimuth.	To station.	Distance.		
					Log (meters).	Meters.	Feet.
Principal points—Continued.	° ′ ″	° ′ ″	° ′ ″				
Job reference mark, 1916.[1]	45 38 46.294 119 18 24.512	10 23 41	190 23 41	Job	1.57576	37.65	123.5
Expansion (Wash.), 1916.	45 57 35.480 119 19 13.808	298 56 39.13 338 46 06.22 358 14 56.65	119 12 05.44 158 56 12.23 178 15 31.97	Laurila Alkali Job	4.5027763 4.7049511 4.5430224	31825.58 50693.36 34915.83	104414.4 166316.5 114553.0
Expansion reference mark (Wash.), 1916.[1]	45 57 35.507 119 19 14.426	273 38 10	93 38 10	Expansion	1.12467	13.325	43.72
Stanfield west base, 1916.	45 46 38.572 119 30 36.269	215 54 12.46 312 39 10.58	36 02 22.30 132 47 54.38	Expansion Job	4.3989889 4.3333427	25060.45 21544.81	82219.2 70684.9
Stanfield west base reference mark, 1916.[1]	45 46 39.306 119 30 36.357	355 10 54	175 10 54	Stanfield west base.	1.35679	22.740	74.61
Stanfield east base, 1916.	45 46 18.955 119 17 48.609	3 10 43.00 92 10 03.98 174 58 49.10	183 10 17.28 272 00 53.87 354 57 47.95	Job Stanfield west base. Expansion	4.1471758 4.2200209 4.3215578	14033.82 16596.668 20968.04	46042.6 54450.90 68792.6
Stanfield east base reference mark No. 1, 1916.[1]	45 46 18.366 119 17 48.727	187 56 54	7 56 54	Stanfield east base.	1.26399	18.365	60.25
Stanfield east base reference mark No. 2, 1916.[1]	45 46 18.763 119 17 48.134	120 03 22	300 03 22	Stanfield east base.	1.07372	11.850	38.88
Echo, 1916	45 44 38.385 119 11 20.222	40 07 46.36 110 20 19.99	220 02 42.70 290 15 41.75	Job Stanfield east base.	4.1540192 3.9518055	14256.71 8949.64	46773.9 29362.3
Echo reference mark, 1916.[1]	45 44 38.674 119 11 20.068	20 28 14	200 28 14	Echo	0.97909	9.530	31.27
Alder (U.S.G.S.) (Wash.), 1916.	45 51 00.583 119 56 22.229	255 32 07.33 294 31 58.83	75 58 47.77 114 59 10.30	Expansion Job	4.6951027 4.7341415	49556.74 54217.75	162587.4 177879.4
Alder reference mark (Wash.), 1916.[1]	45 51 00.753 119 56 21.389	73 48 54	253 48 53	Alder	1.27600	18.88	61.9
Ella, 1916	45 34 17.518 119 46 41.429	157 58 37.33 219 21 19.96 257 10 11.07	337 51 41.58 39 41 00.49 77 30 23.64	Alder Expansion Job	4.5239980 4.7477098 4.5761913	33419.35 55949.96 37686.97	109643.3 183562.5 123644.7
Ella reference mark, 1916.[1]	45 34 17.819 119 46 41.421	1 01 01	181 01 01	Ella	0.96848	9.300	30.51
Toby (U. S. G. S.), 1916.	45 31 20.033 120 08 36.102	203 28 13.64 258 59 38.61	23 36 58.75 79 15 17.06	Alder Ella	4.5994144 4.4630123	39757.07 29041.05	130436.3 95278.8
Toby reference mark, 1916.[1]	45 31 20.275 120 08 36.174	348 13	168 13	Toby	0.88252	7.63	25.0
Montgomery (U. S.G.S.)(Wash.), 1916.	45 48 21.792 120 18 12.439	260 02 05.38 302 18 34.16 338 21 47.43	80 17 45.14 122 41 07.30 158 28 39.66	Alder Ella Toby	4.4579173 4.6858798 4.5304020	28702.34 48515.42 33922.82	94167.6 159171.0 111295.1
Montgomery reference mark (Wash.), 1916.[1]	45 48 21.552 120 18 12.057	132	312	Montgomery	1.04497	11.091	36.39
John, 1916	45 24 06.690 120 36 08.470	207 19 34.79 249 23 52.54	27 32 23.64 69 43 30.33	Montgomery Toby	4.7042787 4.5833204	50614.94 38310.73	166059.2 125691.1
John reference mark No. 1, 1916.[1]	45 24 11.200 120 36 08.474	359 57 42	179 57 42	John	2.14373	139.23	456.8

[1] No check on this position.

GEOGRAPHIC POSITIONS—Continued.

Station.	Latitude and longitude.	Azimuth.	Back azimuth.	To station.	Distance. Log (meters).	Distance. Meters.	Distance. Feet.
Principal points—Continued.	° ′ ″	° ′ ″	° ′ ″				
John reference mark No. 2, 1916.[1]	45 24 10.913 120 36 15.557	310 13 22	130 13 27	John	2.30509	201.88	662.3
Maryhill (U. S. G. S.)(Wash.), 1916.	45 44 26.781 120 43 46.773	257 30 05.88	77 48 25.37	Montgomery	4.5306524	33935.35	111336.2
		297 46 16.09	118 11 24.93	Toby	4.7140780	51769.98	169848.7
		345 10 30.42	165 15 57.71	John	4.5905801	38956.51	127809.8
Maryhill reference mark (Wash.), 1916.[1]	45 44 27.176 120 43 46.780	359 18 46	179 18 46	Maryhill	1.08565	12.180	39.96
Stacker (Wash.), 1916.	45 42 50.650 121 06 00.397	263 59 28.82	84 15 23.73	Maryhill	4.4622498	28990.11	95111.7
		311 34 53.32	131 56 12.69	John	4.7168479	52101.22	170935.4
Stacker reference mark (Wash.), 1916.[1]	45 42 50.905 121 06 00.673	322 49	142 49	Stacker	0.99476	9.88	32.4
Lookout, 1916	45 20 34.650 121 31 23.837	218 33 42.60	38 51 49.73	Stacker	4.7231208	52859.23	173422.3
		234 13 00.60	54 46 59.89	Maryhill	4.8815949	76136.84	249792.3
		264 29 15.90	85 08 35.43	John	4.8599726	72439.03	237660.4
Lookout reference mark, 1916.[1]	45 20 35.037 121 31 23.742	9 46 44	189 46 44	Lookout	1.08386	12.13	39.8
Chinidere, 1916	45 35 12.306 121 48 39.343	74 40 01.18	254 28 11.71	Larch	4.3494121	22356.93	73349.4
		178 56 55.55	358 56 31.90	Red	4.5882886	38751.51	127137.2
		255 25 12.03	75 55 41.91	Stacker	4.7573039	57187.87	187623.9
		320 11 45.25	140 24 03.38	Lookout	4.5467495	35216.77	115540.4
Chinidere reference mark, 1916.[1]	45 35 11.883 121 48 39.052	154 10 32	334 10 32	Chinidere	1.16137	14.50	47.6
Huckle (Wash.), 1916.	45 53 08.624 121 42 13.751	291 54 19.66	112 20 17.76	Stacker	4.7047048	50664.62	166222.2
		346 47 45.74	166 55 30.20	Lookout	4.7920196	61946.90	203237.5
		14 07 18.56	194 02 42.42	Chinidere	4.5347838	34259.72	112400.4
		37 25 34.20	217 09 06.90	Larch	4.6923608	49244.85	161564.1
		121 28 43.52	301 23 42.86	Red	4.0242390	10573.99	34691.5
Huckle reference mark (Wash.), 1916.[1]	45 53 07.932 121 42 12.676	132 39 47	312 39 46	Huckle	1.49872	31.53	103.4
Supplementary points.							
Oxford north base, 1915.	42 16 07.490 111 58 58.296	90 50 23.0	270 45 46.1	Oxford	3.974764	9435.5	30956.3
Oxford south base, 1915.	42 15 12.153 111 58 59.493	101 06 01.2	281 01 25.1	Oxford	3.981655	9586.4	31451.4
		180 55 14.0	0 55 14.8	Oxford north base.	3.232391	1707.618	5602.4
Oxford railroad station, south gable, 1915.	42 16 07.395 111 58 59.873	90 51 38.2	270 47 02.4	Oxford	3.973099	9399.4	30837.9
		265 20 39.7	85 20 40.8	Oxford north base.	1.559545	36.3	119.1
		359 42 25.0	179 42 25.3	Oxford south base.	3.231591	1704.5	5592.2
Bonida iron elevator, north gable, 1915.	42 13 41.386 111 59 00.035	116 18 54.8	296 14 19.1	Oxford	4.020393	10480.8	34385.8
		180 15 14.3	0 15 14.7	Oxford south base.	3.447255	2800.6	9188.3
		180 30 23.1	0 30 24.3	Oxford north base.	3.654000	4508.2	14790.7
Precise level B. M. E., 1915.[1]	42 16 07.545 111 58 58.312	347 42 15	167 42 15	Oxford north base.	0.23805	1.73	5.7
Henry, 1915	42 55 16.033 111 24 12.540	89 27 36.86	268 57 57.19	Putnam	4.7729308	59283.08	194479.9
		201 26 45.39	21 30 32.61	Caribou	4.3140094	20606.74	67607.3
Henry (U. S. G. S.), 1915.[1]	42 55 16.158 111 24 12.634	330 51 37	150 51 37	Henry	0.64345	4.40	14.4
Woodall, 1915	42 45 09.778 111 31 06.002	109 54 36.31	289 29 40.56	Putnam	4.7248885	53074.82	174129.6
		204 00 42.22	24 09 10.66	Caribou	4.6179988	41495.29	136139.1
		206 36 52.24	26 41 33.36	Henry	4.3208124	20932.08	68674.7

[1] No check on this position.

GEOGRAPHIC POSITIONS—Continued.

Station.	Latitude and longitude.	Azimuth.	Back azimuth.	To station.	Distance.		
					Log (meters).	Meters.	Feet.
Supplementary points—Con.	° ′ ″	° ′ ″	° ′ ″				
Woodall (U. S. G. S.), 1915.[1]	42 45 09.664 111 31 06.037	192 49 13	12 49 13	Woodall	0.55751	3.61	11.8
Stump, 1915	42 54 06.635 111 11 21.129	97 03 01.17 155 04 10.31	276 54 15.94 334 59 11.41	Henry Caribou	4.2462222 4.3713583	17628.78 23515.72	57837.1 77151.2
Caribou (U. S. G. S.), 1915.[1]	43 05 37.522 111 18 39.392	7 37 05	187 37 05	Caribou	0.40654	2.55	8.4
Teton Peak, 1915[2]	43 44 32.13 110 48 04.41	29 59 10 49 56 52	209 38 09 229 02 11	Caribou Putnam	4.919280 5.151343	83039 141691	272437 464865
Putnam (U. S. G. S.), 1915.[1]	42 54 49.499 112 07 45.923	146 46 59	326 46 59	Putnam	0.74036	5.50	18.0
Blackfoot B. M. Q_6, 1915.	43 09 31.276 112 22 39.390	117 01 16.55 141 47 32.44	296 34 46.64 321 32 43.27	Big Butte Middle Butte	4.7678082 4.6728246	58587.93 47078.72	192217.2 154457.4
Precise level B. M. Q_6, 1915.[1]	43 09 31.303 112 22 39.325	60 48 05	240 48 05	Blackfoot B. M. Q_6	0.22789	1.69	5.5
Middle Butte (U. S. G. S.), cairn, 1915.[1]	43 29 28.038 112 44 15.297	3 41	183 41	Middle Butte	0.32634	2.12	7.0
Little Butte (U. S. G. S.), cairn, 1915.[2]	43 29 51.91 112 39 50.30	68 53 40 82 57 06	248 38 54 262 54 03	Big Butte Middle Butte	4.492430 3.778143	31077.0 5999.9	101958.5 19684.7
Jacob Gohl's ranch house, 1915.[2]	43 25 58.32 112 50 53.33	74 01 15 234 05 34	253 54 05 54 10 08	Big Butte Middle Butte	4.165438 4.043046	14636.5 11042.0	48019.9 36227.0
Big Butte (U. S. G. S.), cairn, 1915.[1]	43 23 47.263 113 01 18.725	256 41 01	76 41 01	Big Butte	0.52504	3.35	11.0
Dietrich standpipe, 1915.[1]	42 54 55.99 114 15 51.19	30 54 03 192 24 58	210 47 55 12 29 29	Flat Picabo	4.379932 4.618645	23984.6 41557.1	78689.5 136341.9
Green (U. S. G. S.), cairn, 1915.[1]	43 12 51.338 114 54 42.278	15 53	195 53	Green	0.38021	2.40	7.9
Camas (U.S.G.S.), cairn, 1915.[1]	43 14 57.838 115 26 01.375	258 35 07	78 35 08	Camas	1.25648	18.05	59.2
Precise level B.M. M_4, 1915.[1]	43 07 54.161 115 41 42.493	334 14 16	154 14 21	Mountain Home.	2.525162	335.09	1099.4
Mitchell, 1915	43 46 15.043 117 10 44.769	234 23 15.38 244 26 45.50 269 32 13.44	54 31 31.86 64 58 42.44 90 17 30.37	Nyssa Squaw Shafer	4.2942909 4.8339845 4.9436789	19692.05 68231.44 87837.29	64606.3 223856.0 288179.5
Mitchell reference mark, 1915.[1]	43 46 15.215 117 10 45.113	303 03 17	123 03 17	Mitchell	0.96237	9.17	30.1
Idaho-Oregon boundary monument, 1915.	43 43 22.433 117 01 33.651	113 25 04.83 192 27 05.50	293 18 43.75 12 29 00.33	Mitchell Nyssa	4.1281596 4.2350163	13432.59 17179.73	44070.1 56363.8
B. M. G, 1915	43 52 31.742 116 59 28.724	281 03 02.55 52 29 01.48	101 03 30.95 232 21 13.37	Nyssa Mitchell	2.9694990 4.2801862	932.18 19062.78	3058.3 62541.8
Precise level B. M. G, 1915.[1]	43 52 42.642 116 59 28.690	0 07 39	180 07 39	B. M. G	2.526869	336.41	1103.7
B. M. G reference mark, 1915.[1]	43 52 31.118 116 59 28.764	182 39 19	2 39 19	B. M. G	1.28511	19.28	63.3
Mitchell (U. S. G. S.), cairn, 1915.[1]	43 46 15.302 117 10 44.369	48 08 17	228 08 17	Mitchell	1.07918	12.0	39.4
Pressure standpipe, 1915.[1]	43 49 53.10 117 02 09.02	59 46 36 223 36 00	239 40 39 43 38 19	Mitchell Nyssa	4.125460 3.814021	13349.6 6516.6	43797.8 21379.9

[1] No check in this position.
[2] Checked by vertical angles only.

GEOGRAPHIC POSITIONS—Continued.

Station.	Latitude and longitude.	Azimuth.	Back azimuth.	To station.	Distance. Log (meters).	Distance. Meters.	Distance. Feet.
Supplementary points—Con.	° ′ ″	° ′ ″	° ′ ″				
Nyssa standpipe, 1915.	43 52 32.220	274 02 57.8	94 03 04.3	B. M. G	2.321141	209.5	687.3
	116 59 38.082	279 45 58.5	99 46 33.4	Nyssa	3.057050	1140.4	3741.5
		52 03 38.7	231 55 57.1	Mitchell	4.276613	18906.6	62029.4
Castle Rock Butte, 1916.[1]	44 01 16.94	206 12 59	26 29 43	Beaver	4.855743	71737.0	235357.1
	118 10 57.19	248 19 49	68 41 35	Dry	4.651821	44856.1	147165.4
Dry (U.S. G. S.), cairn, 1916.[1]	44 10 09.206	210 47 10	30 47 10	Dry	0.56820	3.70	12.1
	117 39 40.930						
Iron (U. S. G. S.), 1915.[1]	44 33 04.741	32 35 31	212 35 30	Iron	1.61595	41.30	135.5
	117 01 39.166						
Granite, 1916	45 08 08.179	329 58 30.8	150 18 28.2	Iron	4.874531	74908.5	245762.3
	117 29 58.267	12 07 34.3	192 06 51.5	Medical	3.798734	6291.2	20640.4
		20 44 57.4	200 32 56.3	Beaver	4.803614	63623.0	208736.5
Bennet, 1916[1]	45 02 19.67	331 42 09	151 57 39	Iron	4.788799	61489.2	201735.8
	117 23 40.74	115 43 24	295 38 14	Medical	4.026633	10632.4	34883.1
Rock Creek Mountain, cairn, 1916.	44 48 37.106	168 25 20.0	348 24 42.1	Maxwell	3.769198	5877.6	19283.4
	118 04 25.804	235 31 06.5	55 54 44.5	Medical	4.726367	53255.8	174723.4
		315 21 10.4	135 33 25.9	Beaver	4.516035	32812.2	107651.4
Ireland Mountain, lookout cupola, 1916.	44 50 14.508	230 56 06.5	51 02 54.8	Powder	4.213333	16343.0	53618.7
	118 19 11.299	261 21 10.1	81 30 56.7	Maxwell	4.266500	18471.4	60601.6
		301 39 01.6	122 01 40.3	Beaver	4.699215	50028.2	164134.2
Tower, 1916	45 03 17.797	182 29 01.08	2 30 27.29	Big Hill	4.7826883	60630.10	198917.3
	118 33 46.925	220 53 47.87	41 13 46.85	Emily	4.7486174	56055.39	183908.4
		246 27 01.97	67 02 31.09	Fanny	4.8532500	71326.34	234009.8
		293 25 09.90	113 42 18.09	Powder	4.5410051	34754.02	114022.1
Fanny (U.S.G.S.), cairn, 1916.[1]	45 18 30.115	56 28 17	236 28 17	Fanny	0.78319	6.07	19.9
	117 43 45.194						
Precise level B.M. 2782A, cor. Foley Hotel, La Grande, 1916.[1]	45 19 47.305	196 00 08.3	16 00 14.6	La Grande	1.84155	69.43	227.8
	118 05 48.136						
La Grande Astronomic, 1916.[1]	45 19 51.942	71 40 33	251 40 33	La Grande reference mark No. 2.	0.53445	3.42	11.2
	118 05 41.196						
State Forestry Service lookout tower, northwest corner, 1916[1]	45 26 06.217	127 02	307 02	Emily	1.53656	34.4	112.9
	118 05 37.264						
Arbuckle, 1916[1]	45 11 38.50	198 54 23	19 01 28	Alkali	4.602149	40008.2	131260.2
	119 15 05.19	231 09 21	51 40 12	Big Hill	4.859344	72334.2	237316.5
Echo Catholic Church spire, 1916.	45 44 25.314	38 17 11.8	218 12 38.0	Job	4.126290	13374.9	43880.8
	119 12 01.861	115 07 20.1	295 03 11.7	Stanfield east base.	3.917756	8274.8	27148.2
		245 50 51.3	65 51 21.2	Echo	2.994082	986.5	3236.5
Gate, 1916	45 54 42.020	201 48 40.9	21 49 52.4	Expansion	3.761093	5768.9	18926.8
	119 20 53.346						
Gravel, 1916	45 54 54.574	77 55 02.0	257 54 01.7	Gate	3.267244	1850.3	6070.5
	119 19 29.397	183 51 56.6	3 52 07.8	Expansion	3.697169	4979.3	16336.3
43 R (U. S. E.) (Wash.), 1916.	45 56 03.824	358 22 56.6	178 22 58.6	Gravel	3.330201	2139.0	7017.7
	119 19 32.199	34 42 13.3	214 41 15.0	Gate	3.487407	3071.9	10078.4
44 L (U. S. E.), 1916.	45 55 55.174	27 00 55.2	207 00 23.4	Gravel	3.322245	2100.1	6890.1
	119 18 45.133	50 44 47.3	230 43 15.2	Gate	3.552491	3568.5	11707.7
		104 45 35.2	284 45 01.4	43 R (U.S.E.)	3.020596	1048.6	3440.3
Concrete gatehouse, northwest corner, 1916.[1]	45 54 41.987	135 07	315 07	Gate	0.16137	1.45	4.8
	119 20 53.299						
U. S. G. S. B. M., 1916.[1]	45 46 38.583	272 07 32	92 07 32	Stanfield west base.	0.97580	9.458	31.03
	119 30 36.706						

[1] No check on this position.

GEOGRAPHIC POSITIONS—Continued.

Station.	Latitude and longitude.	Azimuth.	Back azimuth.	To station.	Distance. Log (meters).	Meters.	Feet.
Supplementary points—Con.	° ′ ″	° ′ ″	° ′ ″				
Umatilla standpipe, 1916.	45 55 08.188	205 29 50.8	25 31 03.2	Expansion....	3.702322	5038.7	16531.1
	119 20 54.535	225 54 57.3	45 55 56.5	43 R (U.S.E.).	3.392590	2469.4	8101.7
		242 29 59.0	62 31 32.0	44 L (U.S.E.).	3.497349	3143.0	10311.7
		282 53 45.8	102 54 47.0	Gravel........	3.274685	1882.3	6175.5
		358 11 05.7	178 11 06.6	Gate..........	2.907600	808.4	2652.2
Umatilla high school flagpole, 1916.	45 55 01.688	56 01 27.9	236 00 57.9	Gate..........	3.036030	1086.5	3564.6
	119 20 11.541	194 40 18.0	14 40 59.5	Expansion....	3.690947	4908.5	16104.0
		203 50 07.9	23 50 36.2	43 R (U.S.E.).	3.321677	2097.4	6881.2
		283 35 32.2	103 36 02.5	Gravel........	2.970543	934.4	3065.6
North (Wash.), 1916.	45 40 58.980	105 15 15.4	285 08 15.5	Stacker.......	4.119017	13152.8	43152.1
	120 56 13.710	248 16 03.8	68 24 58.4	Maryhill......	4.240129	17383.2	57031.4
South, 1916.......	45 38 04.934	178 52 02.7	358 51 59.2	North.........	3.730332	5374.4	17632.5
	120 56 08.801	233 38 24.1	53 47 14.9	Maryhill......	4.299284	19919.8	65353.5
West (Wash.), 1916.	45 40 12.991	249 11 22.7	69 13 26.3	North.........	3.602009	3999.5	13121.7
	120 59 06.468	315 45 55.7	135 48 02.7	South.........	3.741647	5516.3	18098.1
East (Wash.), 1916.	45 40 10.960	5 52 22.5	185 52 09.3	South.........	3.592329	3911.4	12832.7
	120 55 50.323	90 51 56.3	270 49 36.0	West..........	3.627997	4246.2	13931.1
		161 09 04.2	341 08 47.5	North.........	3.194945	1566.6	5139.8
148 L (U. S. E.), 1916.	45 39 07.044	125 39 10.2	305 37 36.4	West..........	3.543342	3494.2	11463.9
	120 56 55.300	215 28 38.4	35 29 24.9	East..........	3.384417	2423.4	7950.8
149 L ecc. (U. S. E.), 1916.	45 38 52.059	146 01 26.4	326 00 30.8	West..........	3.479048	3013.3	9886.1
	120 57 48.670	226 26 07.4	46 27 32.1	East..........	3.548434	3535.4	11599.1
		248 10 35.6	68 11 13.8	148 L (U.S.E.).	3.095106	1244.8	4084.0
149 L (U. S. E.), 1916.	45 38 52.182	320 55 02.6	140 55 02.6	149 L ecc. (U. S. E.)	0.69020	4.90	16.1
	120 57 48.813	248 23 30.0	68 24 08.3	148 L (U.S.E).	3.095616	1246.3	4088.9
Fallbridge standpipe (Wash.), 1916.	45 39 24.641	134 50 46.5	314 49 56.9	West..........	3.325713	2117.0	6945.5
	120 57 57.127	242 28 15.2	62 29 45.9	East..........	3.490693	3095.2	10154.8
		349 40 55.4	169 41 01.4	149 L ecc. (U. S. E.)	3.009649	1022.5	3354.7
Mount Hood, 1916.	45 22 25.963	120 08 55.2	299 52 09.5	Larch.........	4.549125	35409.9	116174.0
	121 41 41.860	159 04 19.0	338 59 21.4	Chinidere.....	4.403751	25336.8	83125.8
		230 38 51.7	51 04 20.3	Stacker.......	4.777416	59898.5	196517.0
Tygh, 1916........	45 21 20.527	86 44 32.9	266 31 26.1	Lookout......	4.382310	24116.3	79121.6
	121 12 57.924	192 46 22.3	12 51 20.3	Stacker.......	4.611158	40846.8	134011.5
		221 25 08.5	41 45 58.5	Maryhill......	4.757580	57224.2	187743.1
Bald Peter, 1916[1].	45 03 36.47	158 45 55	338 39 17	Lookout......	4.528069	33734.1	110676.0
	121 22 02.64	213 12 08	33 39 23	Maryhill......	4.957318	90639.6	297373.4
Chinidere (U. S. G. S.), cairn, 1916.[1]	45 35 12.200	168	348	Chinidere.....	0.52504	3.35	11.0
	121 48 39.312						
Sedum Point (Wash.), 1916.[1]	45 47 36.99	218 19 09	38 26 04	Red...........	4.303112	20096.1	65932.0
	121 58 50.73	244 27 02	64 38 57	Huckle........	4.377076	23827.4	78173.7
Little (Wash.), 1916.[1]	45 48 00.56	235 34 07	55 46 19	Red...........	4.425600	26644.0	87414.5
	122 06 12.43	252 49 25	73 06 37	Huckle........	4.511477	32469.6	106527.3
Big Huckleberry (Wash.), 1916.[1]	45 50 52.02	163 29 18	343 27 42	Red...........	4.006550	10152.0	33307.0
	121 46 58.41	235 29 11	55 32 35	Huckle........	3.872107	7449.2	24439.6
Observation (Wash.), 1916.[1]	45 56 04.58	269 38 57	89 48 40	Red...........	4.242229	17467.4	57307.6
	122 02 43.14	334 39 55	154 50 00	Chinidere.....	4.630907	42747.1	140246.1
Lemei Rock (Wash.), 1916.[1]	46 01 08.00	4 48 53	184 46 39	Chinidere.....	4.683041	48199.3	158133.9
	121 45 32.72	27 00 18	206 57 40	Red...........	4.017860	10419.8	34185.6
Mount Adams, northwest peak (Wash.), 1916.[1]	46 12 16.78	1 04 08	181 03 09	Lookout......	4.981326	95791.3	314275.3
	121 30 01.77	19 26 34	199 13 12	Chinidere.....	4.862030	72783.0	238788.9
Mount Adams, southeast peak (Wash.), 1916.	46 12 10.611	330 44 20.5	151 01 11.0	Stacker.......	4.793796	62200.8	204070.5
	121 29 26.058	1 32 12.2	181 30 47.9	Lookout......	4.980542	95618.5	313708.4
		20 04 03.1	199 50 15.0	Chinidere.....	4.862504	72862.5	239049.7

[1] No check on this position.

TABLE OF ELEVATIONS.

Station.	Point to which elevation refers.	Elevation.	
		Meters.	*Feet.*
Class 1.[1]			
Precise level B. M. Q_6.	Station mark.	1366.09	4481.9
Alkali	...do	827.17	2713.8
Job	...do	513.78	1685.6
Stanfield west base	...do	188.94	619.9
Stanfield east base	...do	231.11	758.2
Class 2.			
Ogden Peak	...do	2918.45	9574.9
Pilot Peak	...do	3262.47	10703.6
Oxford	...do	2828.81	9280.9
Mountain Home	...do	955.50	3134.8
Nyssa	...do	697.04	2286.9
B. M. G	...do	663.57	2177.1
Cache	...do	3151.73	10340.3
Putnam	...do	2724.78	8939.6
Caribou	...do	2983.27	9787.6
Woodall	...do	2379.43	7806.5
Henry	...do	2530.11	8300.9
Stump	...do	2615.82	8582.1
Middle Butte	...do	1948.97	6394.2
Big Butte	...do	2309.26	7576.3
Kimama	...do	1448.45	4752.1
Picabo	...do	1999.79	6561.0
Flat	...do	1306.08	4285.0
Green	...do	2072.27	6798.8
Blue	...do	1281.13	4203.2
Camas	...do	2267.61	7439.6
Silver	...do	2562.05	8405.7
Shafer	...do	2313.87	7591.4
Mitchell	...do	1067.52	3502.4
Oregon-Idaho boundary monument.	...do	700.89	2299.5
La Grande	...do	849.72	2787.8
Echo	...do	217.04	712.1
Larch	...do	1234.89	4051.5
Red	...do	1517.31	4978.0
Squaw	...do	1800.15	5906.0
Iron	...do	1978.75	6492.0
Dry	...do	1978.10	6489.8
Beaver	...do	1953.92	6410.5
Medical	...do	1988.13	6522.7
Maxwell	...do	2655.61	8712.6
Fanny	...do	2182.57	7160.6
Powder	...do	2714.11	8904.5
Emily	...do	1848.36	6064.2
Birch	...do	1398.79	4589.2
Big Hill	...do	1168.98	3835.2
Laurila	...do	422.93	1387.6
Class 2—Continued.			
Expansion	Station mark.	309.91	1016.8
Alder	...do	396.66	1301.4
Ella	...do	492.21	1614.9
Montgomery	...do	746.71	2449.8
Toby	...do	449.23	1473.8
Maryhill	...do	955.44	3134.6
John	...do	725.16	2379.1
Stacker	...do	984.17	3228.9
Lookout	...do	1988.71	6524.6
Huckle	...do	1458.14	4783.9
Chinidere	...do	1424.64	4674.0
North	...do	855.20	2805.8
South	...do	240.01	787.4
West	...do	365.55	1199.3
149 L eccentric	...do	59.21	194.3
Class 3.			
Bonida, iron elevator.[2]	North gable.	1465.6	4808
Little Butte, cairn.	Base	2013.3	6605
Jacob Gohl's ranch house.	Southwest gable.	1539.4	5050
Dietrich standpipe	Top	1291.2	4236
Nyssa standpipe	...do	702.0	2303
East	Ground	369.1	1211
Bennet[2]	...do	2159.0	7083
Rock Creek Mountain, cairn.[2]	Top	2725.9	8943
Echo Catholic Church, cross.	...do	209.4	687
Gate[2]	Ground	122.8	403
Gravel[2]	...do	125.7	412
Umatilla standpipe	Top	125.7	412
148 L[2]	Ground	96.8	318
Tygh	...do	831.8	2729
Big Huckleberry	...do	1281.2	4203
Bunker Hill[2]	...do	1013.7	3326
Observation[2]	...do	1262.3	4141
Little[2]	...do	1290.9	4235
Teton Peak	...do	4201	13783
Nyssa pressure standpipe on aqueduct.[2]	Top	698.4	2291
Mount Hood	Ground	3430	11253

[1] See note regarding accuracy below.

[2] 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 ±0.04 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 ±1.2 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.

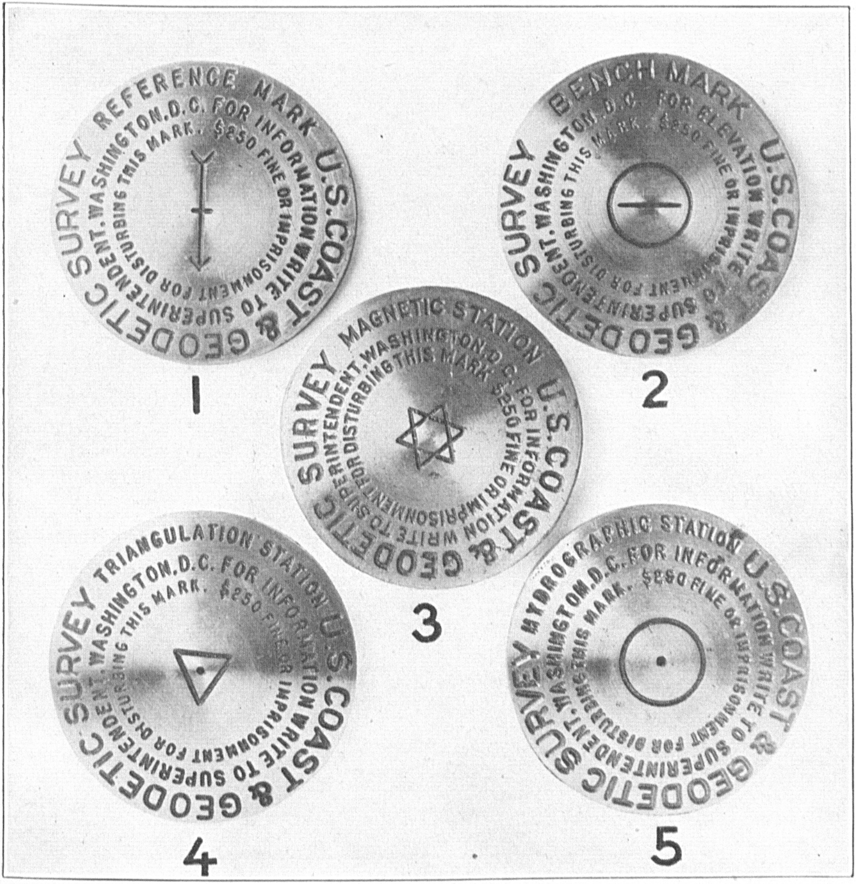

FIG. 1.—STANDARD MARKS OF THE U. S. COAST AND GEODETIC SURVEY.

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

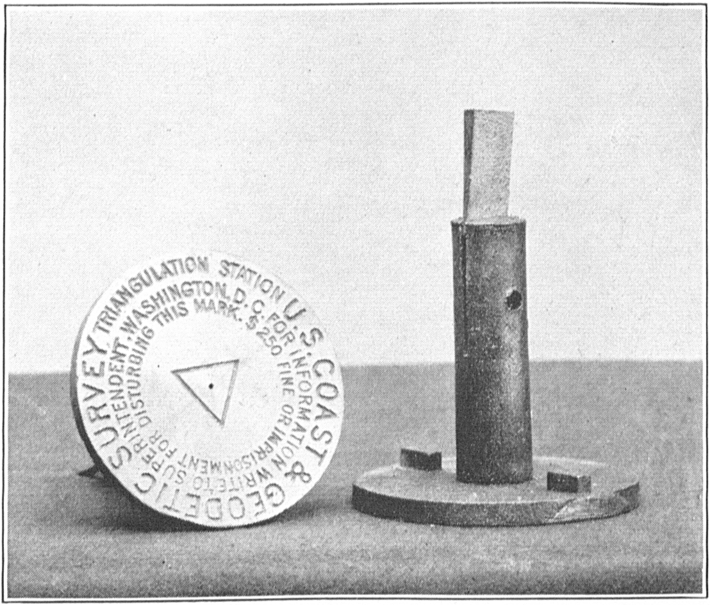

FIG. 2.—STANDARD TRIANGULATION STATION MARK.

DESCRIPTION OF STATIONS.

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

The distance and direction between station mark and reference mark will be found under "Geographic positions" in connection with the reference mark.

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

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

Any person who finds that one of the stations herein described has been disturbed or that the description no longer fits the facts is requested to send such information to the 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. 2. The disk of the station mark is 90 mm. in diameter, with a hole at the center surrounded by a 20-mm. equilateral triangle, and has the following inscribed legend: "U. S. Coast and Geodetic Survey Triangulation Station. For information write to the Superintendent, Washington, D. C. $250 fine or imprisonment for disturbing this mark." The shank is 25 mm. in diameter and 80 mm. long, with a slit at the lower end into which a wedge is inserted, so that when it is driven into a drill hole in the rock it will bulge at the bottom and hold the mark firmly in place.

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

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.

PRINCIPAL POINTS.

Cache (Cassia County, Idaho, P. A. Welker, 1897; 1915).—On Independence Peak, about 12 miles southwest of Elba, Idaho. The station is best reached by pack animals from Elba by going up the canyon past the uppermost lake. The station is marked by a copper bolt embedded in the rock. Four reference marks consisting of holes drilled in the rock 3 feet from the center mark are approximately north, east, south, and west of the station.

Oxford (Oneida County, Idaho, P. A. Welker, 1897; 1915).—On the peak of the same name about 6 miles west of the town of Oxford and about 15 miles east of Malad City, Idaho. The station is best reached from the town of Oxford by means of a log road leading about two-thirds of the distance to the summit. It is marked by a copper bolt embedded in the rock. Four reference marks consisting of holes drilled in the rock 2.5 feet from the center mark are approximately north, east, south, and west of the station.

Big Butte (Bingham-Blaine Counties, Idaho, C. V. Hodgson, 1915).—On the highest point of the mountain of the same name, 23 miles southeast of Arco and 7 miles southwest of Cerro Grande. The station is on or near the boundary line between Bingham and Blaine Counties and is marked by a bronze tablet in a bowlder as described in note 4.[1] The reference mark is a 1-inch hole 3 inches deep in the top of a large bowlder which projects 6 inches above the surface of the ground. A U. S. Geological Survey cairn is near by. (See "Geographic positions.")

Putnam (Bannock County, Idaho, C. V. Hodgson, 1915).—About 14 miles east of Pocatello, 18 miles southeast of Rossfork, and 12 miles north of west from Chesterfield on the southernmost of the two highest peaks of the Putnam Mountains. Another peak of about the same height is about 8 miles to the northward and is locally known as Putnam Mountain. The station is marked by a bronze tablet in concrete as described in note 1a.[1] A U. S. Geological Survey cairn is near by. (See "Geographic positions.")

Middle Butte (Bingham County, Idaho, C. V. Hodgson, 1915).—Nine miles north of Taber on the highest point of Middle Butte Mountain near its western end. The station is marked by a bronze tablet in a bowlder as described in note 4,[1] with a reference mark, a bronze tablet in a bowlder, note 12c.[1] A U. S. Geological Survey cairn is near by. (See "Geographic positions.")

Caribou (Bonneville County, Idaho, C. V. Hodgson, 1915).—On the highest point of Caribou Mountain, a bare round-topped peak easily reached by pack animals from all directions. The station is about 35 miles, air line, N. 25° E. of Soda Springs and 7 miles by trail northeast of Gray post office. It is marked by a bronze tablet in a bowlder as described in note 5,[1] with a reference mark, a bronze tablet in a bowlder, note 12d,[1] on the south slope of the peak, 0.75 meter (2.5 feet) below the station. A U. S. Geological Survey cairn 5 feet high is near by. (See "Geographic positions.")

Kimama (Lincoln County, Idaho, C. V. Hodgson, 1915).—On a low but prominent ridge covered with sagebrush about 5 miles, air line, southeast by east from Owinza, 9 miles, air line, west by north from Kimama, and 3 miles south of the railroad. The station is at the east end of the ridge on a rocky knob about 10 feet higher than the remainder of the ridge, which identifies the ridge from all others in that vicinity. The station is marked by a bronze tablet in rock as described in note 2,[1] with a reference mark, a bronze tablet in rock, note 12b,[1] near the southeast edge of the knob 1.5 meters (4.9 feet) below the station.

Picabo (Blaine County, Idaho, C. V. Hodgson, 1915).—About 5 miles, air line, W. 20° S. from Picabo on the highest and most westerly of a group of hills and about one-half mile south of the old Hailey mine, which is on the same ridge. The station is marked by a bronze tablet in rock, as described in note 3,[1] with a reference mark, a bronze tablet in rock, note 12b,[1] 0.20 meter (0.7 foot) below the station mark.

Flat (Lincoln County, Idaho, C. V. Hodgson, 1915).—About 6 miles north of east of Jerome, three-eights of a mile north of the automobile road leading east from Jerome toward Burley and 1¼ miles south of Jerome reservoir on the highest part and near the center of Flattop Butte and about 8 paces from the southeast edge of a cup-like depression near its middle. The station is marked by a bronze tablet in a bowlder as described in note 5,[1] the bowlder being about 0.1 meter (0.3 foot) above the surface of the ground. The reference mark, a bronze tablet in a bowlder, note 12d,[1] is 0.2 meter (0.7 foot) above the station mark.

Green (Camas County, Idaho, C. V. Hodgson, 1915).—About 7 miles east and 7 miles south of Hill City, 2 miles south and 1 mile west of Henry Bauscher's ranch, on a rocky knob on a flat-topped ridge, the highest point in the vicinity. The station is marked by a bronze tablet in a bowlder as described in note 5,[1] the bowlder being about 0.1 meter (0.3 foot) above the surface of the ground. The reference mark, a bronze tablet in a bowlder, note 12d,[1] is 0.35 meter (1.2 feet) above the station mark. An 8-foot cairn, marking the U. S. Geological Survey station *Greensprings* is near by. (See "Geographic positions.")

Camas (Elmore County, Idaho, C. V. Hodgson, 1915).—About 16 miles northeast of Mountain Home, on the highest point of Bennet Mountain, about ¼ mile southwest of the dug road leading from the Mountain Home—Rocky Bar road near Charles Irwin's ranch to the Tex Riley ranch. The station is marked by a bronze tablet in a bowlder as described in note 5,[1] the bowlder being about 1 meter (3 feet) above the surface of the ground. The reference mark, a bronze tablet in a bowlder, note 12d,[1] is 0.35 meter (1.2 feet) below the station mark. A 6-foot cairn marking the U. S. Geological station is near by. (See "Geographic positions.")

Blue (Owyhee County, Idaho, C. V. Hodgson, 1915).—On the highest point of Blue Ridge Hill, 18 miles south and 3 miles west of Glenns Ferry, 13 miles west of south of the D. B. Warren ranch and 4 miles west of the Glenns Ferry—Garber

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[1] See p. 23.

wagon road. The station is best reached by going 16½ miles from the Warren ranch south along the Garber road to the crest of Blue Ridge, when the hill on which the station is located will be seen about 4 miles along the ridge to the northwest. The station is marked by a bronze tablet in a bowlder as described in note 5,[1] the bowlder being about 0.1 meter (0.3 foot) above the surface of the ground. The reference mark, a bronze tablet in a bowlder, note 12d,[1] is on about the same level as the station mark.

Mountain Home (Elmore County, Idaho, C. V. Hodgson, 1915).—In the town of Mountain Home, southeast of the railroad water tank, on the right of way of the Oregon Short Line Railroad, about 20 paces southwest of the track. The station is marked by a bronze tablet in concrete as described in notes 1a and 7a,[1] with the reference mark, a bronze tablet in concrete, note 11a,[1] in the fence line on the opposite side of the street from the station and at the same elevation. Precise level bench mark M_4 is near by. (See "Geographic positions.")

Silver (Owyhee County, Idaho, C. V. Hodgson, 1915).—About 5 miles southeast of Silver City and 2½ miles southeast of War Eagle Mountain, on the highest point of what is known locally as Cinnabar or Quicksilver Mountain. The station is marked by a bronze tablet in a bowlder as described in note 5,[1] the bowlder extending 5 inches above the surface of the ground. The reference mark, a bronze tablet in a bowlder, note 12d,[1] is 0.2 meter (0.7 foot) below the station.

Shafer (Boise City, Idaho, C. V. Hodgson, 1915).—About 12 miles northeast of Boise on the highest point of Shafer Butte, which is the highest in this group of hills. It is about 6 miles by trail north of where the divide is crossed by a wagon road which leads up Stuarts Gulch around the head of Dry Creek and over to an old sawmill on Daggett Creek. The station is marked by a bronze tablet in a bowlder as described in note 5,[1] the bowlder extending about 0.1 meter (0.3 foot) above the ground. The reference mark, a bronze tablet in a bowlder, note 12d,[1] is on the south side of the remains of a large cairn and is 1.06 meters (3.5 feet) above the station mark.

Squaw (Canyon-Boise Counties, 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 the Van Deusen ranch, 2½ miles E. 10° N. of H. M. Shearer's house, on the highest and most northerly butte of Squaw Mountain, about ¼ mile south of the Cold Springs, well known to the ranchers of that vicinity. The station is marked by a bronze tablet in a bowlder as described in note 5,[1] the bowlder extending 4 inches above the surface of the ground. The reference mark, a bronze tablet in a bowlder, note 12d,[1] is of the same elevation as the station and is 18 inches above the ground.

Nyssa (Canyon County, Idaho, C. V. Hodgson, 1915; 1920).—Three-fourths mile east of Nyssa, Oreg., on a small sand hill covered with sagebrush on the east bluff of the Snake River and about ⅛ mile south of the east end of the wagon bridge across the Snake River at Nyssa. The station is marked by a bronze tablet in concrete as described in notes 1a and 7a[1] with the reference mark, a bronze tablet in concrete, note 11a,[1] 0.3 meter (1 foot) lower than the station.

Iron (Washington County, Idaho, C. V. Hodgson, 1916).—About 1 mile south of Mineral, Idaho, 6 miles east of the Snake River, 22 miles, air line, and 27 miles by road north of Weiser, on a bald peak known as Iron Mountain, the northeastern and higher of two peaks whose tops are nearly level. An old freight road leading from Weiser to Mineral passes around the peak about 250 meters (820 feet) south of the station and 300 feet below it. This road is known as the Jenkins Creek and Sheep Creek road. The station is marked by a bronze tablet in a bowlder as described in note 5,[1] with a reference mark, a bronze tablet in a bowlder, note 12d.[1]

Dry (Malheur County, Oreg., C. V. Hodgson, 1916; 1920).—About 22 miles, air line, northwest of Vale, 8 miles, air line, southwest of Brogan, 6 miles, air line, 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 is marked by a bronze tablet in a bowlder as described in note 5,[1] with a reference mark, a bronze tablet in a bowlder, note 12d.[1] The cairn marking the U. S. Geological Survey station *Dry Ridge* near by, is about 7 feet in diameter at the base and 10 feet high. (See "Geographic positions.")

Beaver (Baker County, Oreg., C. V. Hodgson, 1916).—About 12 miles south and 3 miles east of Baker, on the northern and higher of the two bald grassy knobs on Beaver Mountain or Bald Ridge, which lies just south and east of the head of Beaver Creek, and about 1½ miles south of Echam & Sons' sawmill on Beaver Creek. The station is marked by a nail in a block of concrete and covered by a cairn. The reference mark is a hole in rock flush with the surface of the ground.

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[1] See p. 23.

Maxwell (Baker County, Oreg., C. V. Hodgson, 1916).—About 13 miles, air line, northwest of Baker, 7 miles southwest of Haines, 4 miles southwest of Rock Creek Power Plant, and ¼ mile north of the trail leading over the ridge from the Maxwell mine to the Elkhorn mine, on the highest point of the mountain to the north of the trail. The station is about 1½ miles northeast of the Maxwell mine and is marked by a bronze tablet in a bowlder as described in note 5,[1] with a reference mark, a bronze tablet in a bowlder, note 12d.[1]

Medical (Baker County, Oreg., C. V. Hodgson, 1916).—On the line between Union and Baker Counties, about 7 miles, air line, and 10 miles by trail from Medical Springs, on the highest point, at the south end of a bald ridge known as Flagstaff Butte, at the head of Big Creek. The trail from Medical Springs to Sand Pass goes around the butte on its west side near the top. The station is marked by a bronze tablet in a bowlder as described in note 5,[1] with a reference mark, a bronze tablet in a bowlder, note 12d.[1] Small cairns were left over the station and reference marks.

Fanny (Union County, Oreg., C. V. Hodgson, 1916).—About 18 miles east of La Grande and 5 miles east of Cove post office and about 1½ miles west of Mount Fanny ranger station. The station is on the easternmost and highest peak on Mount Fanny and is marked by a bronze tablet in a bowlder as described in note 5,[1] with a reference mark, a bronze tablet in a bowlder, note 12d.[1] A U. S. Geological Survey cairn is near by. (See "Geographic positions.")

Powder (Baker County, Oreg., C. V. Hodgson, 1916).—About 10 miles, air line, north of west from Haines and 1½ miles north of the North Powder River on the easternmost and highest of the three peaks on the highest ridge north of the North Powder River, on what is known as North Powder Mountain and also as the Three Sisters Peak. The station is very difficult to reach by pack animals. It is marked by a bronze tablet in a bowlder as described in note 5,[1] with a reference mark, a bronze tablet in a bowlder, note 12d.[1]

Emily (Union County, Oreg., C. V. Hodgson, 1916).—About 7 miles direct and 12 miles by road and trail north of La Grande, on the highest bald point at the edge of the timber at the south end of the long ridge known locally as Mount Emily. The station is easily located by the Forest Service lookout tower, which is used as a witness mark. The station is marked by a bronze tablet in rock as described in note 2a,[1] with a reference mark, a bronze tablet in a bowlder, note 12d.[1] This station is about 10 miles west of the U. S. Geological Survey station of the same name.

La Grande (Union County, Oreg., C. V. Hodgson, 1916).—Opposite the freight depot, southwest of the intersection of Chester Street with the street running south of the railroad tracks, on a lot formerly occupied by a building which had been burned. The station was not marked. Reference mark No. 1, a bronze tablet in concrete, note 11a,[1] is in the southwest corner of the small sodded park between the passenger and freight depots. Reference mark No. 2, a bronze tablet in concrete, note 11a,[1] was buried with the top 1 inch below the surface because of the traffic and is just west of the longitude station and about 10 feet north of the north edge of the sidewalk. Reference mark No. 3 is a small cross chiseled in the concrete pavement about 15 inches back from the corner of the curb and on the line to station Fanny at the southwest corner of the intersection of Chester Street with the street along the south side of the railroad.

Birch (Umatilla County, Oreg., C. V. Hodgson, 1916).—About 9 miles east and 6 miles south of Pilot Rock and 5 miles east of Charles Manning's ranch. The station is best located by going east 1½ miles from Pilot Rock and taking the road known as Ridge Road, leading south and southeast over the ridge and following that to a point about 16 miles from Pilot Rock, when the station will lie about one-half mile to the north on a bald knob, with trees on the north and east slopes, which makes out to the north from the main ridge. The station is on the highest point of the knob and is marked by a bronze tablet in rock as described in note 2,[1] with a reference mark, a bronze tablet in rock, note 12a.[1]

Big Hill (Umatilla County, Oreg., C. V. Hodgson, 1916).—About 17 miles south of east from Pendleton, Oreg., 10 miles northwest from Meacham, and 100 meters north of the wagon road between the two towns, on a bald hill the north slope of which is covered with pine timber. About one-third mile to the eastward on the south side of the wagon road and on the same ridge is another bald knob about 10 feet higher than the one on which the station is located. The station is marked by a bronze tablet in a bowlder as described in notes 4 and 8a,[1] with a reference mark, a bronze tablet in a bowlder, note 12c.[1] Two witness marks, triangular blazes on trees, note 15a,[1] are distant, respectively, 21.8 meters (71.5 feet) in azimuth 181° 08′ 42″ and 20.7 meters (67.9 feet) in azimuth 194° 26′ 59″.

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[1] See p. 23.

Alkali (U. S. G. S.) (Umatilla County, Oreg., C. V. Hodgson, 1916).—Seventeen miles southeast of Echo, 12 miles west and 5 miles north of Pilot Rock, 1½ miles north and ¾ mile west of the Reeder ranch in the SW. ¼ sec. 29, T. 1 N., R. 30 E., on the uncultivated top of a rounded knoll of land owned by the Slusher brothers. The station is identical with the U. S. Geological Survey station of the same name and is marked by a U. S. G. S. marker. The reference mark is a bronze tablet in concrete as described in note 11c.[1]

Laurila (Umatilla County, Oreg., C. V. Hodgson, 1916).—About 2 miles north and 12 miles east of Stanfield, Oreg., 9 miles north and 7 miles west of Pendleton, 87 paces east of the center of sec. 20, T. 4 N., R. 31 E., 2 feet south of the east-and-west section-line fence, on land owned by John Laurila, who lives 1 mile south on the Missouri Gulch wagon road. The station is marked by a bronze tablet in concrete as described in notes 1b and 7a.[1]

Job (Umatilla County, Oreg., C. V. Hodgson, 1916).—About 9 miles southwest of Echo and 3 miles southwest of the Spike ranch on the highest part of a dome-shaped hill locally known as Service Butte. The station is identical with the U. S. Geological Survey station of the same name and is marked by a U. S. G. S. tablet cemented into the top of a large bowlder about 4 inches above the surface of the ground. The reference mark is a bronze tablet in rock as described in note 12a.[1]

Expansion (Benton County, Wash., C. V. Hodgson, 1916).—On the highest point of the group of hills just north of the Columbia River, 3 miles northeast of Umatilla, Oreg., 2 miles northeast of the Umatilla ferry landing on the Washington side of the Columbia River, and one-third mile north of the wagon trail leading from the ferry landing northeast over the hills. The station is identical with the U. S. Geological Survey station of the same name and is marked by a U. S. G. S. metal station mark cemented into the top of a bowlder about flush with the surface of the ground. The reference mark is a bronze tablet in rock as described in note 12a.[1]

Stanfield west base (Morrow County, Oreg., C. V. Hodgson, 1916).—Thirteen miles west of Stanfield, 7 miles south of Irrigon, 5 miles west and one-half mile north of the Stapish ranch, on the east side of an abandoned wagon trail leading from Irrigon to Sand Hollow. The stamped elevation on the U. S. Geological Survey bench mark is 620 feet. The 20-foot swath cleared through the sagebrush along the base line will locate the station for some years to come. The station is marked by a bronze tablet in concrete as described in notes 1a and 7a,[1] with a reference mark, a bronze tablet in concrete, note 11a.[1]

Stanfield east base (Umatilla County, Oreg., C. V. Hodgson, 1916).—Three and one-half miles west and one-half mile south of Stanfield, a station on the Oregon-Washington Railroad and Navigation Co. The station is near the west face of the middle mound of a prominent low hill called Emigrant Butte. A smaller hill lies about one-half mile to the southward with a wagon trail between. The station is marked by a bronze tablet in concrete as described in notes 1a and 8b.[1] Reference mark No. 1 is a bronze tablet in concrete as described in note 11a.[1] Reference mark No. 2 is similar to No. 1, except that in place of the standard reference mark is a wooden plug with a nail in the center.

Echo (Umatilla County, Oreg., C. V. Hodgson, 1916).—In the town of Echo, about 225 meters northeast of the railroad depot, 25 meters east of the upper irrigation canal, on a point of ridge nearest the town. The station is marked by a bronze tablet in concrete as described in notes 1a and 7a,[1] except that the underground mark bears an iron bolt in place of the usual metal mark. The reference mark is a bronze tablet in concrete as described in note 11a.[1] The center chimney of the concrete schoolhouse at Echo is in azimuth 0° 38′ 26″ and the center of the red wooden water tank at Echo is in azimuth 42° 03′ 08″.

Alder (U. S. G. S.) (Klickitat County, Wash., C. V. Hodgson, 1916).—On the highest point of a ridge about 2 miles north of the Columbia River and about the same distance west of north of Alderdale, Wash. The station is identical with the U. S. Geological Survey station of the same name and is marked by a U. S. G. S. marker in a bowlder as described in note 5,[1] with a reference mark, a bronze tablet in rock, note 12b.[1] The east gable of the Alderdale schoolhouse is in azimuth 324° 06′ 30″.

Ella (Morrow County, Oreg., C. V. Hodgson, 1916).—About 5 miles north and about one-half mile east of Ione, 3½ miles south and 1½ miles east of what was formerly Ella post office, 1 mile south and one-half mile west of U. S. Geological Survey station Ella, on a flat-topped ridge in a cultivated field in the NE. ¼ sec. 14, T. 1 N., R. 24 E., on the highest point in the vicinity. The fence line to the west is about 135 meters distant. The station is marked by a bronze tablet in concrete as de-

[1] See p. 23.

scribed in notes 1a and 7a,[1] with a reference mark, a bronze tablet in concrete, note 11a.[1]

Toby (U. S. G. S.) (Gilliam County, Oreg., C. V. Hodgson, 1916).—About 15 miles south and 2 miles east of Arlington, Oreg., ½ mile south and 1 mile east of the Toby ranch, in a cultivated field on the highest point of a ridge and just east of three large cisterns which are used for storing water for the Toby ranch. The station is identical with the U. S. Geological Survey station of the same name and is marked by an iron pipe and cap extending 8 inches above the surface, with a bronze tablet in concrete as reference mark, note 11a.[1]

Montgomery (U. S. G. S.) (Klickitat County, Wash., C. V. Hodgson, 1916).—On the highest part of a ridge about 8 miles northwest of Arlington, Oreg., and 7 miles northwest of Roosevelt, Wash., on land formerly owned by a Mr. Montgomery. Fred Emily's ranch is about 1 mile to the east and a conspicuous rocky knob near the edge of the bluff is 135 paces to the southwest. The hill is covered with large bowlders. The station is identical with the U. S. Geological Survey station of the same name and is marked by a U. S. G. S. marker in a bowlder as described in note 5, with a bronze tablet in rock as a reference mark, note 12b.[1]

John (Sherman County, Oreg., C. V. Hodgson, 1916).—In the northwest corner of the NW. ¼ sec. 17, T. 2 S., R. 18 E., on the highest part of a knoll in a cultivated field now leased by Joseph Eddy. Moro, Oreg., is about 7 miles north and 7 miles west of the station. The station is marked by a bronze tablet in concrete as described in notes 1a and 7a,[1] with a bronze tablet in concrete as a reference mark, note 11a.[1] Reference mark No. 2, a bronze tablet in a bowlder, note 12d,[1] is at the northwest corner of section 17. Permission was given to remove the surface mark but the underground mark can be recovered from the reference marks.

Maryhill (U. S. G. S.) (Klickitat County, Wash., C. V. Hodgson, 1916).—About 8 miles southeast of Goldendale, 5 miles northeast of Maryhill, and 5 miles east of the Maryhill-Goldendale road, on the highest point of the hills overlooking the Columbia River. The station is identical with the U. S. Geological Survey station of the same name and is marked by a U. S. G. S. marker in a bowlder according to note 5,[1] with a reference mark, a bronze tablet in rock, note 12b.[1]

Stacker (Klickitat County, Wash., C. V. Hodgson, 1916).—About 9 miles northeast of The Dalles, Oreg., and 10 miles southwest of Centerville, Wash., on a high bald hill on the first high ridge north of the Columbia River, 1 mile south of the Lyle-High Prairie-Centerville road and 1 mile east of the steep road which leads north from Grand Dalles over the ridge to the Lyle-High Prairie-Centerville road. The station is on land belonging to Leo F. Brun and is marked by a bronze tablet in a bowlder as described in notes 5 and 9a,[1] with a bronze tablet in a bowlder as a reference mark, note 12d.[1] The underground mark is about 2 feet below the surface.

Lookout (Hood River County, Oreg., C. V. Hodgson, 1916).—On the highest part of Lookout Mountain near the U. S. Geological Survey station of the same name marked by a cairn which was not removed. A Forest Service ranger cabin and lookout station is near by, a little to the south and west. Dufur is about 24 miles by road and trail to the northeast. The station is marked by a bronze tablet in a bowlder as described in note 5,[1] with a bronze tablet in a bowlder as a reference mark, note 12d.[1]

Chinidere (Hood River County, Oreg., C. V. Hodgson, 1916).—On the highest point of Chinidere Mountain, about 10 miles southeast of Cascade Locks, Oreg., 1 mile west of Wahtum Lake, and 10½ miles by trail south of Herman ranger station, on the Columbia River Highway. The station is marked by a bronze tablet in a bowlder as described in note 5, with a reference mark, a bronze tablet in a bowlder, note 12d.[1] A U. S. Geological Survey cairn is near by. (See "Geographic positions.")

Huckle (Skamania County, Wash., C. V. Hodgson, 1916).—On the highest point of Little Huckleberry Mountain, about 14 miles south of Guler post office and 8 miles south of Peterson Prairie ranger station. The station is marked by a bronze tablet in rock as described in note 2,[1] with a bronze tablet in rock as a reference mark, note12 a.[1]

SUPPLEMENTARY POINTS.

Oxford north base (Bannock County, Idaho, C. V. Hodgson, 1915).—Used only in connecting precise level B. M. E near Oxford railroad station to station *Oxford*. The station is 1.73 meters (5.7 feet) south of the bench mark and 25.905 meters (84.99 feet) east of the east rail of the railroad track. The station is not marked.

Oxford south base (Bannock County, Idaho, C. V. Hodgson, 1915).—Used only in connecting precise level B. M. E near Oxford railroad station with station *Oxford*. The point is about 1 mile south of the railroad station on the east side of the railroad

[1] See p. 23.

and 11.195 meters (36.73 feet) east of the east rail of the track. The station is not marked.

Precise level B. M. E (Bannock County, Idaho, C. V. Hodgson, 1915).—Near Oxford, Idaho, in the yard of an abandoned creamery, 12 feet south of the gate and 30 paces east of the main track of the Oregon Short Line Railroad. The station is marked by a stone or cement post projecting about 6 inches from the ground with the letters "U. S. B. M." cut in the top.

Henry (Bannock County, Idaho, C. V. Hodgson, 1915).—About 6½ miles east of Henry post office on a bald-topped hill with pine trees on the north slope. The station was marked by a wooden stake. It may be recovered by reference to the U. S. Geological Survey station of the same name which is marked by a U. S. G. S. marker and cairn. (See "Geographic positions.")

Woodall (Bannock County, Idaho, C. V. Hodgson, 1915).—About 9 miles northeast of Soda Springs and three-fourths mile east of the Woodall ranch in sec. 2, T. 8 S., R. 42 E. The station is not marked, but may be recovered by reference to a U. S. Geological Survey marker and cairn. (See "Geographic positions.")

Stump (Bannock County, Idaho, C. V. Hodgson, 1915).—About 8 miles northeast of Williamsburg post office and 5 miles east of the "Upper Dairy" ranch owned by Mr. Kuntz, on a bald peak at the head of Stump and Lane Creeks, the former flowing into Salt River and the latter into Black River. The station is identical with the U. S. Geological Survey station of the same name and is marked by a U. S. G. S. marker, 8 inches below the surface, and a cairn.

Blackfoot B. M. Q_6 (Bingham County, Idaho, C. V. Hodgson, 1915).—This station may be best located by comparison with precise level B. M. Q_6. (See "Geographic positions.")

Precise level B. M. Q_6 (Bingham County, Idaho, C. V. Hodgson, 1915).—About 2⅔ miles south of Blackfoot, Idaho, at the road crossing, 12 telegraph poles north of mile pole 155, one-half meter (1.6 feet) west of the Oregon Short Line Railroad right of way in the southeast corner of the public road junction. The station is marked by a U. S. Coast and Geodetic Survey metal bench mark disk.

Precise level B. M. M_4 (Elmore County, Idaho, C. V. Hodgson, 1915).—At Mountain Home, Idaho, on the foundation of the Oregon Short Line Railroad water tank in the southeast corner of the southeast capstone 5 inches from the south and 5 inches from the west side. The station is marked by a hole in a horizontal surface with the letters "U. S. B. M."

Mitchell (Malheur County, Oreg., C. V. Hodgson, 1915; 1920).—About 12 miles southwest of Nyssa, Oreg., on the highest part of Mitchell Butte near its north edge. The station is marked by a bronze tablet in a bowlder as described in note 5[1], with a bronze tablet in a bowlder as a reference mark, note 12d.[1] A U. S. Geological Survey cairn is near by. (See "Geographic positions.")

Idaho-Oregon boundary monument (Canyon-Malheur Counties, Idaho and Oreg., C. V. Hodgson, 1915).—In the big bend of the Snake River about 2½ miles east and about one-half mile south of River View Ferry, 2 miles south and 3 miles west of Roswell, Idaho, at the intersection of the State line with the east and west section line between sections 19 and 30, T. 21 S., R. 47 E., State of Oregon, and one-fourth mile south of Lee Baldridge's farmhouse. The station is 5 feet east of the east wagon track of the boundary road and is marked by a standard disk station mark set in the top of a stone 14 inches square and 26 inches long which projects 2 inches above the surface and marks the southeast corner of section 19 and the northeast corner of section 30, State of Oregon. A standard disk reference mark was set in the top of a stone in the middle of the road. The stone projects 2 inches above the surface and marks the southwest corner of sec. 35, T. 5 N., R. 6 W., and the northwest corner of sec. 2, T. 4 N., R. 6 W., State of Idaho, at the intersection of the township and State lines.

B. M. G (Malheur County, Oreg., C. V. Hodgson, 1915).—In the town of Nyssa, on the east side of the Oregon Short Line Railroad, about 1.5 meters (4.9 feet) west of the east fence along the railroad right of way and 190 meters (623 feet) south of the wagon road leading east to the bridge across the Snake River. The nearest rail of the railroad track is 23.5 meters (77.1 feet) west of the station, which is marked by a bronze tablet in concrete as described in note 1a.[1] The underground mark is a one-half inch iron pipe 8 inches long, the top of which is 10 inches below the surface of the ground. A reference mark, a bronze tablet in concrete, note 11a,[1] is in the fence line along the east side of the right of way.

Precise level B. M. G (Malheur County, Oreg., C. V. Hodgson, 1915).—At Nyssa, Oreg., in the capstone of the Oregon Short Line Railroad water tank, 0.1 meter (0.3

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[1] See p. 23.

foot) from the north edge and 0.1 meter (0.3 foot) from the east edge. The station is marked by a hole in a horizontal surface.

Granite (Wallowa County, Oreg., C. V. Hodgson, 1916).—On the summit of the Wallowa Mountains along the divide south of Minam River, in the northeast corner of the unsurveyed sec. 13, T. 5 S., R. 42 E. The peak is flat-topped and covered with large bowlders, in the top of one of which near the south side of the summit the station was placed. The peak has an elevation of about 8700 feet and is best reached from Medical Springs over Forest Service trails. The station is marked by a bronze tablet in rock, as described in note 3.

Bennet (Wallowa County, Oreg., C. V. Hodgson, 1916).—The cupola on the Forest Service lookout house on the summit of Bennet Peak, in the SW. ¼ sec. 13, T. 6 S., R. 43 E., W. M. The station is most easily reached over Forest Service trails from Medical Springs.

Ireland Mountain lookout cupola (Baker-Grant Counties, Oreg., C. V. Hodgson, 1916).—The station is the center of the top of the Forest Service lookout house on Ireland Mountain in sec. 29, T. 8 S., R. 36 E., W. M. The lookout house is situated on the highest point of the mountain on the divide between Grant and Baker Counties, near the head of Powder River.

Tower (Umatilla County, Oreg., C. V. Hodgson, 1916).—About 14 miles by road southeast of Lehman Springs in sec. 13, T. 6 S., R. 34 E., W. M. on a bare rocky point about one-fourth mile east of the Forest Service lookout tower on Lookout Mountain. The station is best reached by a wagon road which leads to the ranger station on top. It is marked by a bronze tablet in rock as described in note 3.[1]

Precise level B. M. 2782 A (Union County, Oreg., C. V. Hodgson, 1916).—At La Grande, Oreg., in the north face of the brick building of the Foley Hotel in the third course of plaster facing of the wall on the Chestnut Street side. The station is marked by a U. S. Geological Survey bench mark.

Arbuckle (Morrow County, Oreg., C. V. Hodgson, 1916).—About 100 yards east of the highest point of Arbuckle Mountain in sec. 29, T. 4 S., R. 29 E., W. M., directly beneath the top of a large tree. The station is best reached by wagon road from Heppner or Ukiah. It is marked by a bronze tablet in a bowlder as described in note 5.[1]

Gate (Umatilla County, Oreg., C. V. Hodgson, 1916).—On the north bank of the Reclamation Service irrigation canal about one-half mile south of Umatilla, Oreg., near the concrete house at the top of the small spillway leading down to the river. The station was used only in making connection with the U. S. Engineers' triangulation and was not marked.

Gravel (Umatilla County, Oreg., C. V. Hodgson, 1916).—At the top of a gravel bank which was being excavated by the railroad for ballast. The station was used only in making connection with the U. S. Engineers' triangulation and was not marked.

43 R (U. S. E.) (Benton County, Oreg., C. V. Hodgson, 1916).—About one-half mile east of the ferry landing, where the rocky ridge from the group of hills on which station *Expansion* is located meets the river. The station is described by the U. S. Engineers as "marked by a small cement patch on the first bench of rock near the ferry landing," and is on the Washington side of the Columbia River, across from Umatilla, Oreg.

44 L (U. S. E.) (Umatilla County, Oreg., C. V. Hodgson, 1916).—About 1½ miles east of Umatilla, Oreg., and about 10 meters (33 feet) back from the bank of the Columbia River on the Oregon side. The station is marked by a cedar hub with a nail in the top.

Tygh (Wasco County, Oreg., C. V. Hodgson, 1916).—About 2 miles east of Friend, Oreg., in the NW. ¼ sec. 32, T. 2 S., R. 13 E., in a bowlder pile near the top of a cultivated knoll on land belonging to Michael Glavey. The station is marked by a bronze tablet in a bowlder as described in note 5.[1]

Bald Peter (Wasco County, Oreg., C. V. Hodgson, 1916).—In the extreme southeast corner of the Oregon forest in sec. 1, T. 6 S., R. 11 E., W. M., on the northwest corner of the top of a bald rocky knob. The station is best reached by a wagon road from Wapinitia. It is marked by a bronze tablet in concrete as described in note 1a.[1]

Sedum Point (Skamania County, Wash., C. V. Hodgson, 1916).—On a rocky outcrop on the crest of Rock Creek Ridge, about 3½ miles southwest of Hemlock ranger station in sec. 31, T. 4 N., R. 7 E., W. M. The top is reached by trail from the ranger station. Sedum Point is about 4 miles southwest of Bunker Hill. The station is marked by a bronze tablet in rock as described in note 3.[1] Two witness marks, tri-

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[1] See p. 23.

angular blazes on trees, note 15,[1] are located, respectively, 15 feet southeast and 15 feet northwest of the station.

Little (Skamania County, Wash., C. V. Hodgson, 1916).—On the highest point of Lookout Mountain on the divide between Washougal River and the south fork of Lewis River and reached by Forest Service trails from Hemlock ranger station. The station is marked by a bronze tablet in rock as described in note 3.[1]

Big Huckleberry (Skamania County, Wash., C. V. Hodgson, 1916).—On the divide between Panther Creek and the Little White Salmon River about 4 miles southeasterly from station *Huckle*, on the highest point of the most southerly of the three summits forming Big Huckleberry Mountain. The station is best reached over the Forest Service trails from Wind River. It is marked by a bronze tablet in concrete as described in note 1a.[1]

Observation (Skamania County, Wash., C. V. Hodgson, 1916).—On the highest point of Sister Rocks about 21 miles northeast of Carson. A Forest Service lookout house is on the summit. The station is marked by a bronze tablet in rock as described in note 3,[1] the tablet being cemented in the rock floor beneath the tower. It is best reached from Carson via Government Mineral Springs over the Forest Service trails.

148 L (U. S. E.) (Wasco County, Oreg., C. V. Hodgson, 1916).—About eight-tenths mile east of Celilo, Oreg., and 190 feet above the river level, opposite, and 200 feet above mile post No. 101 of the Oregon-Washington Railroad & Navigation Co. tracks. The station is marked by a small pipe cemented in rock.

149 L (U. S. E.) (Wasco County, Oreg., C. V. Hodgson, 1916).—On the southern edge of the village of Celilo, at the southeast corner of the land reserved for the lock-keeper's quarters. The station is marked by brass monument No. 15.

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[1] See p. 23.

CONVERSION TABLES.

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

[Reduction factor: 1 foot=0.3048006096 meter.]

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

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

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

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

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

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

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

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

[Reduction factor: 1 meter=3.280833333 feet.]

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

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

Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.
250	820.20833	300	984.25000	350	1,148.29167	400	1,312.33333	450	1,476.37500
1	823.48917	1	987.53083	1	1,151.57250	1	1,315.61417	1	1,479.65583
2	826.77000	2	990.81167	2	1,154.85333	2	1,318.89500	2	1,482.93667
3	830.05083	3	994.09250	3	1,158.13417	3	1,322.17583	3	1,486.21750
4	833.33167	4	997.37333	4	1,161.41500	4	1,325.45667	4	1,489.49833
5	836.61250	5	1,000.65417	5	1,164.69583	5	1,328.73750	5	1,492.77917
6	839.89333	6	1,003.93500	6	1,167.97667	6	1,332.01833	6	1,496.06000
7	843.17417	7	1,007.21583	7	1,171.25750	7	1,335.29917	7	1,499.34083
8	846.45500	8	1,010.49667	8	1,174.53833	8	1,338.58000	8	1,502.62167
9	849.73583	9	1,013.77750	9	1,177.81917	9	1,341.86083	9	1,505.90250
260	853.01667	310	1,017.05833	360	1,181.10000	410	1,345.14167	460	1,509.18333
1	856.29750	1	1,020.33917	1	1,184.38083	1	1,348.42250	1	1,512.46417
2	859.57833	2	1,023.62000	2	1,187.66167	2	1,351.70333	2	1,515.74500
3	862.85917	3	1,026.90083	3	1,190.94250	3	1,354.98417	3	1,519.02583
4	866.14000	4	1,030.18167	4	1,194.22333	4	1,358.26500	4	1,522.30667
5	869.42083	5	1,033.46250	5	1,197.50417	5	1,361.54583	5	1,525.58750
6	872.70167	6	1,036.74333	6	1,200.78500	6	1,364.82667	6	1,528.86833
7	875.98250	7	1,040.02417	7	1,204.06583	7	1,368.10750	7	1,532.14917
8	879.26333	8	1,043.30500	8	1,207.34667	8	1,371.38833	8	1,535.43000
9	882.54417	9	1,046.58583	9	1,210.62750	9	1,374.66917	9	1,538.71083
270	885.82500	320	1,049.86667	370	1,213.90833	420	1,377.95000	470	1,541.99167
1	889.10583	1	1,053.14750	1	1,217.18917	1	1,381.23083	1	1,545.27250
2	892.38667	2	1,056.42833	2	1,220.47000	2	1,384.51167	2	1,548.55333
3	895.66750	3	1,059.70917	3	1,223.75083	3	1,387.79250	3	1,551.83417
4	898.94833	4	1,062.99000	4	1,227.03167	4	1,391.07333	4	1,555.11500
5	902.22917	5	1,066.27083	5	1,230.31250	5	1,394.35417	5	1,558.39583
6	905.51000	6	1,069.55167	6	1,233.59333	6	1,397.63500	6	1,561.67667
7	908.79083	7	1,072.83250	7	1,236.87417	7	1,400.91583	7	1,564.95750
8	912.07167	8	1,076.11333	8	1,240.15500	8	1,404.19667	8	1,568.23833
9	915.35250	9	1,079.39417	9	1,243.43583	9	1,407.47750	9	1,571.51917
280	918.63333	330	1,082.67500	380	1,246.71667	430	1,410.75833	480	1,574.80000
1	921.91417	1	1,085.95583	1	1,249.99750	1	1,414.03917	1	1,578.08083
2	925.19500	2	1,089.23667	2	1,253.27833	2	1,417.32000	2	1,581.36167
3	928.47583	3	1,092.51750	3	1,256.55917	3	1,420.60083	3	1,584.64250
4	931.75667	4	1,095.79833	4	1,259.84000	4	1,423.88167	4	1,587.92333
5	935.03750	5	1,099.07917	5	1,263.12083	5	1,427.16250	5	1,591.20417
6	938.31833	6	1,102.36000	6	1,266.40167	6	1,430.44333	6	1,594.48500
7	941.59917	7	1,105.64083	7	1,269.68250	7	1,433.72417	7	1,597.76583
8	944.88000	8	1,108.92167	8	1,272.96333	8	1,437.00500	8	1,601.04667
9	948.16083	9	1,112.20250	9	1,276.24417	9	1,440.28583	9	1,604.32750
290	951.44167	340	1,115.48333	390	1,279.52500	440	1,443.56667	490	1,607.60833
1	954.72250	1	1,118.76417	1	1,282.80583	1	1,446.84750	1	1,610.88917
2	958.00333	2	1,122.04500	2	1,286.08667	2	1,450.12833	2	1,614.17000
3	961.28417	3	1,125.32583	3	1,289.36750	3	1,453.40917	3	1,617.45083
4	964.56500	4	1,128.60667	4	1,292.64833	4	1,456.69000	4	1,620.73167
5	967.84583	5	1,131.88750	5	1,295.92917	5	1,459.97083	5	1,624.01250
6	971.12667	6	1,135.16833	6	1,299.21000	6	1,463.25167	6	1,627.29333
7	974.40750	7	1,138.44917	7	1,302.49083	7	1,466.53250	7	1,630.57417
8	977.68833	8	1,141.73000	8	1,305.77167	8	1,469.81333	8	1,633.85500
9	980.96917	9	1,145.01083	9	1,309.05250	9	1,473.09417	9	1,637.13583

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

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

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

Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.	Meters.	Feet.
750	2,460.62500	800	2,624.66667	850	2,788.70833	900	2,952.75000	950	3,116.79167
1	2,463.90583	1	2,627.94750	1	2,791.98917	1	2,956.03083	1	3,120.07250
2	2,467.18667	2	2,631.22833	2	2,795.27000	2	2,959.31167	2	3,123.35333
3	2,470.46750	3	2,634.50917	3	2,798.55083	3	2,962.59250	3	3,126.63417
4	2,473.74833	4	2,637.79000	4	2,801.83167	4	2,965.87333	4	3,129.91500
5	2,477.02917	5	2,641.07083	5	2,805.11250	5	2,969.15417	5	3,133.19583
6	2,480.31000	6	2,644.35167	6	2,808.39333	6	2,972.43500	6	3,136.47667
7	2,483.59083	7	2,647.63250	7	2,811.67417	7	2,975.71583	7	3,139.75750
8	2,486.87167	8	2,650.91333	8	2,814.95500	8	2,978.99667	8	3,143.03833
9	2,490.15250	9	2,654.19417	9	2,818.23583	9	2,982.27750	9	3,146.31917
760	2,493.43333	810	2,657.47500	860	2,821.51667	910	2,985.55833	960	3,149.60000
1	2,496.71417	1	2,660.75583	1	2,824.79750	1	2,988.83917	1	3,152.88083
2	2,499.99500	2	2,664.03667	2	2,828.07833	2	2,992.12000	2	2,156.16167
3	2,503.27583	3	2,667.31750	3	2,831.35917	3	2,995.40083	3	3,159.44250
4	2,506.55667	4	2,670.59833	4	2,834.64000	4	2,998.68167	4	3,162.72333
5	2,509.83750	5	2,673.87917	5	2,837.92083	5	3,001.96250	5	3,166.00417
6	2,513.11833	6	2,677.16000	6	2,841.20167	6	3,005.24333	6	3,169.28500
7	2,516.39917	7	2,680.44083	7	2,844.48250	7	3,008.52417	7	3,172.56583
8	2,519.68000	8	2,683.72167	8	2,847.76333	8	3,011.80500	8	3,175.84667
9	2,522.96083	9	2,687.00250	9	2,851.04417	9	3,015.08583	9	3,179.12750
770	2,526.24167	820	2,690.28333	870	2,854.32500	920	3,018.36667	970	3,182.40833
1	2,529.52250	1	2,693.56417	1	2,857.60583	1	3,021.64750	1	3,185.68917
2	2,532.80333	2	2,696.84500	2	2,860.88667	2	3,024.92833	2	3,188.97000
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 geographical 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.

RECONNOISSANCE AND SIGNAL BUILDING.

Detailed specifications for reconnoissance for precise triangulation, such as governed the selection of the stations on this arc, are given in U. S. Coast and Geodetic Survey Special Publication No. 19. In brief, the principal requirements are that such stations and figures should be selected as to make the total cost of reconnoissance, building, and observing a minimum, that the R_1 between bases should be about 100 and should not exceed 150, that Laplace stations should be provided at intervals of from four to six figures, that connections to precise level bench marks should be provided at intervals of 100 to 150 miles, and that if the line of a figure in the direction of progress is more than 40 miles in length, then additional stations, which need not be occupied, should be interpolated.

The reconnoissance for this arc was made by J. S. Bilby, signalman, in the early summer of 1915, and for the first time a motor truck was used as a means of transportation by the reconnoissance party. It had previously been thought that trucks could not be economically used on such work in mountainous regions, but although a large percentage of the stations were mountain stations and the roads were very poor on the average, yet the extremely good progress made and the low costs of the reconnoissance demonstrated conclusively that horse or mule teams on reconnoissance are expensive and should be abandoned in the future.

Only 64 working days were consumed by Mr. Bilby in doing the reconnoissance and in preparing a large part of the stations. The reconnoissance started at a point near Pocatello, Idaho, and extended to a junction with the California-Washington arc in the vicinity of Portland, Oreg. The reconnoissance from the transcontinental arc to the vicinity of Pocatello had been done during a previous season in connection with another scheme of triangulation. The stations from the line Ogden Peak-Pilot Peak of the transcontinental arc in Utah to the Stanfield base in Oregon were prepared for the observer by setting the marks and building the stands for the theodolite. So long as the stations were being prepared for observing the party consisted of two men besides the chief of party, but west of the Stanfield base only one man besides the chief of party was employed. The total cost of the reconnoissance and signal building for the entire arc, including $310 spent in 1916 in preparing the stations on the western end, was only $1870. Some of the principal cost factors are tabulated below.

Length of main scheme of reconnoissance, in statute miles	520
Area, in square statute miles	20 100
New points selected	37
Stations prepared	39
Cost per mile of progress, in dollars	3.60
Total miles run by truck	4262
Miles per gallon of gasoline	11⅔
Cost per mile, running expenses of truck, not including any depreciation of truck or tires, in cents	2.3

HORIZONTAL ANGLE OBSERVATIONS.

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. In that manner a rough measure was obtained of the change in refraction between the day and night observations, and the night observations could be corrected accordingly. The errors of the trigonometric leveling will be discussed later (p. 71), but it may be said here that night observations for elevations are unsatisfactory, even with the precautions indicated above. If connections are made to bench marks at the intervals prescribed on this arc, the intermediate elevations are sufficiently accurate to reduce the lengths of the lines to sea-level lengths, but they should be used with caution in topographic mapping. Night observations for verticals were made only when it was necessary to do so in order not to delay the progress of the work.

The instructions for azimuth work along the line were to the effect that besides the Laplace stations, which were located four to six figures apart, primary azimuth observations were to be made at intervals of from 40 to 80 miles, with the lower limit preferred. At the Laplace stations azimuth observations were to be made on two nights with an accuracy for the station represented by a probable error of not more than ±0.″3, while at the primary azimuth stations a probable error not greater than 0.″5 was permitted, and the observations could be made on a single night. In no case were a night's observations for azimuth to depend upon less than 10 positions of the circle.

INSTRUMENTS AND METHODS.

The instrument used for the horizontal angle observations was a 12-inch direction theodolite, made in the shops of the U. S. Coast and Geodetic Survey, and read to single seconds by each of three micrometer microscopes equally spaced about the circle. Practically all the precise triangulation of the Survey since the early nineties has been done by precise theodolites of this type. A full description of the instrument is given in Appendix 8, Report for 1894.

The signal lamps used were the carbide type with 6½″ reflecting Mangin lenses, delivering about 1500-beam candlepower at 100 feet, with an angle of dispersion of the principal cone of rays of about 7°. These lamps under ordinarily favorable atmospheric conditions are visible to the unaided eye for 40 miles and under very favorable conditions in the West for more than 100 miles. The longest line observed over was 133 miles in length. This is practically the limit of visibility for these lamps.

The heliotropes used by the light keepers, upon which observations for vertical angles were made, were of the box type, with either 3¾-inch or 6-inch mirrors, depending upon the length of line. The 6-inch mirror has since that time been adopted as the standard size for all lengths of line.

A vertical circle with 6-inch graduated arc was used for the vertical-angle observations for trigonometric leveling, and also for the time observations for azimuth.

ORGANIZATION OF PARTY.

The observing party consisted of the writer, who was the chief of party and observer, a recorder, and two truck drivers. The party lived in tents and cooked their own meals over an open fire in order to avoid the extra weight of a cook and his outfit. All members of the party helped equally in cooking, making and breaking camp, and in packing. The outfit of instruments, camp equipment, and stores of the observing party varied in weight from 2500 to 3500 pounds, and was transported on two three-quarter ton trucks.

Eight light keepers were employed and assigned singly to stations. Each had his own camp outfit, which with instruments, carbide, 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 International Morse code for signaling with the signal lamps and heliotropes, in order that the observer could keep in close touch with him and keep him informed of the observer's requirements. Detailed "Instructions to Light keepers" are given in Special Publication No. 65.

The light keepers moved from station to station by means of hired teams, pack animals, and railroads. On the western end of the arc, where the distances between stations were shorter, one of the trucks of the observing party was often used to advantage in moving the light keepers.

TIME SPENT ON OBSERVING.

The observations on this arc were completed during the seasons of 1915 and 1916. For the first season lack of funds prevented beginning the work until the middle of June, and a total of only 4.4 months was spent in the field. Because of unfavorable observing conditions three months were consumed on the first two figures of the scheme, during which time only six primary stations and four secondaries were occupied. Several of the lines were more than 100 miles in length. After the long lines were completed an average of eight stations per month was made, and the close of the season found the observing completed to the Idaho-Oregon line.

The following season work was begun in the early part of May. Because of the heavy snows on the mountains, where many of the stations were located, the Stanfield (Oreg.) base was measured before the horizontal angle observations were begun. While the base was being measured, two men were sent out with one of the motor trucks to mark and prepare the stations to the westward. The necessary training of the light keepers and the overhauling of outfit was also done during this period.

Beginning the middle of June at the Stanfield base, the observing was first completed to the westward to a junction with stations of the California-Washington arc in the vicinity of Portland, Oreg. Because of unusually heavy winter snows and a late spring, even in mid-July, the stations in the Cascade Range were reached only after packing over snow several feet deep on the upper slopes of the mountains. This condition not only delayed the party in moving but also was the cause of the peaks being cloud-capped to a degree not usually found at that period of the year.

A rather unusual combination of methods of transportation occurred in the one-day move from station Chinidere to station Larch, both in the Cascade Range, which also illustrates the economy of truck transportation for a triangulation party even in mountain regions. Following a period of rain and fog, observations were finished at Chinidere one morning about daylight. The instrumental outfit was then back packed 1½ miles down to the upper camp, the point nearest to the station to which pack animals could be taken on account of the deep snow. From there pack animals were used to pack the outfit to the trucks at the base camp 9 miles below, which was reached about noon. Transferring the outfit to the trucks, the run of 48 miles to the foot of Larch Mountain was made in time to catch the last train up the mountain on the little logging railroad. This 8-mile lift took the party to within 1½ miles of the top. The instruments were back packed to the station by dark and the horizontal angle observations finished by 3 a. m. After a trip down to the cook shack of the logging camp for breakfast and a couple of hours' sleep the party returned to the station and finished the vertical-angle observations by 11 a. m. and was 30 miles on the road to the next station by dark.

Such moves were made possible by having the instrumental outfit which was needed at each station so conveniently and compactly arranged that it could be quickly transferred from the trucks to pack animals or to the backs of the members of the party. Extreme care was also taken to make the outfit as light as possible. The theodolite head, when fitted into its carrying crate of wood and canvas fitted with shoulder straps, weighed only 70 pounds and was carried by one man. The theodolite telescope and the vertical circle, the latter being a separate instrument, were fitted into a special carrying crate and were packed by one man, who also carried canteens and record books. Both of these carrying crates fitted into strong boxes which were left in the trucks and could be thus transported without any change in packing and without danger of being broken. The observing tent was of the hexagonal type, the poles and spider constructed of light steel tubing, and the walls of balloon silk. The tent and poles, together with a knapsack containing small instruments, lunch, etc., made a pack for a third man.

The occupation of station Larch completed the connection between the Stanfield base and the California-Washington arc of precise triangulation, after which the light keepers were sent to their new stations east of the Stanfield base in preparation for the observing on the remaining portion of the arc between the base and the junction with the work of the previous season at the Idaho-Oregon line. The observing party stopped long enough on the way to make the reconnoissance and observations for a connection with the triangulation of the Corps of Engineers, U. S. Army, at Celilo, Oreg., along the Columbia River. A similar connection had been made at the beginning of the season with triangulation of the Corps of Engineers along the Columbia River at Umatilla, Oreg.

Of the remaining 14 stations 5 were reached by long packs and 2 were located by the observing party after it was found that one of the reconnoissance lines was obstructed, so that six weeks were required to complete the observing.

A total for the two seasons of 7.4 months were spent on the observing, exclusive of the time spent in measuring the base. Measured through the axis of the scheme the arc is about 640 miles in length, so that an average of about 85 miles of progress per month was made. Forty-nine stations of the main scheme were occupied, and 20 stations of supplemental schemes. It has been the custom to estimate two supplemental stations as equal to one primary station in cost and time consumed. On that basis the party averaged 8 stations per month on the arc.

ACCURACY SECURED.

Seven stations were reoccupied because of poor triangle closures, two in 1915 and five in 1916. Two or three of these reoccupations gave interesting evidence of the causes of horizontal refraction and the magnitude of their effects. In 1915 the triangles on each side of the line Camas-Silver failed by about 6″, and since the direction to Silver at Camas had been observed on a helio in order to save a delay in finishing the station, those observations were at once suspected. Upon reoccupying the station and reobserving at night the line in doubt the direction was changed by almost 5″.

Of the five stations reoccupied in 1916 three of them were reoccupied twice before there was a change in the atmospheric conditions which would cause a change of more than a second in the observed direction. At station Stacker there was a 6″ triangle closure, but the first reoccupation gave a value almost identical with the original observation, and it was not until a second reoccupation that the closures were bettered. The line passed near no obstruction but lay over a deep valley, diverging about 30° to the northward from a high ridge leading west for several miles from the station, at about the same elevation as the point occupied. The only variation in the observing conditions which was noticeable was that during the first and second occupations there was a gentle breeze blowing off the ridge toward the line of sight, and that the weather was warm. On the last night the weather was cool, and a brisk wind blew from the line of sight toward the ridge. Previous observers have pointed out the refraction which takes place when a line is observed close to a slope with the wind blowing down the slope, if there is a marked difference of temperature between the air and the ground, but a line so far away from a slope as the one from Stacker would not ordinarily be suspected.

STATEMENT OF COSTS.

The principal elements of the costs of the observing on this arc can be readily seen from the tabulation below.

Total expenses (including depreciation of trucks and salary of observer, plus annual leave earned, but excluding cost of base)	$18 166.71
Linear miles of progress through scheme	640
Cost per mile of progress	$28.39
Number of square miles covered	30 190
Cost per square mile	$0.60
Number of stations of main scheme	49
Number of stations of supplemental schemes	20
Cost per station (two supplemental equal one primary)	$307.91
Points whose geographical position were determined	163
Cost per point determined	$111.45

BASE MEASUREMENT.

DESCRIPTION OF BASE.

The only base measured with precise accuracy on the Utah-Washington arc was one about 10 miles long just west of Stanfield, Oreg. This was measured by the party of the writer prior to beginning the observations for triangulation in 1916. The base traversed a rolling country with small and even grades except near the east end of the base, where the grade was as much as 12 per cent, and near the middle of the base, where the line crossed a creek bottom and the grades reached 8 per cent.

The soil was almost uniformly a firm sand, which permitted the 4 by 4 inch stakes to be driven to a depth of 1½ to 2 feet. This made the stakes unusually firm and no trouble or error was introduced by unstable tape supports.

METHODS USED.

The measurement was made with 50-meter invar tapes, using the same methods which have been employed for several years in the U. S. Coast and Geodetic Survey. These methods are indicated in brief by the following extracts from the instructions given in Special Publication No. 19.

Very little increase in the average accuracy of the lengths of the triangle sides in the triangulation connected with a base will result from increasing the accuracy of the base measurement beyond that represented by a probable error of 1 part in 500 000 in the length of the base. The following limits of accuracy are selected with a view of attaining a probable error but little, if any, greater than 1 part in 500 000. You will strive to keep as far within these limits as is possible by the use of good judgment and skill, but you will restrict the time and money expended upon each operation substantially to that required to keep barely within them.

Four invar tapes are to be standardized at the Bureau of Standards both before and after the measurement of the bases. Each base is to be measured with three of these invar tapes used in daylight or at night. A base shall be measured in sections approximately 1 kilometer in length, except that one shorter section may be used. Each section of a base shall be measured with at least two different invar tapes. Different pairs of invar tapes shall be used on different sections, so that the three tapes used on the base shall thereby be thoroughly intercompared. Two, and only two, measurements of each section shall be made, unless the discrepancy between these two measurements exceeds 20 millimeters $\sqrt{K}$ (in which K is the length of the section in kilometers), in which case additional measurements must be made until two are obtained which agree within this limit. The fourth invar tape standardized is to be retained for use in case of serious damage to any of the three tapes with which the measurements would otherwise be made.

Such precautions should be taken to secure accurate horizontal and vertical alignment of the tapes and the determination of the tension applied to the tapes as is necessary to insure that the errors arising from these sources on a base shall each be less than 1 part in 1 000 000.

STANDARDIZATIONS OF TAPES.

The equations of the tapes supported at the 0, 25, and 50 meter points and under a tension of 15 kilograms as determined before the measurement by the Bureau of Standards on July 28 and September 17, 1915, are:

$$T_{516} = 50m + (9.647mm \pm 0.011mm) + (0.0178mm \pm 0.0007mm) \times (t - 30^\circ.3C).$$
$$T_{517} = 50m + (9.909mm \pm 0.014mm) + (0.0160mm \pm 0.0007mm) \times (t - 30^\circ.3C).$$
$$T_{521} = 50m + (10.185mm \pm 0.010mm) + (0.0205mm \pm 0.0008mm) \times (t - 30^\circ.3C).$$
$$T_{522} = 50m + (10.625mm \pm 0.015mm) + (0.0591mm \pm 0.0011mm) \times (t - 24^\circ.8C).$$

The equations of the same tapes under similar conditions of tension and support as given by the Bureau of Standards from the standardization of November 23, 1916, when reduced to the temperatures of the July, 1915, standardization, are:

$$T_{516} = 50m + 9.382mm \text{ at } 30^\circ.3C.$$
$$T_{517} = 50m + 9.779mm \text{ at } 30^\circ.3C.$$
$$T_{521} = 50m + 10.039mm \text{ at } 30^\circ.3C.$$
$$T_{522} = 50m + 10.640mm \text{ at } 24^\circ.8C.$$

Tape No. 522 was carried to the field but was not used.

The adopted equations of the tapes used in the final computations of the Stanfield base are:

$$T_{516} = 50m + 9.515mm \text{ at } 30^\circ.3C.$$
$$T_{517} = 50m + 9.844mm \text{ at } 30^\circ.3C.$$
$$T_{521} = 50m + 10.112mm \text{ at } 30^\circ.3C.$$

The adopted values are the means of the two standardizations and are based upon the assumption that the change was not a function of the elapsed time between the two standardizations but was produced at a uniform rate by the use of the tapes while measuring the base, or was due to errors in the standardizations of the tape.

REDUCTION TO SEA LEVEL.

The mean elevation of the Stanfield base is 184.4 meters. The formula used in reducing the measured length of the base to its length at sea level is:

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

in which C is the reduction to sea level for a section of length S and mean elevation h, and r is the radius of the earth's curvature for the section in question. The reduction to sea level for each section is given in the table of results in the column headed "Correction, sea level."

Computation of Stanfield (Oreg.) base line.

Section.	Date.	Dir. of meas.	Tape No.	Uncorrected length. Tape lengths.	Uncorrected length. Meters.	Temp.	Corrections. Temp.	Corrections. Tape and catenary.	Corrections. Set-up. Set-back.	Corrections. Inclination.	Corrections. Sea level.	Reduced length.	Means by tapes.	Adopted length.	(v)	(vv)
	1916					°C.	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*mm.*	*mm.*
West base-20	May 30	E	516	20	1000	22.4	−0.0028	+0.1903	−0.0512	−0.0329	−0.0295	1000.0739			+0.9	0.81
	May 31	W	517	20	1000	22.5	−.0025	+.1969	−.0564	−.0329	−.0295	1000.0756		1000.0748	−.8	.64
20-40	May 30	E	516	20	1000	23.2	−.0025	+.1903		−.0193	−.0292	1000.1393	1000.1393		−2.2	4.84
	May 31	W	517	20	1000	21.5	−.0028	+.1969	−.0131	−.0193	−.0292	1000.1325				
	June 3	W	517	20	1000	31.0	+.0002	+.1969	−.0112	−.0193	−.0292	1000.1374	1000.1350	1000.1371	+2.1	4.41
40-60	May 30	E	516	20	1000	23.1	−.0026	+.1903	−.0633	−.0523	−.0289	1000.0432	1000.0432		−3.0	9.00
	May 31	W	517	20	1000	21.6	−.0028	+.1969	−.0778	−.0523	−.0289	1000.0351				
	June 3	W	517	20	1000	31.2	+.0003	+.1969	−.0765	−.0523	−.0289	1000.0395	1000.0373	1000.0402	+2.9	8.41
60-80	May 30	E	516	20	1000	22.6	−.0027	+.1903		−.0410	−.0284	1000.1182			+3.6	12.96
	May 31	W	517	20	1000	20.9	−.0030	+.1969	+.0010	−.0410	−.0284	1000.1255		1000.1218	−3.7	13.69
80-100	May 30	E	516	20	1000	22.4	−.0028	+.1903		−.0332	−.0281	1000.1262			+.8	.64
	May 31	W	517	20	1000	20.7	−.0031	+.1969	−.0048	−.0332	−.0281	1000.1277		1000.1270	−.7	.49
100-120	May 30	E	516	20	1000	22.0	−.0029	+.1903		−.0482	−.0276	1000.1116			−2.6	6.76
	May 31	W	517	20	1000	20.0	−.0033	+.1969	−.0115	−.0482	−.0276	1000.1063		1000.1090	+2.7	7.29
120-140	May 30	E	517	20	1000	21.5	−.0028	+.1969	−.1212	−.0384	−.0267	1000.0078			−2.0	4.00
	May 31	W	521	20	1000	18.8	−.0047	+.2022	−.1287	−.0384	−.0267	1000.0037		1000.0058	+2.1	4.41
140-160	May 30	E	517	20	1000	21.1	−.0029	+.1969	−.1262	−.0453	−.0266	999.9959			−.9	.81
	May 31	W	521	20	1000	18.7	−.0048	+.2022	−.1314	−.0453	−.0266	999.9941		999.9950	+.9	.81
160-180	May 30	E	517	20	1000	20.3	−.0032	+.1969	−.0590	−.0608	−.0265	1000.0474			−1.2	1.44
	May 31	W	521	20	1000	17.4	−.0053	+.2022	−.0647	−.0608	−.0265	1000.0449		1000.0462	+1.3	1.69
180-200	May 30	E	517	20	1000	20.0	−.0033	+.1969		−.1470	−.0280	1000.0186			−2.0	4.00
	May 31	W	521	20	1000	16.4	−.0057	+.2022	−.0068	−.1470	−.0280	1000.0147		1000.0166	+1.9	3.61
200-220	May 30	E	517	20	1000	19.4	−.0035	+.1969	−.0665	−.1245	−.0297	999.9727				
	May 31	W	521	20	1000	15.3	−.0062	+.2022	−.0765	−.1245	−.0297	999.9653				
	June 2	E	521	20	1000	17.6	−.0052	+.2022	−.0774	−.1245	−.0297	999.9654	999.9654		−3.8	14.44
	June 3	W	517	20	1000	28.1	−.0007	+.1969	−.0686	−.1245	−.0297	999.9734	999.9730	999.9692	+3.8	14.44
220-240	June 2	E	521	20	1000	18.5	−.0048	+.2022	+.0317	−.0249	−.0308	1000.1734			+4.1	16.81
	June 3	W	516	20	1000	27.7	−.0009	+.1903	+.0479	−.0249	−.0308	1000.1816		1000.1775	−4.1	16.81
240-260	June 2	E	521	20	1000	20.2	−.0041	+.2022		−.4466	−.0286	999.7229			+4.1	16.81
	June 3	W	516	20	1000	28.2	−.0007	+.1903	+.0168	−.4466	−.0286	999.7312		999.7270	−4.2	17.64
260-280	June 2	E	521	20	1000	24.5	−.0023	+.2022	+17.1400	−.7427	−.0290	1016.5682			+1.0	1.00
	June 3	W	516	20	1000	25.8	−.0016	+.1903	+17.1532	−.7427	−.0290	1016.5702		1016.5692	−1.0	1.00
280-300	June 2	E	521	20	1000	27.7	−.0011	+.2022	−.0611	−.0945	−.0310	1000.0145			−1.5	2.25
	June 3	W	516	20	1000	24.5	−.0021	+.1903	−.0511	−.0945	−.0310	1000.0116		1000.0130	+1.4	1.96
300-320	June 2	E	521	20	1000	27.4	−.0012	+.2022	+.0482	−.0374	−.0311	1000.1807			−4.5	20.25
	June 3	W	516	20	1000	23.3	−.0025	+.1903	+.0525	−.0374	−.0311	1000.1718		1000.1762	+4.4	19.36
320-East base	June 2	E	521	11	550	27.3	−.0007	+.1112	+30.5009	−1.2266	−.0192	579.3656			−3.2	10.24
	June 3	W	516	11	550	22.1	−.0016	+.1047	+30.5019	−1.2266	−.0192	579.3592		579.3624	+3.2	10.24

The length of the Stanfield base is 16 596.6680 meters. The probable error of the measured length, not including the probable error of the standardizations of the tapes is ±7.6 mm., which corresponds to 1 part in 2 183 772.

STATEMENT OF COST.

The actual time spent in measuring the base with the tapes was only 13.1 hours. The length of the base, doubled, was 33.2 kilometers, giving 2.52 kilometers of completed base per hour. The time given above includes that spent in remeasuring 4 kilometers, so that the actual average rate was 2.82 kilometers per hour.

The total cost of the base was about $780, which includes labor, expressage, salary of chief of party, lumber, running expenses, and depreciation of truck, etc., but no charges for standardization. This is an approximate cost of $47 per kilometer, or about $76 per mile. If $200 were added as the cost of one standardization of the four tapes the total cost to the Government would be $980. This gives a cost of about $60 per kilometer, or $97 per mile.

ASTRONOMIC WORK.

The astronomic latitudes and longitudes of four stations of this arc were determined by J. E. McGrath and W. B. Fairfield, hydrographic and geodetic engineers, during the summer of 1916. The principal purpose of this work was to obtain the astronomic longitudes at the Laplace stations for the purpose of controlling the azimuths in the triangulation as explained in the paragraph following. The astronomic latitude was observed at each longitude station for the purpose of determining the deflection of the vertical in the meridian. The observations for latitude were made at a station while the other longitude observer was moving to his next station and setting up his instruments, so that no delay was caused thereby.

LAPLACE POINTS.

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

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

It is possible to carry the geodetic longitudes throughout a continuous system of triangulation with very little error, but the geodetic azimuth is affected by the accidental errors of the observations of horizontal directions and also by the systematic error which seems almost always to be present in an arc of triangulation.[2] The effect on the azimuth is, in general, of such a magnitude that it is very desirable that true or Laplace azimuths be introduced into the scheme and held in the adjustment of the triangulation. This was done in the triangulation covered by this report. The Laplace azimuths are at Echo and La Grande, Oreg., and Mountain Home, Idaho.

ASTRONOMIC LATITUDES.

The observations for latitude were made with the Bamberg broken telescope type transit during the occupation of the stations for longi-

[2] *See pp. 64–79 of U. S. Coast and Geodetic Survey Special Publication No. 19.*

tude. The Bamberg transit may be used for the determination of latitude by the Horrebow-Talcott method in much the same manner as with the zenith telescope except in some minor details. The general methods followed in this work were those given in U. S. Coast and Geodetic Survey Special Publication No. 14.

At each station from 15 to 19 pairs of stars were observed on from one to three nights, with a resulting accuracy represented by a probable error for the station of from ±0.″06 to ±0.″11.

In every case, with the exception of station Blackfoot, the astronomic station was referred to the triangulation station, the descriptions of which may be found by consulting the index.

The following table gives the names of the latitude stations, their geodetic latitudes and longitudes, their astronomic latitudes reduced to sea level, and the values A–G, the astronomic minus the geodetic latitude, which is the deflection of the vertical in the meridian. The astronomic latitudes have not been reduced for the variation of latitude.

Deflections in the meridian.

Station.	Geodetic latitude.	Geodetic longitude.	Astronomic latitude.	A–G.
	° ′ ″	° ′ ″	″	″
Echo, Oreg.	45 44 38.385	119 11 20.222	38.89	+0.50
La Grande, Oreg.	45 19 49.467	118 05 39.346	52.99	+3.52
Mountain Home, Idaho	43 07 44.382	115 41 36.050	41.91	−2.47
Blackfoot longitude station, Idaho	43 10 59.710	112 21 01.412	58.49	−1.22

ASTRONOMIC LONGITUDES.

The five observed differences of longitude connected the four new stations in this longitude chain with the old longitude stations at Walla Walla, Wash., and Salt Lake City, Utah, both the latter being points in the adjusted longitude net of the United States. (See Appendix No. 2. Report for 1897.)

The observations were made with Bamberg broken telescope transits, Nos. 20 and 21, equipped with self-registering micrometers. The methods used were those described in U. S. Coast and Geodetic Survey Special Publication No. 14, modified to conform to the requirements of the broken telescope type of transit.

The descriptions of the new stations and the data connected with each of the five differences of longitude follow.

Difference of longitude between Echo, Oreg., and Walla Walla, Wash.

Date of exchange of time signals.	Observer.		Difference of longitude.	v.
	Western station, *Echo*.	Eastern station, *Walla Walla*.		
1916.			m. s.	s.
August 2	W. B. Fairfield	J. E. McGrath	3 23.204	+0.007
August 3			23.218	−.007
Mean			3 23.211 ± .005	

At Echo a new station was established. Bamberg transit No. 21 was mounted on a temporary wooden pier 2.973 meters due north of Echo triangulation station. (See description on p. 28.)

At Walla Walla, Bamberg transit No. 20 was mounted on a temporary pier 188.064 meters (0ˢ.583) east of the station of 1887–1888.

	h.	m.	s.
Echo transit (1916) to Walla Walla transit (1887–1888)	0	3	22.628
Correction for loop closure	...	..	−0.006
Adjusted difference	0	3	22.622
Longitude Walla Walla transit (1887–1888), 1897 adjustment[3]	7	53	23.331
Longitude Echo transit (1916), adjusted	7 119°	56 11′	45.953 29″.295
Reduction to Echo triangulation station	...	..	.000
Longitude, Echo triangulation station	119	11	29.295

Difference of longitude between Echo and La Grande, Oreg.

Date of exchange of time signals.	Observer.		Difference of longitude.	v.
	Western station, *Echo.*	Eastern station, *La Grande.*		
1916.			m. s.	s.
August 19	W. B. Fairfield	J. E. McGrath	4 23.436	−0.023
August 20			23.457	− .002
August 21			23.483	+ .024
Mean			4 23.459 ± .009	

At Echo, Bamberg transit No. 21 was mounted on the temporary pier of the 1916 station. (See p. 51.)

At La Grande a new station was established. Bamberg transit No. 20 was mounted on a temporary wooden pier 76.396 meters (2″.47) north and 40.290 meters (1″.850) west of La Grande triangulation station. (See description on p. 27.)

	h.	m.	s.
Echo transit (1916) to La Grande transit (1916)	0	4	23.459
Correction for loop closure	...	..	+0.006
Adjusted difference	0	4	23.465
Longitude Echo transit (1916), adjusted	7	56	45.953
Longitude La Grande transit (1916), adjusted	7 118°	52 05′	22.488 37″.320
Reduction to La Grande triangulation station	...	..	−1.850
Longitude, La Grange triangulation station	118	05	35.470

Difference of longitude between La Grande, Oreg., and Mountain Home, Idaho.

Date of exchange of time signals.	Observer.		Difference of longitude.	v.
	Western station, *La Grande.*	Eastern station, *Mountain Home.*		
1916.			m. s.	s.
September 1	J. E. McGrath	W. B. Fairfield	9 35.781	−0.012
September 5			35.810	+ .017
September 6			35.789	− .004
Mean			9 35.793 ± .006	

At La Grande, Bamberg transit No. 20 was mounted on the temporary pier of the 1916 station. (See above.)

[3] See App. No. 2, Report for 1897, p. 254.

At Mountain Home a new station was established. Bamberg transit No. 21 was mounted on a temporary wooden pier 7.495 meters (0".332) due west from Mountain Home triangulation station. (See description on p. 26.)

	h.	m.	s.
La Grande transit (1916) to Mountain Home transit (1916)	0	9	35.793
Correction for loop closure	...	..	+0.006
Adjusted difference	0	9	35.799
Longitude La Grande transit (1916), adjusted	7	52	22.488
Longitude Mountain Home transit (1916), adjusted	7	42	46.689
	115°	41′	40".335
Reduction to Mountain Home triangulation station	...	..	−0.332
Longitude, Mountain Home triangulation station	115	41	40.003

Difference of longitude between Mountain Home and Blackfoot, Idaho.

Date of exchange of time signals.	Observer.		Difference of longitude.	v.
	Western station, *Mountain Home*.	Eastern station, *Blackfoot*.		
1916.			m. s.	s.
September 20	W. B. Fairfield	J. E. McGrath	13 21.933	+0.008
September 21			21.916	− .009
September 24			21.927	+ .002
Mean			13 21.925 ± .003	

At Mountain Home, Bamberg transit No. 21 was mounted on the temporary pier of the 1916 station. (See above.)

At Blackfoot a new station was established. Bamberg transit No. 20 was mounted on a temporary wooden pier which is connected by traverse with B. M. Q_6, a triangulation station of secondary accuracy.

	h.	m.	s.
Mountain Home transit (1916) to Blackfoot transit (1916)	0	13	21.925
Correction for loop closure	...	..	+0.006
Adjusted difference	0	13	21.931
Longitude Mountain Home transit (1916), adjusted	7	42	46.689
Longitude Blackfoot transit (1916), adjusted	7	29	24.758
	112°	21′	11".370

Difference of longitude between Blackfoot, Idaho, and Salt Lake City, Utah.

Date of exchange of time signals.	Observer.		Difference of longitude.	v.
	Western station, *Blackfoot*.	Eastern station, *Salt Lake City*.		
1916.			m. s.	s.
October 16	J. E. McGrath	W. B. Fairfield	1 49.535	+0.044
October 18			49.553	+ .026
October 19			49.594	− .015
October 20			49.635	− .056
Mean			1 49.579 ± .015	

At Blackfoot, Bamberg transit No. 20 was mounted on the temporary pier of the 1916 station. (See above.)

At Salt Lake City, Bamberg transit No. 21 was mounted on the sandstone pier of the 1869 station. (See App. No. 2, Report for 1897).

	h.	m.	s.
Blackfoot transit (1916) to Salt Lake City transit (1869–1916)	0	01	49.579
Correction for loop closure	.	..	+0.006
Adjusted difference	0	01	49.585
Longitude Blackfoot transit (1916), adjusted	7	29	24.758
Longitude Salt Lake City transit (1897), adjustment [3]	7	27	35.173

The following table gives for each longitude station the name of the station, the geodetic latitude and longitude, the astronomic longitude, the difference between the astronomic and geodetic longitude, A–G, the cosine of the geodetic latitude, ϕ', and finally the deflection in the prime vertical.

The astronomic longitudes have not been corrected for variation of latitude. They have in each case, with the exception of station Blackfoot, been reduced to the triangulation station.

Deflections in the prime vertical.

Station.	Geodetic latitude.			Geodetic longitude.			Astronomic longitude.	A–G.	Cos ϕ'.	A–G (P. V.)
	°	′	″	°	′	″	″	″		″
Echo, Oreg	45	44	38.385	119	11	20.222	29.29	+9.07	0.6979	+6.33
La Grande, Oreg	45	19	49.467	118	05	39.346	35.47	−3.88	.7030	−2.73
Mountain Home, Idaho	43	07	44.382	115	41	36.050	40.00	+3.95	.7298	+2.88
Blackfoot longitude station, Idaho	43	10	59.710	112	21	01.412	11.37	+9.96	.7292	+7.26

ASTRONOMIC AZIMUTHS.

An astronomic azimuth was measured at each of 13 triangulation stations of this arc, the observations being made by the triangulation party at such times as did not interfere with the progress of the horizontal angle measurements. The chronometer correction was obtained by observation on stars near the prime vertical with a 6-inch vertical circle, and the angle measures were made by the direction method with the 12-inch theodolite used for the regular angle measures. Detailed descriptions of these methods may be found in U. S. Coast and Geodetic Survey Special Publication No. 14.

Three of these stations—Echo, La Grande, and Mountain Home—were Laplace stations (see p. 50), at which the astronomic azimuth was determined on two different nights, with a prescribed probable error for the station of not to exceed ±0.″3. At the other stations azimuth observations were made on a single night, the instructions permitting a probable error of ±0.″5. The azimuths at the Laplace stations only were used in the adjustment of the triangulation, the other azimuths being observed for use in investigations concerning the deflections of the vertical, the figure of the earth, and the relative densities of different portions of the earth's crust.

[3] See App. No. 2, Report for 1897, p. 251.

Program of occupation of azimuth stations by party of C. V. Hodgson, hydrographic and geodetic engineer.

Station.	Date of occupation.	Number of positions.[1]	Probable error.
	1915		"
Oxford, Idaho	June 26	11	±0.43
Cache, Idaho	July 16, 19	8	± .50
Caribou, Idaho	July 24	11	± .27
Big Butte, Idaho	August 19	11	± .53
Flat, Idaho	September 29	12	± .26
Silver, Idaho	October 20	12	± .40
Nyssa, Idaho	November 4	12	± .38
	1916		
Echo, Oreg	June 15, 18	26	± .32
Ella, Oreg	June 22	11	± .39
John, Oreg	July 5	13	± .40
La Grande, Oreg	August 19, 20	27	± .17
Beaver, Oreg	September 10	13	± .23
Mountain Home, Idaho	October 6, 15	26	± .33

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

The table below gives for each azimuth station its geographic position, the geodetic azimuth of a line of the main scheme of the triangulation, the astronomic azimuth of the same, the difference between the astronomic and geodetic azimuths, A–G, the negative cotangent of the geodetic latitude of the occupied station ($-\cot\phi'$), and finally the value of A–G (P. V.), the deflection in the prime vertical.

In each case the azimuth and triangulation stations are coincident. The mark used was the signal lamp accurately centered over the triangulation station at the distant end of the line of triangulation for which the azimuth is given.

Deflections in prime vertical.

Station.	Geodetic latitude.	Geodetic longitude.	Geodetic azimuth.	To station—	Astronomic azimuth.	A–G.	$-\cot\phi'$.	A–G (P. V.)
	° ′ ″	° ′ ″	° ′ ″		″	″		″
Oxford, Idaho	42 16 11.766	112 05 49.972	177 53 20.64	Putnam	25.41	−4.23	−1.1001	+4.65
Cache, Idaho	42 11 09.402	113 39 37.544	201 01 01.81	Big Butte	01.68	− .13	−1.1034	+ .14
Caribou, Idaho	43 05 37.440	111 18 39.407	73 36 19.32	Putnam	14.75	−4.57	−1.0680	+4.88
Big Butte, Idaho	43 23 47.288	113 01 18.580	82 25 25.71	Picabo	25.48	− .23	−1.0576	+ .24
Flat, Idaho	42 43 48.702	114 24 52.624	199 03 28.85	Picabo	25.09	−3.76	−1.0826	+4.07
Silver, Idaho	42 58 51.394	116 39 24.485	286 55 56.66	Blue	62.94	+6.28	−1.0731	−6.74
Nyssa, Idaho	43 52 25.950	116 58 47.747	54 31 31.86	Mitchell	27.10	−4.76	−1.0401	+4.95
Echo, Oreg. (Laplace)	45 44 38.385	119 11 20.222	110 20 19.99	Stanfield east base.	13.34	−6.65	−0.9744	+6.48
Ella, Oreg	45 34 17.518	119 46 41.429	257 10 11.07	Job	09.89	−1.18	−0.9802	+1.16
Mountain Home, Idaho (Laplace)	43 07 44.382	115 41 36.050	332 31 17.89	Blue	15.31	−2.58	−1.0676	+2.75
John, Oreg	45 24 06.690	120 36 08.470	85 08 35.43	Lookout	36.36	+ .93	−0.9861	− .92
Beaver, Oreg	44 35 59.517	117 47 00.282	183 05 10.22	Fanny	01.07	−9.15	−1.0141	+9.28
La Grande, Oreg. (Laplace)	45 19 49.467	118 05 39.346	180 05 15.10	Emily	17.78	+2.68	−0.9885	−2.65

The astronomic azimuth is corrected for diurnal aberration, eccentricities, elevation of mark, but not for variation of latitude.

The Laplace azimuths computed at these stations are undoubtedly more accurate than the geodetic azimuths computed through the triangulation, and therefore the former were considered free from error. The discrepancy between the Laplace and the geodetic azimuth was considered as a deviation of the triangulation in azimuth. The differences between the deflections in the prime vertical as derived from longitude observations and from azimuth observations are due to the method of adjustment.

COST OF ASTRONOMIC WORK.

Since the azimuth observations were made at such times as would not interfere with the progress of the triangulation party, their cost is included with that of the triangulation.

The two parties engaged on latitude and longitude work determined eight differences of longitude during their season, of which five were along the arc of triangulation covered by this publication. The total cost of the two parties for the entire season was about $5250. Five-eighths of that cost may properly be charged to this arc, or about $3255, giving an average cost for each of the five differences of longitude of $651. This is under the supposition that the latitude observations did not increase the cost of the work, since they were made on nights when longitude observations were not possible.

TRUCK TRANSPORTATION.

PROBLEMS INVOLVED.

At first sight it may seem strange that this should be the first arc on which automobile trucks were used to transport the reconnoissance and observing parties. There is a single distinguishing feature about the travel attendant upon such work, however, which will make plain the difficulty in the use of trucks, and that is that the triangulation parties travel from mountain to mountain instead of from town to town. This simple statement, with the further explanation that the desired point on a mountain is almost invariably the highest point, will mean much to one familiar with western mountain roads.

Previously the triangulation parties of the U. S. Coast and Geodetic Survey had used wagons and teams to transport their outfits, with the advantage that after the wagons had been taken as close to the peak as possible pack saddles could be put on the animals and the instruments and outfit packed to the station. When trucks are used, pack animals must be hired, or else the trucks must be taken fairly close to the station and the instruments then back packed to the station. Year by year pack animals are becoming increasingly hard to obtain, and a back pack of more than 2 miles is neither easy nor economical. Since camp must be kept at the trucks and the climb from the camp to the station made for each observing period, which is usually at night, the problem of proper transportation of a triangulation party is by no means solved. Under average conditions, however, the use of trucks will accomplish a great saving of time.

The trucks used were of three-quarter-ton size and standard make, equipped with pneumatic tires and platform body, but without top, cab, wind shield, electric lights, or starter. The first season they were operated they had a five to one gear ratio, but at the beginning of the second season a special rear axle and special differential gears were put in which changed the gear ratio to seven to one. This resulted in reducing the speed from about 30 miles per hour as a maximum to 18, but it gave greatly increased pulling power, which was needed on the soft roads and mountain grades. It reduced the average number of miles per hour from 12.1 in 1915 to 10.9 in 1916, but the miles per gallon of gasoline used were not changed by one-tenth mile, being about 10.5 for each season.

UNIT COSTS.

The tabulation below gives in condensed form the cost data for the trucks for the period 1915–16.

	Truck No. 3.	Truck No. 4.
Total miles traveled	8457	7800
Miles per hour	10.9	10.9
Miles per gallon of gasoline	10.6	10.3
Miles per gallon of oil and grease	154	145
Cost per mile for gasoline	2.10¢	2.15¢
Cost per mile for oil and grease	0.56	0.60
Cost per mile for repairs and extra parts, including pay of hands while overhauling	1.29	1.88
Cost per mile for tires, partly estimated	5.70	5.70
Cost per mile, depreciation, estimating the life of truck to be 18 000 miles	12.97	12.97
Total cost per mile	22.62	23.30
Cost per ton-mile load of 1800 lbs	25.24	25.78

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 (163).	Cost per mile of progress (640).	Cost per square mile (30 190).
	Dollars.	*Dollars.*	*Dollars.*	*Dollars.*
Reconnoissance and signal building	1870.00	11.47	2.92	0.06
Triangulation and azimuth observations	18 166.71	111.45	28.39	0.60
Base measurement	780.00	4.79	1.22	0.03
Astronomical observations	3255.00	19.97	5.09	0.11
Total, field	24 071.71	147.68	37.62	0.80
Office computation	1064.00	6.53	1.66	0.04
Compiling and publishing (estimated)	1500.00	9.20	2.34	0.05
Total, office	2564.00	15.73	4.00	0.09
Field and office	26 635.71	163.41	41.62	0.89

Different arcs of triangulation show a great divergence in the cost per point 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 ninety-eighth meridian arc (after 1901) cost $63, the Texas-California arc $32, and the one hundred and fourth meridian arc $40 per mile.

STATEMENT OF ADJUSTMENTS AND DISCREPANCIES.

The precise triangulation considered in this publication starts from the line Pilot Peak-Ogden Peak, Utah, and ends on the line Red-Larch, in Washington and Oregon. Pilot Peak-Ogden Peak is a line of the thirty-ninth parallel arc of precise triangulation, and is fixed in length, azimuth, and position by the adjustments contained in U. S. Coast and Geodetic Survey Special Publication No. 19. Red-Larch is a line of the California-Washington arc of precise triangulation and is fixed in length, azimuth, and position by the adjustment contained in U. S. Coast and Geodetic Survey Special Publication No. 13.

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

A single least square adjustment served for the entire precise scheme. The measured base, Stanfield, caused the use of two length equations and the Laplace azimuths computed at Echo, La Grande, and Mountain Home made four azimuth equations necessary.

This arc closes a loop of precise triangulation which extends from the line Pilot Peak-Ogden Peak, Utah, westward along the thirty-ninth parallel to the line Mount Lola-Round Top, Calif., northward through Oregon to the line Red-Larch, which is partly in Washington and partly in Oregon, then southeastward through Oregon and Idaho to the line Pilot Peak-Ogden Peak, Utah. The total length of the arc considered in this publication is about 640 miles.

When the preliminary position computation was completed, it was found that the discrepancy in position was about 67½ feet, or 1 part in 50 000 of the distance run. If the whole loop, instead of this arc only, is considered, the discrepancy in position is only 1 part in 141 000 of the distance run.

As all of the loop except the present arc had been adjusted previously, the old work was held fixed and all the latitude and longitude discrepancies were put into this arc. The adjustment required the use of 69 angle, 25 side, 2 length, 4 azimuth, 1 latitude, and 1 longitude equations. The total number of normal equations solved was 102.

The least square adjustment of the main scheme of triangulation was made by O. S. Adams, geodetic computer. Sarah Beall, geodetic computer, made the astronomic computations and adjustments.

The length discrepancy developed between the Stanfield base and the line Red-Larch, which was fixed in the adjustment of the California-Washington arc of precise triangulation, was 76 in the seventh place of logarithms or 1 part in 57 300 before the angle and side equations were satisfied. The measured length of the Stanfield base is shorter than the length computed through the triangulation from the line Red-Larch.

The length discrepancy developed between the Stanfield base and the line Pilot Peak-Ogden Peak, which was fixed in the adjustment of the thirty-ninth parallel arc of precise triangulation, was 239 in the seventh place of logarithms or 1 part in 18 200 before the angle and side equations were satisfied. After the adjustment of the angle and side equations the discrepancy in length was less than 1 part in 25 000. The measured length of the Stanfield base is shorter than the length computed through from the line Pilot Peak-Ogden Peak as it was from the other adjusted line.

The probable error of the base longitude station at Walla Walla, as determined by the adjustment of the longitude net of the United States, is ±0ˢ.052. This error, combined with the probable error of the observed value of each longitude station in this loop, gives a probable error for the longitude of each station of about ±0ˢ.054, or ±0″.81. The probable error of the observed astronomic azimuths at Mountain Home, La Grande, and Echo are ±0″.33, ±0″.17, and ±0″.32, respectively. Combining these probable errors with the probable errors of the longitude determinations at these stations gives a probable error for the Laplace azimuths at the three stations named above of ±0″.82, ±0″.77, and ±0″.81, respectively.

The unadjusted azimuth, as computed through the triangulation from the line Pilot Peak-Ogden Peak to the Laplace station at Mountain Home, showed a discrepancy as compared with the Laplace azimuth at that station of +2″.05. Similarly, from Mountain Home Laplace to La Grande Laplace the discrepancy was −2″.75, from La Grande Laplace to Echo Laplace the discrepancy was +5″.80, and from Echo Laplace to the line Red-Larch it was −1″.22. A plus sign indicates that the azimuth as computed through the triangulation, starting from the previous Laplace azimuth, is larger than the Laplace azimuth at the forward Laplace station. A minus sign signifies the reverse.

The probable error of the geodetic azimuth of a line of the triangulation between the line Pilot Peak-Ogden Peak and the Laplace azimuth at Mountain Home is ±0″.81, computed by the formula

$$r_0 = \frac{\text{probable error of a direction} \times \sqrt{2n}}{\sqrt{m}},$$

where n is the number of stations through which the azimuth is computed and m the number of ways (ordinarily four) by which the azimuth may be carried through a figure. Similarly, the probable error of the geodetic azimuth due to the triangulation observations alone, computed from Mountain Home to La Grande is ±0″.92, from La Grande to Echo is ±0″.85, and from Echo to the line Red-Larch is ±0″.92.

An additional indication of the amount of the azimuth accumulation may be obtained by comparing the probable error of the Laplace azimuth at a station with the probable error of the azimuth at that station as computed through the triangulation from the previous fixed azimuth. This latter probable error, obtained by combining the probable error of the geodetic azimuth due to the triangulation observations, with the probable error of the preceding fixed azimuth, is given below for each of the four stations which were held fixed, north of the starting line:

Mountain Home	±1″.11
La Grande	±1.23
Echo	±1.15
Red-Larch (fixed line)	±1.23

HORIZONTAL DIRECTIONS AND ELEVATIONS OF TELESCOPE ABOVE THE STATION MARKS.

All observed directions in the triangulation along the Utah-Washington arc have been given equal or unit weight. Those directions were reduced to center where either the instrument or the object observed was not coincident with the center of the station mark.

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

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

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

In the following table are given the lists of observed and adjusted directions and also the elevations of the telescope of the theodolite above the station mark at each of the stations of the precise triangulation considered in this publication. The elevations enable the reader to judge of the amount of building done and they indicate to the engineer or surveyor who may use the station in the future the probable amount of building required by him. In the table is included a column showing the number assigned to each direction in the figure adjustment of the main scheme.

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

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

Station occupied and elevation of instrument above station mark.	Number of direction.	Object observed.	Observed direction reduced to sea level. ° ′ ″	Final seconds after figure adjustment. ″
Pilot Peak	....	Reference mark	0 00 00.00	....
	1	Cache	2 19 20.57	20.14
	2	Oxford	36 43 38.29	38.02
	3	Ogden Peak	70 34 22.99	23.69
Ogden Peak	....	Reference mark	0 00 00.00	....
	4	Pilot Peak	112 45 16.17	15.84
	5	Cache	155 14 17.35	17.36
	6	Oxford	199 39 17.00	17.33
Oxford, 1.29 meters	11	Putnam	0 00 59.99	00.23
	12	Caribou	30 59 48.38	48.13
	7	Ogden Peak	173 26 36.11	35.72
	8	Pilot Peak	232 42 45.09	45.02
	9	Cache	268 29 56.90	57.65
	10	Big Butte	331 17 09.11	08.82
Cache, 1.20 meters	32	Big Butte	0 00 00.09	00.04
	33	Putnam	35 43 38.88	38.57
	34	Oxford	64 19 23.46	22.97
	35	Ogden Peak	104 51 41.00	40.36
	36	Pilot Peak	174 08 33.25	33.81
	29	Flat	293 29 51.32	50.65
	30	Kimama	320 42 18.82	19.39
	31	Picabo	320 45 40.00	41.02

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

Station occupied and elevation of instrument above station mark.	Number of direction.	Object observed.	Observed direction reduced to sea level.			Final seconds after figure adjustment.
			°	′	″	″
Putnam, 1.40 meters	17	Caribou	0	00	00.10	00.11
	....	Henry	15	55	07.82	07.75
	....	Woodall	36	26	50.72	51.12
	13	Oxford	104	49	21.84	21.64
	14	Cache	164	43	57.83	58.14
	15	Big Butte	233	42	48.93	49.12
	16	Middle Butte	249	32	31.46	31.13
Caribou, 1.31 meters	19	Putnam	0	00	00.09	00.11
	20	Middle Butte	37	45	16.74	16.51
	....	Stump	261	22	52.32	52.20
	....	Henry	307	54	12.85	13.40
	....	Woodall	310	32	52.27	51.45
	18	Oxford	321	48	57.10	57.31
Stump, 1.19 meters	....	Caribou	0	00	00.00	00.12
	....	Henry	301	58	51.10	50.98
Henry, 0.80 meters	....	Caribou	0	00	00.00	59.65
	....	Stump	75	27	30.08	30.20
	....	Woodall	185	14	47.40	47.62
	....	Putnam	248	00	51.12	51.12
Woodall, 1.34 meters	....	Caribou	0	00	00.00	00.38
	....	Henry	2	36	10.40	10.40
	....	Putnam	265	53	54.85	54.47
Middle Butte, 1.21 meters	23	Big Butte	0	00	00.10	59.56
	21	Caribou	224	50	23.46	23.65
	....	Precise level B. M. Q_6	256	00	13.38	13.11
	22	Putnam	256	37	51.34	51.68
Big Butte, 1.34 meters	24	Middle Butte	0	00	00.09	00.62
	....	Precise level B. M. Q_6	51	14	00.92	01.19
	25	Putnam	60	48	15.94	15.78
	26	Cache	136	06	18.41	18.20
	27	Kimama	166	15	27.89	27.90
	28	Picabo	197	04	40.45	40.26
Kimama, 1.27 meters	38	Flat	0	00	00.05	00.54
	39	Picabo	90	39	00.77	00.63
	40	Big Butte	159	57	03.59	04.17
	37	Cache	270	30	32.47	31.75
Picabo, 1.27 meters	44	Green	0	00	00.03	00.39
	45	Camas	5	06	40.80	41.01
	41	Big Butte	178	14	33.64	33.37
	42	Kimama	258	07	29.43	29.23
	43	Flat	295	49	53.87	53.77
Flat, 1.24 meters	50	Kimama	0	00	00.05	59.78
	51	Cache	63	18	09.70	10.02
	46	Blue	196	12	46.60	47.01
	47	Camas	234	24	39.83	39.39
	48	Green	252	26	33.02	32.99
	49	Picabo	308	21	19.30	19.31
Green, 1.36 meters	52	Picabo	0	00	00.03	59.40
	53	Flat	59	55	15.77	15.62
	54	Blue	130	34	02.31	02.21
	55	Camas	192	33	48.15	49.03
Camas, 1.32 meters	63	Green	0	00	00.03	58.88
	64	Flat	29	19	36.92	37.22
	65	Blue	81	04	35.22	35.42
	66	Mountain Home	142	38	47.24	48.40
	67	Silver	158	38	60.25	59.75
	68	Shafer	222	46	29.63	29.80
	62	Picabo	352	32	48.59	48.41
Blue, 1.27 meters	59	Camas	0	00	59.98	59.74
	60	Green	36	55	42.89	43.05
	61	Flat	90	03	21.80	21.76
	56	Silver	291	35	43.79	44.28
	57	Mountain Home	336	31	48.18	48.37
	58	Shafer	338	35	25.15	24.56

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

Station occupied and elevation of instrument above station mark.	Number of direction.	Object observed.	Observed direction reduced to sea level. °	′	″	Final seconds after figure adjustment. ″
Mountain Home, 1.29 meters	69	Camas	0	00	00.12	59.14
	70	Blue	94	57	37.87	38.28
	71	Silver	200	56	00.47	01.04
Silver, 1.15 meters	75	Camas	0	00	00.07	59.32
	76	Mountain Home	4	55	51.66	51.69
	77	Blue	34	01	35.38	35.64
	72	Nyssa	272	25	45.74	46.40
	73	Squaw	296	39	06.54	06.97
	74	Shafer	314	34	11.40	10.79
Shafer, 1.25 meters	78	Camas	0	00	59.87	59.52
	79	Blue	16	53	37.84	37.69
	80	Silver	70	26	59.40	59.57
		Mitchell	132	52	32.07	32.16
	81	Nyssa	141	51	22.47	22.89
	82	Squaw	180	53	04.42	01.31
Squaw, 1.26 meters	83	Shafer	0	00	59.87	59.37
	84	Silver	51	38	59.89	59.99
		Mitchell	106	54	05.26	05.73
	85	Nyssa	110	55	45.46	46.18
	86	Dry	140	56	51.75	51.25
	87	Iron	181	35	49.56	49.73
Nyssa, 1.28 meters		Mitchell	0	00	00.06	59.22
		B. M. G	46	31	56.55	58.31
	88	Dry	66	42	13.98	14.91
	89	Iron	122	34	42.49	42.29
	90	Squaw	194	05	09.81	09.19
	91	Shafer	224	07	45.25	45.48
	92	Silver	290	35	15.40	15.09
Dry, 1.34 meters	99	Maxwell	0	00	59.89	00.85
	100	Beaver	12	13	07.01	06.62
	101	Iron	73	25	07.75	07.65
	102	Squaw	121	49	17.08	16.58
	103	Nyssa	144	25	23.68	23.62
Iron, 1.38 meters	95	Dry	0	00	00.11	00.28
	96	Beaver	45	14	23.13	23.50
	97	Maxwell	62	31	47.47	47.65
	98	Medical	96	40	24.46	24.47
	93	Squaw	269	02	55.82	55.13
	94	Nyssa	306	52	33.59	33.55
Beaver, 1.49 meters	104	Maxwell	0	00	59.86	00.13
	105	Fanny	42	40	16.71	17.08
	106	Medical	61	04	32.60	32.34
	107	Iron	134	29	22.87	22.37
	108	Dry	208	03	05.17	05.28
Medical, 1.60 meters	109	Iron	0	00	59.90	59.19
	110	Beaver	55	09	16.38	16.60
	111	Maxwell	95	27	06.36	06.62
	112	Fanny	180	06	53.40	53.64
Maxwell, 1.39 meters	113	Powder	0	00	59.86	00.10
	114	Emily	35	59	42.21	42.56
	115	Fanny	65	57	15.51	15.56
	116	Medical	97	56	16.91	16.68
	117	Iron	148	20	41.48	41.53
	118	Beaver	176	33	59.75	59.27
Powder, 1.28 meters	135	Maxwell	0	00	59.86	59.73
	131	Birch	181	59	56.07	56.62
	132	Big Hill	195	13	41.32	40.01
	133	Emily	221	35	37.27	37.93
	134	Fanny	255	04	08.35	08.56

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

Station occupied and elevation of instrument above station mark.	Number of direction.	Object observed.	Observed direction reduced to sea level.			Final seconds after figure adjustment.
			°	′	″	″
Fanny, 1.33 meters	124	Emily	0	00	59.92	00.16
	119	Medical	210	05	10.37	09.81
	120	Beaver	246	43	21.56	21.13
	121	Maxwell	273	26	25.22	25.60
	122	Powder	282	33	20.52	20.21
	123	La Grande	338	37	37.30	37.97
La Grande, 1.39 meters	235	Fanny	0	00	59.98	59.31
	234	Emily	265	19	03.24	03.91
Emily, 1.41 meters	125	Fanny	0	00	59.91	59.36
	126	Maxwell	63	28	57.42	56.40
	127	La Grande	63	56	39.98	42.62
	128	Powder	69	04	53.45	53.03
	129	Birch	149	10	48.80	48.67
	130	Big Hill	182	18	09.99	09.47
Big Hill, 1.42 meters	141	Emily	0	00	59.92	59.65
	142	Powder	40	24	49.61	50.37
	143	Birch	80	01	07.46	08.30
	144	Alkali	142	32	45.26	44.93
	145	Laurila	188	04	37.79	36.29
Birch, 1.15 meters	136	Alkali	0	00	59.97	59.70
	137	Laurila	38	16	34.17	34.31
	138	Big Hill	86	07	28.68	27.77
	139	Emily	152	59	00.01	00.53
	140	Powder	213	17	28.88	29.41
Alkali, 1.23 meters	146	Job	0	00	59.97	00.21
	147	Expansion	33	13	34.98	33.99
	148	Laurila	71	03	12.82	12.29
	149	Big Hill	134	34	21.28	21.83
	150	Birch	165	55	18.69	19.40
Laurila, 1.24 meters	151	Big Hill	0	00	59.94	59.67
	152	Birch	24	05	39.93	40.53
	153	Alkali	70	57	01.69	02.09
	154	Job	108	18	07.60	07.57
	155	Expansion	173	18	00.02	59.32
Expansion, 1.27 meters	162a	Laurila	0	00	59.98	00.06
	163a	Alkali	30	49	26.42	27.15
	164	Stanfield east base	56	01	08.58	08.88
	165	Job	59	18	17.83	17.58
	166	Stanfield west base	97	05	44.05	43.23
	167	Ella	100	44	21.13	21.42
	168	Alder	137	02	09.02	08.70
Job, 1.40 meters	156	Ella	0	00	00.01	59.37
	157	Alder	37	28	45.67	46.03
	158	Stanfield west base	55	17	29.34	30.11
	159	Expansion	100	45	08.10	07.70
	160	Stanfield east base	105	39	53.25	53.01
	161	Echo	142	32	18.54	18.43
	162	Laurila	156	27	00.81	00.85
	163	Alkali	228	02	44.78	44.98
Stanfield east base, 1.18 meters	173	Job	0	00	00.00	00.16
	174	Stanfield west base	88	59	21.42	21.14
	175	Expansion	171	48	05.34	06.26
	172	Echo	287	04	59.70	58.91
Stanfield west base, 4.17 meters	169	Expansion	0	00	00.00	59.72
	170	Stanfield east base	56	06	40.97	41.13
	171	Job	96	44	57.71	57.84
Echo, 1.20 meters	177	Stanfield east base	0	00	00.00	59.90
	176	Job	289	47	26.16	26.27
Ella, 1.18 meters	178	Toby	0	00	00.01	59.29
	179	Montgomery	43	25	49.23	49.53
	180	Alder	78	43	19.37	19.56
	181	Expansion	140	06	01.81	02.19
	182	Job	177	54	53.46	53.30

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

Station occupied and elevation of instrument above station mark.	Number of direction.	Object observed.	Observed direction reduced to sea level. °	′	″	Final seconds after figure adjustment. ″
Alder, 1.25 meters	183	Expansion	0	00	00.01	00.53
	184	Job	38	59	51.99	52.03
	185	Ella	82	19	35.30	34.78
	186	Toby	128	04	51.75	51.95
	187	Montgomery	184	45	38.58	38.34
Montgomery, 1.17 meters	188	Alder	0	00	00.01	00.36
	189	Ella	42	16	29.25	29.14
	190	Toby	78	19	42.69	42.41
	191	John	127	30	18.77	18.62
	192	Maryhill	177	46	20.17	20.35
Toby, 1.07 meters	193	John	0	00	00.03	59.43
	194	Maryhill	48	27	53.84	54.03
	195	Montgomery	88	45	08.81	08.76
	196	Alder	133	44	42.64	42.74
	197	Ella	189	16	07.35	07.71
John, 1.20 meters	200	Maryhill	0	00	59.97	59.96
	201	Montgomery	42	03	36.47	37.04
	202	Toby	84	07	54.54	54.79
	198	Lookout	279	52	37.93	37.68
	199	Stacker	326	40	15.52	14.94
Maryhill, 1.22 meters	203	Montgomery	0	00	00.02	59.85
	204	Toby	40	16	10.09	10.06
	205	John	87	40	24.21	24.39
	206	Lookout	157	16	54.32	53.86
	207	Stacker	186	45	17.12	17.70
Stacker, 1.22 meters	208	Maryhill	0	00	00.01	59.69
	209	John	47	35	24.06	24.19
	210	Lookout	134	52	19.88	20.60
	211	Chinidere	171	56	13.30	12.78
	212	Huckle	208	20	48.66	48.63
Lookout, 1.37 meters	215	Stacker	0	00	00.05	59.77
	216	Maryhill	15	39	17.83	17.77
	217	John	45	55	32.76	33.07
	213	Chinidere	281	50	20.17	20.55
	214	Huckle	308	21	47.71	47.37
Huckle, 1.20 meters	218	Stacker	0	00	59.96	59.92
	219	Lookout	54	53	25.95	26.00
	220	Chinidere	82	12	58.74	58.82
	221	Larch	105	31	14.46	14.46
	222	Red	189	34	23.87	23.78
Chinidere, 1.32 meters	226	Stacker	0	00	00.03	00.46
	227	Lookout	64	46	33.96	33.68
	223	Larch	179	14	49.89	49.61
	224	Red	283	31	43.71	43.98
	225	Huckle	298	37	30.99	30.85
Red, 1.09 meters	229	Chinidere	0	00	00.00	59.81
	230	Larch	26	04	44.91	45.22
	228	Huckle	302	27	10.83	10.77
Larch, 1.30 meters	....	Star	0	00	00.00	00.24
	231	Red	51	09	49.54	49.29
	232	Huckle	63	29	06.07	06.83
	233	Chinidere	100	48	10.82	11.64

CONDITION EQUATIONS.

No.

1. 0 = −2.67 − (1) + (3) − (4) + (5) − (35) + (36).
2. 0 = −1.95 − (2) + (3) − (4) + (6) − (7) + (8).
3. 0 = −1.31 − (5) + (6) − (7) + (9) − (34) + (35).
4. 0 = +0.18 − (9) + (11) − (13) + (14) − (33) + (34).

5. 0 = +0.43 − (14) + (15) − (25) + (26) − (32) + (33).
6. 0 = +0.89 − (11) + (12) + (13) − (17) − (18) + (19).
7. 0 = −0.24 − (16) + (17) − (19) + (20) − (21) + (22).
8. 0 = +2.09 − (15) + (16) − (22) + (23) − (24) + (25).
9. 0 = +1.92 − (26) + (27) − (30) + (32) + (37) − (40).

No.

10. 0=−0.59−(27)+(28)−(39)+(40)−(41)+(42).
11. 0=+0.81−(38)+(39)−(42)+(43)−(49)+(50).
12. 0=−3.26−(29)+(30)−(37)+(38)−(50)+(51).
13. 0=−0.98−(43)+(44)−(48)+(49)−(52)+(53).
14. 0=−1.24−(43)+(45)−(47)+(49)−(62)+(64).

15. 0=−2.89−(47)+(48)−(53)+(55)−(63)+(64).
16. 0=+0.59−(46)+(48)−(53)+(54)−(60)+(61).
17. 0=−2.73−(54)+(55)−(59)+(60)−(63)+(65).
18. 0=−1.92−(57)+(59)−(65)+(66)−(69)+(70).
19. 0=+0.42−(56)+(59)−(65)+(67)−(75)+(77).

20. 0=−0.09−(56)+(57)−(70)+(71)−(76)+(77).
21. 0=−0.11−(56)+(58)−(74)+(77)−(79)+(80).
22. 0=−1.05−(67)+(68)−(74)+(75)−(78)+(80).
23. 0=+1.56−(72)+(74)−(80)+(81)−(91)+(92).
24. 0=−0.70−(72)+(73)−(84)+(85)−(90)+(92).

25. 0=−1.54−(81)+(82)−(83)+(85)−(90)+(91).
26. 0=+0.32−(85)+(87)−(89)+(90)−(93)+(94).
27. 0=−1.23−(86)+(87)−(93)+(95)−(101)+(102).
28. 0=+0.88−(88)+(89)−(94)+(95)−(101)+(103).
29. 0=−1.10−(95)+(96)−(100)+(101)−(107)+(108).

30. 0=−0.33−(96)+(98)−(106)+(107)−(109)+(110).
31. 0=−1.08−(97)+(98)−(109)+(111)−(116)+(117).
32. 0=+0.74−(104)+(106)−(110)+(111)−(116)+(118).
33. 0=−0.38−(104)+(105)−(115)+(118)−(120)+(121).
34. 0=−0.64−(111)+(112)−(115)+(116)−(119)+(121).

35. 0=+0.91−(114)+(115)−(121)+(124)−(125)+(126).
36. 0=+1.22−(113)+(115)−(121)+(122)−(134)+(135).
37. 0=−0.23−(122)+(124)−(125)+(128)−(133)+(134).
38. 0=−1.42−(123)+(124)−(125)+(127)−(234)+(235).
39. 0=−2.90−(128)+(130)−(132)+(133)−(141)+(142).

40. 0=−0.41−(128)+(129)−(131)+(133)−(139)+(140).
41. 0=−2.15−(129)+(130)−(138)+(139)−(141)+(143).
42. 0=+1.65−(136)+(138)−(143)+(144)−(149)+(150).
43. 0=−1.45−(136)+(137)−(148)+(150)−(152)+(153).
44. 0=−1.08−(144)+(145)−(148)+(149)−(151)+(153).

45. 0=+1.04−(146)+(148)−(153)+(154)−(162)+(163).
46. 0=−0.01−(147)+(148)−(153)+(155)−(162a)+(163a).
47. 0=+0.56−(154)+(155)−(159)+(162)−(162a)+(165).
48. 0=+1.33−(158)+(159)−(165)+(166)−(169)+(171).
49. 0=+1.48−(158)+(160)−(170)+(171)−(173)+(174).

50. 0=−0.52−(164)+(166)−(169)+(170)−(174)+(175).
51. 0=−0.87−(160)+(161)−(172)+(173)−(176)+(177).
52. 0=+1.31−(157)+(159)−(165)+(168)−(183)+(184).
53. 0=−0.24−(156)+(159)−(165)+(167)−(181)+(182).
54. 0=−0.09−(156)+(157)−(180)+(182)−(184)+(185).

55. 0=−1.26−(178)+(179)−(189)+(190)−(195)+(197).
56. 0=−1.89−(178)+(180)−(185)+(186)−(196)+(197).
57. 0=+0.29−(179)+(180)−(185)+(187)−(188)+(189).
58. 0=−0.36−(190)+(191)−(193)+(195)−(201)+(202).
59. 0=−0.36−(190)+(192)−(194)+(195)−(203)+(204).

60. 0=−1.15−(191)+(192)−(200)+(201)−(203)+(205).
61. 0=−1.53−(199)+(200)−(205)+(207)−(208)+(209).
62. 0=−0.08−(198)+(200)−(205)+(206)−(216)+(217).
63. 0=−0.85−(198)+(199)−(209)+(210)−(215)+(217).
64. 0=+2.61−(210)+(211)−(213)+(215)−(226)+(227).

65. 0=+0.60−(210)+(212)−(214)+(215)−(218)+(219).
66. 0=−1.18−(211)+(212)−(218)+(220)−(225)+(226).
67. 0=−0.12−(220)+(221)−(223)+(225)−(232)+(233).
68. 0=+0.71−(220)+(222)−(224)+(225)−(228)+(229).
69. 0=−1.56−(223)+(224)−(229)+(230)−(231)+(233).

70. 0=+2.98−2.24(1)+3.08(2)−0.84(3)−2.30(4)+4.45(5)−2.15(6)+0.19(7)+2.92(8)−3.11(9).
71. 0=+6.77+0.06(9)+8.95(10)−9.01(11)+5.11(13)−5.11(15)+0.55(25)−0.55(26)−2.93(32)+6.79(33) −3.86(34).
72. 0=−7.46−8.95(10)+11.74(11)−2.79(12)−5.11(13)+5.11(15)−2.68(18)+5.40(19)−2.72(20)−3.40(21) +2.90(22)+0.50(23)−1.18(24)+1.18(25).
73. 0=−6.84−3.62(26)+7.15(27)−3.53(28)−4.10(29)+6.67(30)−2.57(32)−0.38(41)+3.10(42)−2.72(43) −1.67(49)+2.73(50)−1.06(51).
74. 0=+466.10−4(29)+3576(30)−3572(31)−1417(37)+1417(39)+3(42)−3(43)−2(49)+3(50)−1(51).

75. 0=+14.52−1.02(43)+24.56(44)−23.54(45)−6.47(47)+7.90(48)−1.43(49)−16.09(62)+10.84(63) −3.75(64).
76. 0=−3.22−1.41(46)+6.47(47)−5.06(48)−2.80(59)+4.38(60)−1.58(61)−3.42(63)+3.75(64)−0.33(65).
77. 0=−32.80−2.11(56)+6.96(57)−4.85(59)−1.14(65)+8.48(66)−7.34(67)−24.40(75)+28.18(76)−3.78(77).
78. 0=+4.92−0.83(56)+5.37(58)−4.54(59)−2.07(74)+5.19(75)−3.12(77)−6.18(78)+6.93(79)−0.75(80).
79. 0=−10.51−4.68(72)+11.19(73)−6.51(74)+0.78(80)+2.60(81)−3.38(82)−3.88(90)+3.64(91)+0.24(92).

No.

80. 0=+4.32−2.90(85)+3.64(86)−0.74(87)−2.71(93)+4.29(94)−1.58(95)−0.72(101)+5.06(102)−4.34(103).

81. 0=+22.75−2.09(95)+8.85(96)−6.76(97)−17.14(99)+18.30(100)−1.16(101)+7.42(104)−7.42(108) −3.92(117)+3.92(118).

82. 0=−2.57−5.08(96)+6.76(97)−1.68(98)−1.47(109)+3.95(110)−2.48(111)−0.42(116)+3.92(117) −3.50(118).

83. 0=−1.94−1.16(104)+6.33(105)−5.17(106)−3.37(115)+3.79(116)−0.42(118)−1.78(119)+2.83(120) −1.05(121).

84. 0=+21.63−1.96(113)+2.90(114)−0.94(115)−13.12(121)+13.59(122)−0.47(124)−0.80(125)+21.48(126) −20.68(128).

85. 0=+20.13+0.90(128)+3.23(129)−4.13(130)− 8.96(131)+13.21(132)−4.25(133)−2.50(138)+ 0.90(139) +1.60(140).

86. 0=− 6.09−0.14(136)+1.91(137)−1.77(138)− 1.05(148)+ 4.51(149)−3.46(150)−3.98(151)+ 4.71(152) − 0.73(153).

87. 0=− 1.53−2.49(146)+3.21(147)−0.72(148)− 2.76(153)+ 3.74(154)−0.98(155)−1.25(162a)+5.95(163a) −4.70(165).

88. 0=+22.48−1.75(158)+24.50(159)−22.75(160)−34.25(164)+36.67(165)−2.42(166)−1.41(169)+3.86(170) −2.45(171).

89. 0=− 6.83−3.15(156)+2.75(157)+0.40(159)− 2.38(165)+ 5.25(167)−2.87(168)−0.29(183)+ 2.24(184) −1.95(185).

90. 0=+ 0.13−0.42(178)+2.98(179)−2.56(180)− 1.88(188)+ 2.32(189)−0.44(190)−2.10(195)+ 3.55(196) −1.45(197).

91. 0=− 3.06−0.05(193)+2.48(194)−2.43(195)− 2.33(200)+ 4.66(201)−2.33(202)−2.40(203)+ 2.49(204) −0.09(205).

92. 0=− 1.63−0.37(198)+3.20(199)−2.83(200)− 4.02(208)+ 1.92(209)+2.10(210)−7.51(215)+11.12(216) −3.61(217).

93. 0=+ 7.72−2.79(210)+5.65(211)−2.86(212)− 3.78(213)+ 4.22(214)−0.44(215)−0.29(218)+ 4.08(219) −3.79(220).

94. 0=− 9.84+1.18(223)+7.80(224)−8.98(225)− 1.10(228)+ 1.34(229)−0.24(230)−9.64(231)+12.40(232) −2.76(233).

95. 0=+23.95−0.84(1)+0.84(3)−2.15(5)+ 2.15(6)− 0.19(7)−2.48(9)+2.67(10)− 1.55(26) +1.55(28)−4.08(29)+3.70(31)− 1.21(32)+ 1.59(34)+0.80(35)−0.80(36)− 0.80(43) +0.80(45)−2.68(46)+2.68(47)− 0.98(49)+ 0.98(51)−0.83(56)+0.83(59)+ 2.82(62) −2.82(64)−1.02(67)+1.02(68)− 2.33(72)+ 2.33(74)+3.12(75)−3.12(77)+ 0.75(78) −0.75(80)−2.60(81)+2.60(82)− 0.80(83)+ 0.06(85)+0.74(87)−1.43(88)+ 1.43(89) +0.92(91)−0.92(92)+2.71(93)− 2.71(94)− 2.18(95)−0.92(97)+3.10(98)− 2.81(99) +3.53(101)−0.72(103)−0.20(109)+ 0.20(112)− 0.94(113)+0.94(115)+1.05(119)− 1.05(121) −0.47(122)+0.47(124)+0.80(125)− 0.80(128)− 3.23(129)+3.23(130)−2.55(131)+ 2.55(133) −0.56(134)+0.56(135)−0.14(136)+ 0.14(138)+ 1.20(139)−1.20(140)+0.37(141)− 0.37(143) −2.07(144)+2.07(145)−0.72(146)+ 0.72(148)+ 3.46(149)−3.46(150)+0.73(151)− 0.73(153) −0.98(154)+0.98(155)−2.07(158)+ 2.07(159)+ 0.70(162)+1.25(162a)−0.70(163) −2.42(164) −1.25(165)+2.42(166)−0.25(169)+ 0.25(171)+ 0.26(174)−0.26(175).

96. 0=− 7.60−2.75(156)+2.75(157)+2.07(158)− 2.07(159)+ 2.42(164)−0.46(165)−2.42(166)+ 0.46(168) +0.25(169)−0.25(171)−0.26(174)+ 0.26(175)− 0.42(178)+0.08(180)+0.34(182)+ 2.60(183) −2.60(184)−1.38(186)+1.38(187)+ 0.44(188)− 0.44(190)−1.75(191)+1.75(192)− 0.05(193) +0.05(195)+1.45(196)−1.45(197)− 1.98(198)+ 1.98(199)+2.33(201)−2.33(202)+ 0.09(203) +0.25(205)−0.34(207)+1.92(208)− 1.92(209)− 2.86(211)+2.86(212)−0.44(213)+ 2.48(215) −2.04(217)+0.29(218)+0.36(220)− 0.65(222)+ 0.54(223)−0.54(224)+0.99(226)− 0.99(227) +1.34(228)−1.34(229)+1.79(231)− 1.79(233).

97. 0=+ 2.05+(1)−(3)+(29)−(36)+(46)−(51)+(57)−(61).

98. 0=− 2.75−(66)+(68)+(69)−(70)−(78)+(82)−(83)+(87)−(93)+(98)−(109)+(112)−(119)+(123) +(234)−(235).

99. 0=+ 5.80−(127)+(130)−(141)+(145)−(151)+(155)−(162a)+(164)+(172)−(175).

100. 0=− 1.22−(172)+(175)−(164)+(168)−(183)+(187)−(188)+(192)−(203)+(207)−(208)+(212)−(218) +(222)−(228)+(230).

101. 0=−0.8831+0.64(1)−0.64(3)−1.20(5)+1.20(6)−0.76(7)+0.16(9)+0.60(10)−0.35(26) +0.35(28)+0.03(29)+0.61(31)−0.27(32)−0.36(34)+1.10(35)−1.10(36)−0.81(43) +0.81(45)+0.13(46)−0.13(47)+0.52(49)−0.52(51)+0.43(56)+0.13(59)−0.56(61) −0.11(62)+0.11(64)−0.64(67)+0.64(68)+0.20(72)−0.20(74)+1.07(75)−1.07(77) −0.32(78)+0.32(80)−0.75(81)+0.75(82)−0.53(83)+0.01(85)+0.52(87)+0.30(88) −0.30(89)+0.62(91)−0.62(92)−0.09(93)+0.09(94)−0.60(95)+0.07(97)+0.53(98) −0.23(99)+0.71(101)−0.48(103)−0.34(109)+0.34(112)+0.33(113)−0.33(115)−0.26(119) +0.26(121)−0.35(122)+0.35(124)−0.27(125)+0.27(128)−0.39(129)+0.39(130)+0.25(131) −0.25(133)+0.34(134)−0.34(135)+0.29(136)−0.29(138)+0.36(139)−0.36(140)−0.27(141) +0.27(143)−0.29(144)+0.29(145)+0.25(146)−0.25(148)+0.36(149)−0.36(150)−0.22(151) +0.22(153)−0.24(154)+0.24(155)+0.15(156)−0.15(157)+0.26(162)−0.26(163)−0.20(162a) −0.03(165)+0.23(168)+0.16(178)−0.16(182)−0.18(183)+0.18(184)−0.18(186)+0.18(187) −0.14(188)+0.14(190)−0.16(191)+0.16(192)+0.13(193)−0.13(195)+0.17(196)−0.17(197) +0.04(198)−0.04(199)+0.15(201)−0.15(202)−0.11(203)+0.01(205)+0.10(207)−0.05(208) +0.05(209)−0.06(211)+0.06(212)+0.06(213)+0.03(215)−0.09(217)+0.01(220)−0.01(222) +0.08(226)−0.08(227)+0.03(228)−0.03(229).

102. 0=+6.8112−1.36(1)+1.36(3)−0.38(5)+0.38(6)+0.58(7)−1.89(9)+1.31(10)−0.76(26) +0.76(28)−2.36(29)+1.49(31)−0.59(32)+1.46(34)−0.38(35)+0.38(36)+0.22(43) −0.22(45)−1.51(46)+1.51(47)−0.93(49)+0.93(51)−0.80(56)+0.32(59)+0.48(61) +1.83(62)−1.83(64)+0.22(67)−0.22(68)−1.19(72)+1.19(74)+0.71(75)−0.71(77) +0.77(78)−0.77(80)−0.38(81)+0.38(82)+0.14(83)+0.02(85)−0.16(87)−0.66(88) +0.66(89)−0.07(91)+0.07(92)+1.16(93)−1.16(94)−0.38(95)−0.12(97)+0.50(98) −0.81(99)+0.77(101)+0.04(103)+0.15(109)−0.15(112)−0.34(113)+0.34(115)+0.43(119) −0.43(121)+0.08(122)−0.08(124)+0.36(125)−0.36(128)−0.52(129)+0.52(130)−0.66(131) +0.66(133)−0.25(134)+0.25(135)−0.09(136)+0.09(138)+0.18(139)−0.18(140)+0.17(141) −0.17(143)−0.27(144)+0.27(145)−0.14(146)+0.14(148)+0.62(149)−0.62(150)+0.19(151) −0.19(153)−0.10(154)+0.10(155)−0.33(156)+0.33(157)+0.10(162)−0.10(163)+0.24(162a) −0.26(165)+0.02(168)−0.06(178)+0.01(180)+0.05(182)+0.44(183)−0.44(184)−0.06(186) +0.06(187)+0.12(188)−0.12(190)−0.03(191)+0.03(192)−0.03(193)+0.03(195)+0.15(196) −0.15(197)−0.13(198)+0.13(199)+0.19(201)−0.19(202)+0.10(203)+0.02(205)−0.12(207) +0.24(208)−0.24(209)+0.06(211)−0.06(212)−0.06(213)+0.11(215)−0.05(217)+0.06(218) −0.06(222)+0.06(228)−0.06(229).

COMPUTED CORRECTIONS TO OBSERVED DIRECTIONS.

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

Table of corrections to observed directions.

Number of direction.	Correction to direction.	Number of direction.	Correction to direction.	Number of direction.	Correction to direction.	Number of direction.	Correction to direction.
1	−0.432	61	−0.038	121	+0.381	181	+0.383
2	−0.271	62	−0.178	122	−0.308	182	−0.156
3	+0.703	63	−1.152	123	+0.670	183	+0.522
4	−0.331	64	+0.305	124	+0.245	184	+0.041
5	+0.006	65	+0.202	125	−0.548	185	−0.521
6	+0.325	66	+1.158	126	−1.021	186	+0.197
7	−0.386	67	−0.499	127	+2.635	187	−0.239
8	−0.067	68	+0.165	128	−0.420	188	+0.355
9	+0.754	69	−0.980	129	−0.131	189	−0.103
10	−0.291	70	+0.413	130	−0.515	190	−0.280
11	+0.237	71	+0.567	131	+0.552	191	−0.151
12	−0.246	72	+0.658	132	−1.307	192	+0.178
13	−0.195	73	+0.430	133	+0.665	193	−0.602
14	+0.312	74	−0.615	134	+0.214	194	+0.191
15	+0.194	75	−0.753	135	−0.124	195	−0.052
16	−0.326	76	+0.022	136	−0.270	196	+0.100
17	+0.015	77	+0.258	137	+0.136	197	+0.364
18	+0.214	78	−0.348	138	−0.909	198	−0.241
19	+0.017	79	−0.144	139	+0.517	199	−0.574
20	−0.231	80	+0.173	140	+0.526	200	−0.008
21	+0.196	81	+0.428	141	−0.268	201	+0.572
22	+0.343	82	−0.109	142	+0.756	202	+0.252
23	−0.538	83	−0.504	143	+0.840	203	−0.170
24	+0.534	84	+0.103	144	−0.327	204	−0.027
25	−0.154	85	+0.726	145	−1.000	205	+0.071
26	−0.205	86	−0.499	146	+0.240	206	−0.457
27	+0.012	87	+0.174	147	−0.982	207	+0.578
28	−0.188	88	+0.922	148	−0.528	208	−0.317
29	−0.668	89	−0.208	149	+0.556	209	+0.135
30	+0.571	90	−0.625	150	+0.712	210	+0.723
31	+1.016	91	+0.226	151	−0.270	211	−0.516
32	−0.056	92	−0.311	152	+0.595	212	−0.025
33	−0.318	93	−0.691	153	+0.400	213	+0.380
34	−0.487	94	−0.043	154	−0.028	214	−0.342
35	−0.636	95	+0.173	155	−0.696	215	−0.284
36	+0.561	96	+0.370	156	−0.634	216	−0.064
37	−0.931	97	+0.182	157	+0.363	217	+0.310
38	+0.496	98	+0.009	158	+0.774	218	−0.039
39	−0.142	99	+0.961	159	−0.395	219	+0.050
40	+0.577	100	−0.391	160	−0.239	220	+0.082
41	−0.273	101	−0.099	161	−0.106	221	−0.004
42	−0.203	102	−0.404	162	+0.040	222	−0.089
43	−0.097	103	−0.066	163	+0.106	223	−0.285
44	+0.359	104	+0.270	164	+0.300	224	+0.272
45	+0.216	105	+0.374	165	−0.251	225	−0.137
46	+0.406	106	−0.260	166	−0.820	226	+0.429
47	−0.437	107	−0.497	167	+0.288	227	−0.278
48	−0.025	108	+0.113	168	−0.323	228	+0.019
49	+0.005	109	−0.714	169	−0.285	229	−0.110
50	−0.271	110	+0.214	170	+0.160	230	+0.090
51	+0.322	111	+0.260	171	+0.124	231	−0.516
52	−0.630	112	+0.240	172	−0.796	232	+0.229
53	−0.150	113	+0.247	173	+0.154	233	+0.288
54	−0.095	114	+0.354	174	−0.277	234	+0.670
55	+0.875	115	+0.054	175	+0.919	235	−0.670
56	+0.495	116	−0.226	176	+0.106	162a	+0.077
57	+0.194	117	+0.053	177	−0.106	163a	+0.729
58	−0.588	118	−0.482	178	−0.719		
59	−0.235	119	−0.558	179	+0.302		
60	+0.171	120	−0.430	180	+0.189		

CORRECTIONS TO ANGLES AND CLOSURES OF TRIANGLES.

The correction to each angle is the algebraic sum of the corrections to two directions. In order to make it possible to study the corrections to the separate angles, they are shown in the following table for every triangle in the 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 angle from figure adjustment.	Error of closure of triangle.	Corrected spherical angle.	Spherical excess.	Station.	Correction to angle from figure adjustment.	Error of closure of triangle.	Corrected spherical angle.	Spherical excess.
	″	″	° ′ ″	″		″	″	° ′ ″	″
Cache	+1.20	+2.67	69 16 53.45	58.52	Picabo	......	......	79 47 48.58	29.66
Ogden Peak	+ .34		42 29 01.52		Big Butte	+0.02		60 58 22.06	
Pilot Peak	+1.13		68 15 03.55		Cache	−1.07		39 14 19.02	
Oxford	+ .32	+1.95	59 16 09.30	56.46	Picabo	......	......	0 05 07.28	.03
Ogden Peak	+ .66		86 54 01.49		Cache	+ .45		0 03 21.63	
Pilot Peak	+ .97		33 50 45.67		Kimama	− .80		179 51 31.12	
Oxford	+1.14	+1.31	95 03 21.93	30.29	Flat	− .28	−0.81	51 38 40.47	5.10
Ogden Peak	+ .32		44 24 59.97		Picabo	+ .10		37 42 24.54	
Cache	− .15		40 32 17.39		Kimama	− .63		90 39 00.09	
Oxford	+ .82	+2.03	35 47 12.63	41.35	Flat	+ .31	......	114 56 50.71	12.90
Pilot Peak	+ .16		34 24 17.88		Picabo	......		37 47 31.82	
Cache	+1.05		109 49 10.84		Cache	+1.69		27 15 50.37	
Putnam	+ .51	− .18	59 54 36.50	23.48	Flat	+ .59	+3.26	63 18 10.24	7.77
Oxford	− .51		91 30 02.58		Kimama	+1.43		89 29 28.79	
Cache	− .18		28 35 44.40		Cache	+1.24		27 12 28.74	
Big Butte	......	......	22 23 53.86	12.75	Green	+ .48	+ .98	59 55 16.22	9.16
Putnam	+ .39		128 53 27.48		Picabo	+ .46		64 10 06.62	
Oxford	+ .53		28 42 51.41		Flat	+ .04		55 54 46.32	
Big Butte	− .05	− .43	75 18 02.42	31.93	Camas	− .97	−2.63	7 27 10.47	1.46
Putnam	− .12		68 58 50.98		Picabo	− .15		5 06 40.62	
Cache	− .26		35 43 38.53		Green	−1.51		167 26 10.87	
Big Butte	......	......	52 54 08.56	42.66	Camas	+ .48	+1.24	36 46 48.81	15.97
Oxford	−1.04		62 47 11.17		Picabo	+ .31		69 16 47.24	
Cache	− .44		64 19 22.93		Flat	+ .45		73 56 39.92	
Middle Butte	− .88	−2.09	103 22 07.88	5.05	Camas	+1.45	+2.89	29 19 38.34	5.35
Putnam	− .52		15 49 42.01		Green	+1.03		132 38 33.41	
Big Butte	− .69		60 48 15.16		Flat	+ .41		18 01 53.60	
Caribou	− .19	− .89	38 11 02.80	12.23	Blue	+ .40	+2.73	36 55 43.31	6.67
Oxford	− .49		36 59 47.90		Camas	+1.35		81 04 36.54	
Putnam	− .21		104 49 21.53		Green	+ .98		61 59 46.82	
Caribou	− .25	+ .24	37 45 16.40	13.41	Blue	+ .20	− .75	90 03 22.02	12.60
Putnam	+ .34		110 27 28.98		Camas	− .10		51 44 58.20	
Middle Butte	+ .15		31 47 28.03		Flat	− .85		38 11 52.38	
Kimama	−1.52	−1.92	110 33 27.58	17.93	Blue	− .20	− .59	53 07 38.71	11.28
Big Butte	+ .22		30 09 09.70		Green	+ .05		70 38 46.59	
Cache	− .62		39 17 40.65		Flat	− .44		56 13 45.98	
Picabo	+ .07	+ .59	79 52 55.86	11.76	Silver	+1.01	− .42	34 01 30.32	16.11
Big Butte	− .20		30 49 12.36		Camas	− .70		77 34 24.33	
Kimama	+ .72		69 18 03.54		Blue	− .73		68 24 15.46	

Table of triangles—Continued.

Station.	Correction to angle from figure adjustment.	Error of closure of triangle.	Corrected spherical angle.	Spherical excess.
	"	"	° ′ "	"
Mountain Home	+1.39	+1.92	94 57 39.14	3.49
Camas	+ .96		61 34 12.98	
Blue	− .43		23 28 11.37	
Mountain Home	+ .16	+ .09	105 58 22.76	10.80
Blue	− .30		44 56 04.09	
Silver	+ .23		29 05 43.95	
Mountain Home	−1.55	−2.43	159 03 58.10	1.82
Silver	+ .78		4 55 52.37	
Camas	−1.66		16 00 11.35	
Shafer	+ .20	+ .52	16 53 38.17	7.73
Camas	− .03		141 41 54.38	
Blue	+ .35		21 24 35.18	
Shafer	+ .52	+1.05	70 27 00.05	18.63
Camas	+ .67		64 07 30.05	
Silver	− .14		45 25 48.53	
Shafer	+ .32	+ .11	53 33 21.88	27.01
Blue	−1.08		46 59 40.28	
Silver	+ .87		79 27 24.85	
Squaw	+ .60	− .72	51 39 00.62	9.18
Shafer	− .28		110 26 04.74	
Silver	−1.04		17 55 03.82	
Nyssa	+ .85	+1.54	30 02 36.29	4.52
Squaw	+1.22		110 55 46.81	
Shafer	− .53		39 01 41.42	
Nyssa	+ .31	+ .70	96 30 05.90	12.66
Squaw	+ .62		59 16 46.10	
Silver	− .23		24 13 20.57	
Nyssa	− .54	−1.56	66 27 29.61	17.32
Shafer	+ .25		71 24 23.32	
Silver	−1.27		42 08 24.39	
Iron	+ .65	− .32	37 49 38.42	8.87
Squaw	− .55		70 40 03.55	
Nyssa	− .42		71 30 26.90	
Dry	− .30	+1.23	48 24 09.03	12.66
Iron	+ .86		90 57 05.15	
Squaw	+ .67		40 38 58.48	
Dry	+ .04	− .88	71 00 15.97	10.08
Iron	+ .21		53 07 26.73	
Nyssa	−1.13		55 52 27.38	
Dry	+ .34	−2.43	22 36 06.94	6.29
Squaw	−1.22		30 01 05.07	
Nyssa	−1.55		127 22 54.28	
Beaver	+ .61	+1.10	73 33 42.91	7.16
Iron	+ .20		45 14 23.22	
Dry	+ .29		61 12 01.03	
Maxwell	− .53	−1.49	28 13 17.74	4.13
Iron	− .19		17 17 24.15	
Beaver	− .77		134 29 22.24	
Maxwell	......	......	44 03 19.32	13.49
Iron	+ .01		62 31 47.37	
Dry	−1.06		73 25 06.80	
Maxwell	......	......	15 50 01.58	2.20
Beaver	+ .16		151 56 54.85	
Dry	−1.35		12 13 05.77	
Medical	+0.93	+0.33	55 09 17.41	8.41
Iron	− .36		51 26 00.97	
Beaver	− .24		73 24 50.03	
Medical	+ .97	+1.08	95 27 07.43	9.10
Iron	− .17		34 08 36.82	
Maxwell	+ .28		50 24 24.85	
Medical	+ .04	− .74	40 17 50.02	4.82
Beaver	− .53		61 04 32.21	
Maxwell	− .25		78 37 42.59	
Fanny	+ .13	− .48	36 38 11.32	3.62
Medical	+ .02		124 57 37.04	
Beaver	− .63		18 24 15.26	
Fanny	+ .94	+ .64	63 21 15.79	3.93
Medical	− .02		84 39 47.02	
Maxwell	− .28		31 59 01.12	
Fanny	+ .81	+ .38	26 43 04.47	5.13
Beaver	+ .10		42 40 16.95	
Maxwell	− .53		110 36 43.71	
Powder	− .34	−1.22	104 55 51.17	1.24
Fanny	− .69		9 06 54.61	
Maxwell	− .19		65 57 15.46	
Emily	− .47	− .91	63 28 57.04	4.60
Fanny	− .14		86 33 34.56	
Maxwell	− .30		29 57 33.00	
Emily	+ .13	+ .23	69 04 53.67	4.25
Fanny	+ .55		77 26 39.95	
Powder	− .45		33 28 30.63	
Emily	+ .60	− .08	5 35 56.63	.89
Maxwell	+ .11		35 59 42.46	
Powder	− .79		138 24 21.80	
La Grande	−1.34	+1.42	94 40 55.40	.85
Emily	+3.19		63 56 43.26	
Fanny	− .43		21 22 22.19	
Birch	+ .01	+ .41	60 18 28.88	5.83
Emily	+ .29		80 05 55.64	
Powder	+ .11		39 35 41.31	
Big Hill	+1.03	+2.90	40 24 50.72	5.08
Emily	− .10		113 13 16.44	
Powder	+1.97		26 21 57.92	
Big Hill	+1.11	+2.15	80 01 08.65	2.21
Emily	− .39		33 07 20.80	
Birch	+1.43		66 51 32.76	
Big Hill	+ .08	− .34	39 36 17.93	2.96
Powder	−1.86		13 13 43.39	
Birch	+1.44		127 10 01.64	
Alkali	+ .16	−1.65	31 20 57.57	2.27
Big Hill	−1.17		62 31 36.63	
Birch	− .64		86 07 28.07	
Laurila	+ .87	−2.02	24 05 40.86	2.31
Big Hill	−1.84		108 03 27.99	
Birch	−1.05		47 50 53.46	
Laurila	+ .67	+1.08	70 57 02.42	3.32
Big Hill	− .67		45 31 51.36	
Alkali	+1.08		63 31 09.54	

Table of triangles—Continued.

Station.	Correction to angle from figure adjustment.	Error of closure of triangle.	Corrected spherical angle.	Spherical excess.
	″	″	° ′ ″	″
Laurila	−0.20	+1.45	46 51 21.56	3.28
Birch	+ .41		38 16 34.61	
Alkali	+1.24		94 52 07.11	
Job	+ .16	−1.04	71 35 44.13	1.69
Laurila	− .43		37 21 05.48	
Alkali	− .77		71 03 12.08	
Expansion	+ .65	+ .01	39 49 27.09	2.62
Laurila	−1.10		102 20 57.23	
Alkali	+ .46		37 49 38.30	
Expansion	− .33	− .56	59 18 17.52	2.42
Laurila	− .67		64 59 51.75	
Job	+ .44		55 41 53.15	
Expansion	− .98	−1.61	19 28 50.43	1.49
Alkali	−1.23		33 13 33.78	
Job	+ .60		127 17 37.28	
Expansion	−1.12	+ .52	41 04 34.35	.88
Stanfield east base	+1.20		82 48 45.12	
Stanfield west base	+ .44		56 06 41.41	
Job	−1.17	−1.33	45 27 37.59	1.36
Stanfield west base	+ .41		96 44 58.12	
Expansion	− .57		37 47 25.65	
Job	−1.01	−1.48	50 22 22.90	.59
Stanfield west base	− .03		40 38 16.71	
Stanfield east base	− .44		88 59 20.98	
Job	+ .16	+ .37	4 54 45.31	.11
Expansion	− .55		3 17 08.70	
Stanfield east base	+ .76		171 48 06.10	
Echo	− .21	+ .87	70 12 33.63	.30
Job	+ .13		36 52 25.42	
Stanfield east base	+ .95		72 55 01.25	
Alder	− .48	−1.31	38 59 51.50	4.29
Expansion	− .07		77 43 51.12	
Job	− .76		63 16 21.67	
Ella	+ .19	−1.46	61 22 42.63	4.16
Alder	−1.04		82 19 34.25	
Expansion	− .61		36 17 47.28	
Ella	− .35	+ .09	99 11 33.74	3.15
Alder	− .56		43 19 42.75	
Job	+1.00		37 28 46.66	
Ella	− .54	+ .24	37 48 51.11	3.28
Expansion	+ .54		41 26 03.84	
Job	+ .24		100 45 08.33	
Toby	+ .26	+1.89	55 31 24.97	2.41
Alder	+ .72		45 45 17.17	
Ella	+ .91		78 43 20.27	
Montgomery	− .46	− .29	42 16 28.78	2.37
Alder	+ .28		102 26 03.56	
Ella	− .11		35 17 30.03	

Station.	Correction to angle from figure adjustment.	Error of closure of triangle.	Corrected spherical angle.	Spherical excess.
	″	″	° ′ ″	″
Montgomery	−0.63	−0.92	78 19 42.05	2.42
Alder	− .44		56 40 46.39	
Toby	+ .15		44 59 33.98	
Montgomery	− .17	+1.26	36 03 13.27	2.46
Ella	+1.02		43 25 50.24	
Toby	+ .41		100 30 58.95	
John	− .32	+ .36	42 04 17.75	3.29
Montgomery	+ .13		49 10 36.21	
Toby	+ .55		88 45 09.33	
Maryhill	+ .14	+ .36	40 16 10.21	2.88
Montgomery	+ .46		99 26 37.04	
Toby	− .24		40 17 14.73	
Maryhill	+ .24	+1.15	87 40 24.54	3.35
Montgomery	+ .33		50 16 01.73	
John	+ .58		42 03 37.08	
Maryhill	+ .10	+1.15	47 24 14.33	3.76
Toby	+ .79		48 27 54.60	
John	+ .26		84 07 54.83	
Stacker	+ .45	+1.53	47 35 24.50	2.83
Maryhill	+ .51		99 04 53.31	
John	+ .57		33 19 45.02	
Lookout	+ .22	+2.30	15 39 18.00	2.75
Stacker	+1.04		134 52 20.91	
Maryhill	+1.04		29 28 23.84	
Lookout	+ .59	+ .85	45 55 33.30	6.97
Stacker	+ .59		87 16 56.41	
John	− .33		46 47 37.26	
Lookout	+ .37	+ .08	30 16 15.30	7.05
Maryhill	− .53		69 36 29.47	
John	+ .24		80 07 22.28	
Chinidere	− .71	−2.61	64 46 33.22	4.62
Stacker	−1.24		37 03 52.18	
Lookout	− .66		78 09 39.22	
Huckle	+ .09	− .60	54 53 26.08	6.51
Stacker	− .75		73 28 28.03	
Lookout	+ .06		51 38 12.40	
Huckle	+ .12	+1.18	82 12 58.90	4.36
Stacker	+ .49		36 24 35.85	
Chinidere	+ .57		61 22 29.61	
Huckle	+ .03	− .83	27 19 32.82	2.47
Lookout	− .72		26 31 26.82	
Chinidere	− .14		126 09 02.83	
Red	− .13	− .71	57 32 49.04	.87
Huckle	− .17		107 21 24.96	
Chinidere	− .41		15 05 46.87	
Larch	+ .76	+ .73	12 10 17.54	1.31
Red	+ .06		83 37 34.45	
Huckle	− .09		84 03 09.32	
Larch	+ .82	+1.56	40 38 22.35	2.13
Red	+ .19		26 04 45.41	
Chinidere	+ .55		104 16 54.37	
Larch	+ .06	+ .12	37 19 04.81	1.69
Huckle	− .08		23 18 15.64	
Chinidere	+ .14		119 22 41.24	

ACCURACY OF OBSERVATIONS.

The maximum correction to any one angle is +3″.19 to the angle at Emily between the lines to Fanny and La Grande. A table is given below showing statistics in regard to the accuracy of the precise triangulation of the arc considered in this publication. The mean error of an angle $\alpha = \sqrt{\frac{\Sigma\Delta^2}{3n}}$, 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	96
Number of triangles with plus closures	51
Number of triangles with minus closures	38
Number of concluded triangles	7
Average closure of a triangle	1″.12
Maximum closure of a triangle	3″.26
Mean error of an angle	±0.79
Probable error of an observed direction	±0.49

The average closing error of the 89 closed triangles of this arc of primary triangulation is 1″.12. The instructions call for 1″.00 closing error on the average. The instructions say that the closing error of a triangle shall seldom exceed 3″.00. In this work the maximum is exceeded in only one instance, where the triangle closure is 3″.26.

A comparison of the average closing errors in various arcs is given below:

	Average closing error.
Ninety-eighth meridian in United States and Mexico	0″.63
Texas-California arc	.90
Ninety-eighth meridian arc	.92
One hundred and fourth meridian arc	.99
Transcontinental triangulation	1.06
Utah-Washington arc	1.12
Eastern oblique arc	1.19
California-Washington arc	1.22

COMPUTATION, ADJUSTMENT, AND ACCURACY OF THE ELEVATIONS.

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

The difference of elevation of each pair of stations in the main scheme was then computed from the observations over the line joining them by the formula

$$h_2 - h_1 = s \tan \tfrac{1}{2} (\zeta_2 - \zeta_1) \, [A \, B \, C]$$

in which h_2 and h_1 are elevations of the stations, ζ_2 and ζ_1 are the measured zenith distances as corrected for height of instrument and of object observed, s is the horizontal distance between the stations, and A, B, and C are correction factors whose values are nearly unity and whose logarithms may be found on pages 64 and 65 of U. S. Coast and Geodetic Survey Special Publication No. 26.

As there are always two or more lines to each new station, many rigid conditions exist between the observed differences of elevation, even if the connections with the precise leveling were ignored, and the least square adjustment furnishes the readiest accurate means of deriving the elevations.

The elevations of stations of the precise triangulation of the present arc were adjusted in two sets of equations. The solution of the first set fixed all the elevations of the precise stations between the lines Cache-Oxford and Silver-Nyssa.

In the first adjustment the elevations of Ogden Peak and Pilot Peak, stations of the thirty-ninth parallel triangulation, were held fixed at 2918.45 and 3262.47 meters, respectively. These elevations appear on page 148 of U. S. Coast and Geodetic Survey Special Publication No. 19. Besides these elevations those of five other stations, determined either by precise levels or connected directly with precise level bench marks, were held fixed. These stations are Oxford, B. M. Q_6, Mountain Home, Nyssa, and B. M. G, and their respective elevations are, 2828.81, 1366.09, 955.50, 697.04, and 663.57 meters.

The probable error of an observation of weight unity derived from the adjustment is ± 0.78 meter. In other words, the reciprocal observations over a line 31.7 kilometers (19.7 miles) long, this being the length of line corresponding to unit weight, determined the difference of elevation of two points with such accuracy that it is an even chance whether the error is greater or less than 0.78 meter. The probable errors for the lines were assumed to be proportional to their lengths.

The probable error of the elevation of the Salt Lake base is ± 0.04 meter. The probable error of the stations Ogden Peak and Pilot Peak probably does not exceed ± 0.6 meter. The probable error of the other fixed stations probably does not exceed this.

Of the stations whose elevations were determined by reciprocal observations station Stump was assumed to be the one least accurately determined, and its probable error was computed as a limiting value and found to be ± 0.40 meter from the vertical angles alone. When combined with the probable error of the fixed stations, it became ± 0.72 meter.

In the second set of equations the elevations of Silver and Shafer, stations of the first set of equations, were held fixed at 2562.05 and 2313.87 meters, respectively. Stations Nyssa, La Grande, Alkali, Job, Stanfield west base, Stanfield east base, and Echo were determined either by precise levels or connected directly with precise level bench marks, and their elevations were held fixed at 697.04, 849.72, 827.17, 513.78, 188.94, 231.11, and 217.04 meters, respectively. The elevations of Larch and Red, stations of the California-Washington arc of precise triangulation, were held fixed at 1234.89 and 1517.31 meters, respectively.

The probable error of an observation of weight unity derived from the adjustment of this second set of equations is ± 0.99 meter. In other words, the reciprocal observations over a line 31.7 kilometers (19.7 miles) long, this being the length of the line corresponding to unit weight, determined the difference of elevation of two points with such accuracy that it is an even chance whether the error is greater or less than 0.99 meter. The probable errors for other lines were assumed to be proportional to their length.

Station Dry was assumed to be the one least accurately determined, and its probable error was computed as a limiting value and found to be ±1.19 meters.

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 ±0.04 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 ±1.2 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.

The table of elevations is given in Part I. (See p. 22).

INDEX TO POSITIONS, DESCRIPTIONS, ELEVATIONS, AND SKETCHES.

INDEX TO POSITIONS, DESCRIPTIONS, ELEVATIONS, AND SKETCHES—Continued.

O

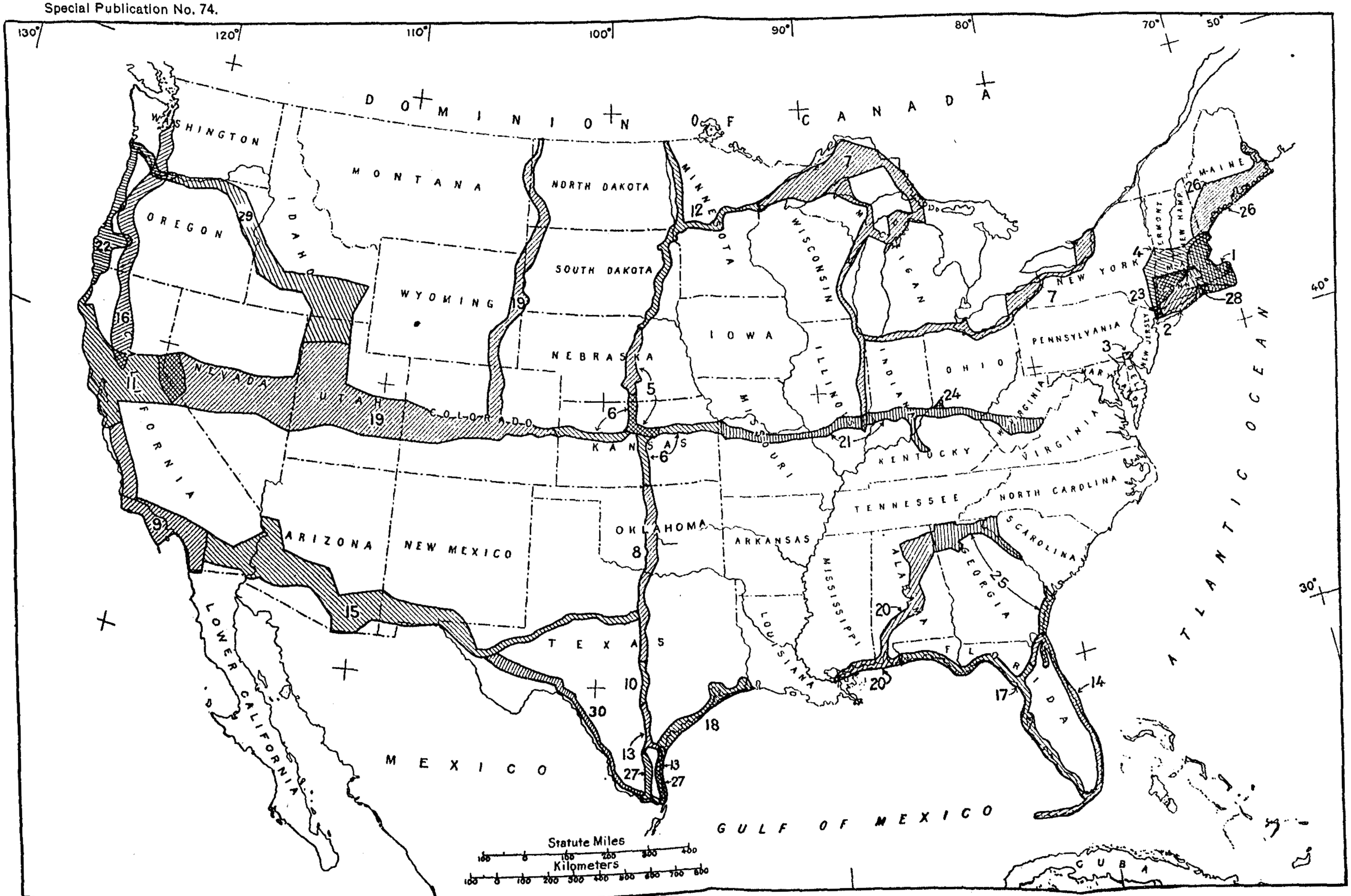

FIG. 3.—INDEX MAP SHOWING AREAS IN THE UNITED STATES COVERED BY PUBLISHED TRIANGULATION WHICH HAS BEEN RIGIDLY COMPUTED ON THE NORTH AMERICAN DATUM.

1. Appendix 8, Report for 1885.
2. Appendix 8, Report for 1888.
3. Appendix 8, Report for 1893.
4. Appendix 10, Report for 1894.
5. Appendix 6, Report for 1901.
6. Special Publication No. 70.
7. Appendix EEE, Annual Report of the Chief of Engineers, 1902.
8. Appendix 4, Report for 1903.
9. Appendix 9, Report for 1904.
10. Appendix 5, Report for 1905.
11. Appendix 5, Report for 1910.
12. Appendix 4, Report for 1911.
13. Appendix 5, Report for 1911.
14. Appendix 6, Report for 1911.
15. Special Publication No. 11.
16. Special Publication No. 13.
17. Special Publication No. 16.
18. Special Publication No. 17.
19. Special Publication No. 19.
20. Special Publication No. 24.
21. Special Publication No. 30.
22. Special Publication No. 31.
23. Report on the triangulation of Greater New York.
24. Report on a plan of sewerage for the city of Cincinnati.
25. Special Publication No. 43.
26. Special Publication No. 46.
27. Special Publication No. 54.
28. Special Publication No. 62.
29. Special Publication No. 74.
30. Special Publication No. — (in preparation).

FIG. 4 - INDEX MAP OF THE UTAH - WASHINGTON ARC

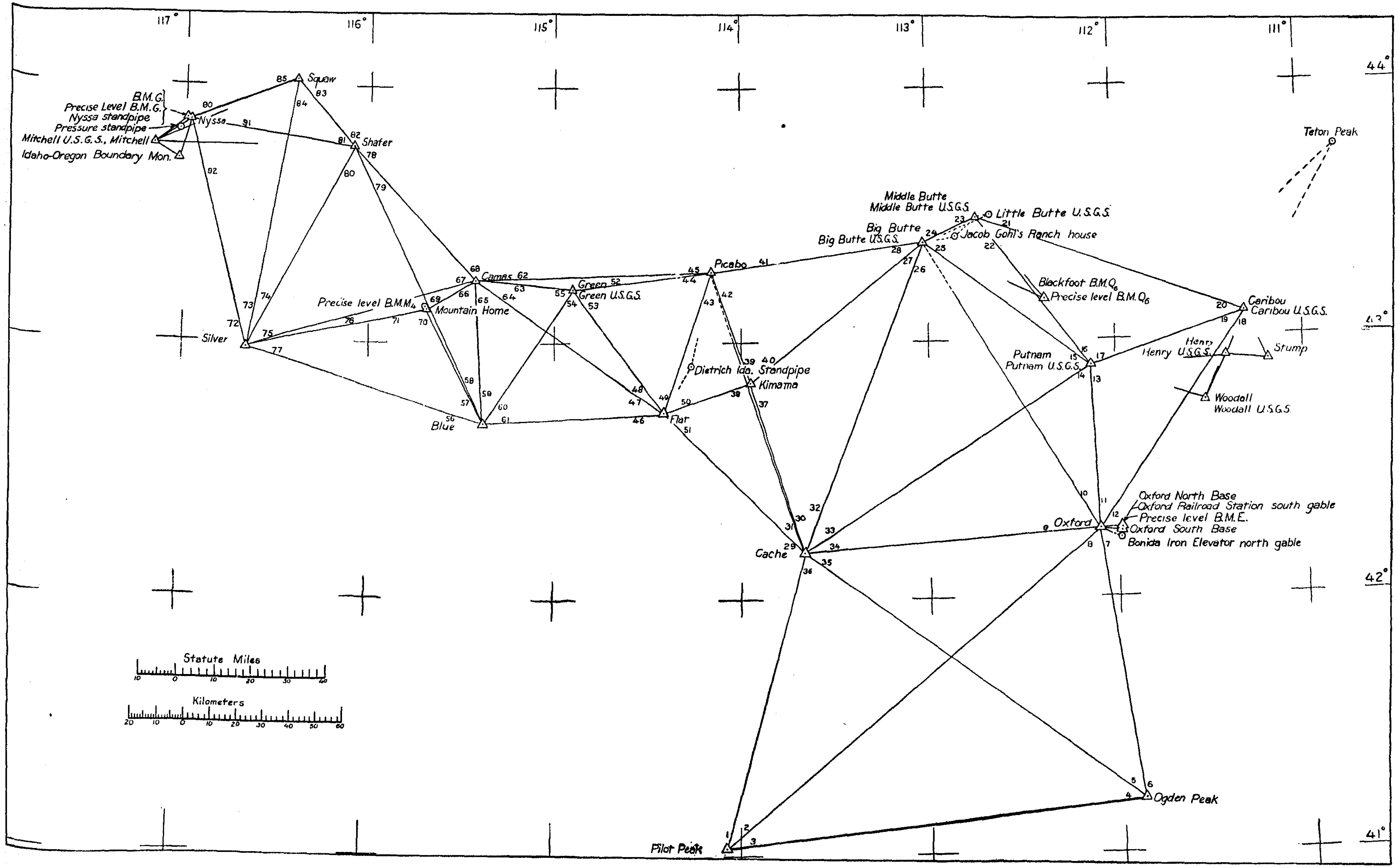

Fig. 5.—TRIANGULATION, SOUTHEASTERN END OF ARC, IN UTAH AND OREGON.

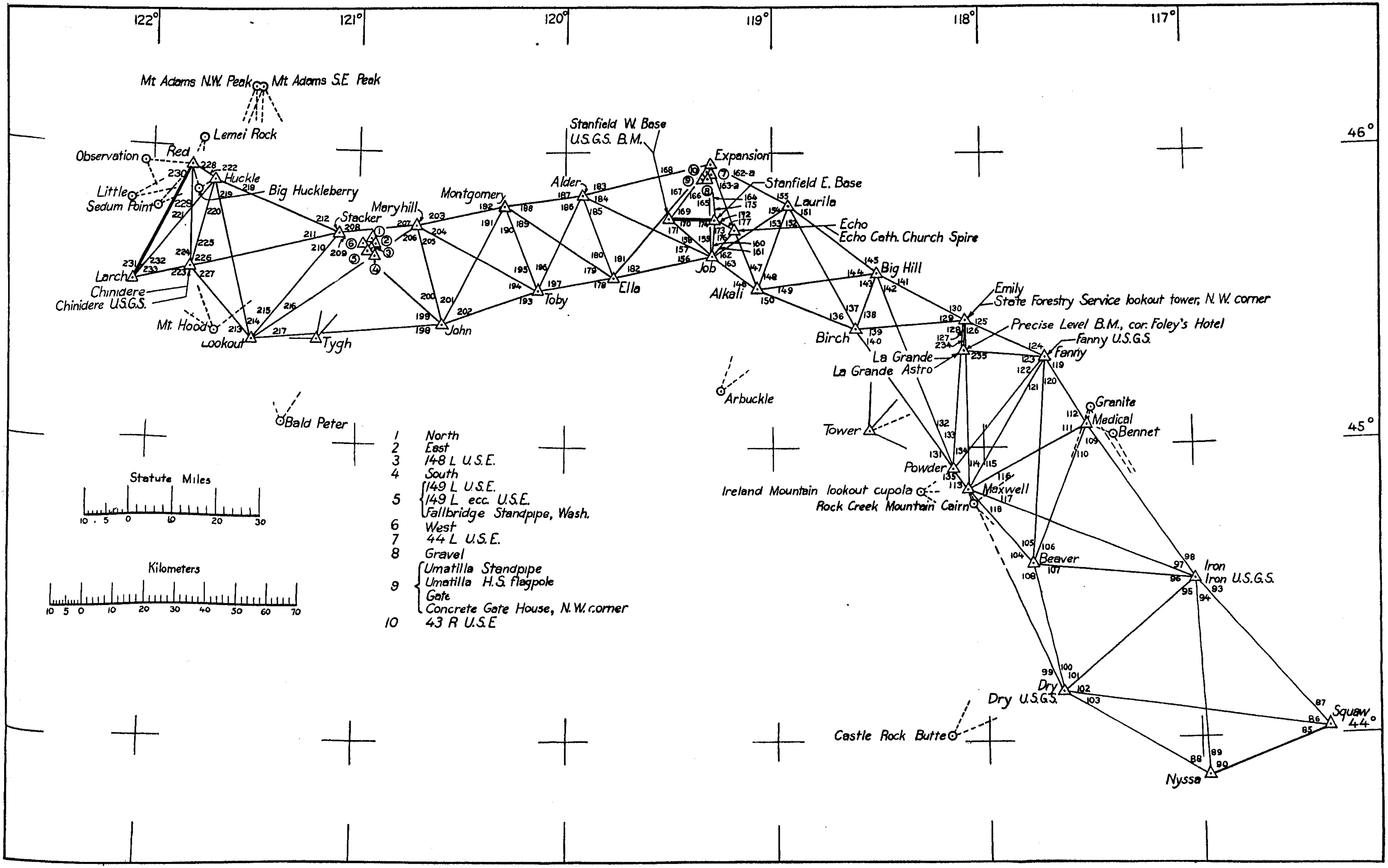

Fig. 6.—TRIANGULATION, NORTHWESTERN END OF ARC, IN OREGON AND WASHINGTON.