

**MANUAL OF INSTRUCTIONS
FOR THE
SURVEY OF THE PUBLIC LANDS
OF THE UNITED STATES
1930**

UNITED STATES DEPARTMENT OF THE INTERIOR
RAY LYMAN WILBUR, SECRETARY
GENERAL LAND OFFICE
C. C. MOORE, Commissioner

MANUAL OF INSTRUCTIONS
FOR THE
SURVEY OF THE PUBLIC LANDS
OF THE UNITED STATES
1930

Prepared and published under the direction
of the Commissioner of the General Land Office



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Standard Field Tables (a supplement to the Manual of Surveying Instructions).

Ephemeris of the Sun and Polaris, and Tables of Azimuths and Altitudes of Polaris, published annually in advance (a supplement to the Manual of Surveying Instructions).

Wall map of the United States, scale 37 miles to 1 inch, and separate maps of the several public-land States, scale 12 miles to 1 inch, showing the developed rectangular surveys.

Copies of the approved field notes and plats of the public-land subdivisional surveys may be procured from the Commissioner of the General Land Office, Washington, D. C., at the current rates for such official copies.

Copies of the approved field notes and plats of the public-land, mineral-patent, and private-land-claim-patent surveys may be procured from the United States public survey offices or the appropriate State office indicated in the Manual, section 1, Chapter I. A charge is usually made for making copies of records furnished to the public, or provision is afforded to the public to make extracts from or copies of such records.

United States cadastral engineers and all others who may have occasion to use this volume are requested to report to the Commissioner of the General Land Office, Washington, D. C., any errors which may be found herein.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GENERAL LAND OFFICE

WASHINGTON, *June 14, 1930.*

The UNITED STATES SUPERVISOR OF SURVEYS.

SIR: This Manual of Instructions for the Survey of the Public Lands of the United States, published as the Manual of 1930, which is issued for the guidance of the cadastral engineering service of the General Land Office under the authority found in sections 458 and 2478 of the Revised Statutes, will supersede all previous manuals or circular instructions on the technical subjects contained therein.

C. C. MOORE,
Commissioner.

Approved June 14, 1930.

JOHN H. EDWARDS,
Assistant Secretary.

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CHAPTER I.

REGULATIONS IMPOSED BY LAW.

THE PUBLIC DOMAIN.

1. The survey of the public lands of the United States is inseparably associated with questions relating to the acquisition and disposal of proprietary title to the lands which have been added to the area included in the original thirteen States. The term "public domain" has been applied broadly to the entire aforementioned area in so far as the lands have been subject to survey and disposal by the United States, and of interest herein may be mentioned the 29 States and the District of Alaska surveyed or in progress of survey under the United States rectangular system, as follows:

Alabama.—Included in the territory of the original thirteen States and admitted into the Union December 14, 1819 (3 Stat. 608); surveys practically completed and original records transferred to the Secretary of State at Montgomery.

Arizona.—Included in the lands ceded by Mexico in 1848 and the Gadsden purchase in 1853 and admitted into the Union February 14, 1912 (36 Stat. 557, 37 Stat. 1728); surveys in progress; United States Public Survey Office at Phoenix.

Arkansas.—Acquired under the Louisiana Purchase in 1803 and admitted into the Union June 15, 1836 (5 Stat. 50); surveys practically completed and original records transferred to the Commissioner of State Lands at Little Rock.

California.—Ceded by Mexico in 1848 and admitted into the Union September 9, 1850 (9 Stat. 452); surveys in progress; United States Public Survey Office at San Francisco.

Colorado.—Acquired largely under the Louisiana Purchase in 1803, but including additional land, title to which was quieted through treaty with Spain in 1819, with other lands annexed with Texas in 1845, and lands ceded by Mexico in 1848, and admitted into the Union August 1, 1876 (18 Stat. 474, 19 Stat. 685); surveys in progress; United States Supervisor of Surveys at Denver.

Florida.—Ceded by Spain in 1819 and admitted into the Union March 3, 1845 (5 Stat. 742); surveys practically completed and original records transferred to the Commissioner of Agriculture at Tallahassee.

Idaho.—Acquired with the Oregon territory, title to which was established in 1846, and admitted into the Union July 3, 1890 (26 Stat. 215); surveys in progress; United States Public Survey Office at Boise.

Illinois.—Included in the territory of the original thirteen States and admitted into the Union December 3, 1818 (3 Stat. 536); surveys practically completed and original records transferred to the Auditor of State at Springfield.

Indiana.—Included in the territory of the original thirteen States and admitted into the Union December 11, 1816 (3 Stat. 399); surveys practically completed and original records transferred to the Auditor of State at Indianapolis.

Iowa.—Acquired under the Louisiana Purchase in 1803 and admitted into the Union December 28, 1846 (9 Stat. 117); surveys practically completed and original records transferred to the Secretary of State at Des Moines.

Kansas.—Acquired under the Louisiana Purchase in 1803 and with lands annexed with Texas in 1845 and admitted into the Union January 29, 1861 (12 Stat. 126); surveys practically completed and original records transferred to the Auditor of State and Register of State Lands at Topeka.

Louisiana.—Included in the Louisiana Purchase in 1803 and boundary extended to include additional lands, title to which was quieted through treaty with Spain in 1819, and admitted into the Union April 30, 1812 (2 Stat. 701); surveys practically completed and original records transferred to the Register of State Lands at Baton Rouge.

Michigan.—Included in the territory of the original thirteen States and admitted into the Union January 26, 1837 (5 Stat. 144); surveys practically completed and original records transferred to the Director, Department of Conservation, at Lansing.

Minnesota.—Included in the territory of the original thirteen States, and with lands acquired under the Louisiana Purchase in 1803, and admitted into the Union May 11, 1858 (11 Stat. 285); surveys practically completed and original records transferred to the Secretary of State at St. Paul.

Mississippi.—Included in the territory of the original thirteen States and admitted into the Union December 10, 1817 (3 Stat. 472); surveys practically completed and original records transferred to the Commissioner of State Lands at Jackson.

Missouri.—Acquired under the Louisiana Purchase in 1803 and admitted into the Union August 10, 1821 (3 Stat. 645, 8 Stat. Appendix II); surveys practically completed and original records transferred to the Secretary of State at Jefferson City.

Montana.—Acquired under the Louisiana Purchase in 1803 and with the Oregon territory, title to which was established in 1846, and admitted into the Union November 8, 1889 (25 Stat. 676, 26 Stat. 1551); surveys in progress; United States Public Survey Office at Helena.

Nebraska.—Acquired under the Louisiana Purchase in 1803 and admitted into the Union March 1, 1867 (14 Stat. 391, 820); surveys practically completed and original records transferred to the Commissioner of Public Lands and Buildings at Lincoln.

Nevada.—Ceded by Mexico in 1848 and admitted into the Union October 13, 1864 (13 Stat. 30, 749); surveys in progress; United States Public Survey Office at Reno.

New Mexico.—Included with lands annexed with Texas in 1845, with lands ceded by Mexico in 1848, and the Gadsden Purchase in 1853, and admitted into the Union January 6, 1912 (36 Stat. 557, 37 Stat. 1723); surveys in progress; United States Public Survey Office at Santa Fe.

North Dakota.—Included in the territory of the original thirteen States, and with lands acquired under the Louisiana Purchase in 1803, and admitted into the Union November 2, 1889 (25 Stat. 676, 26 Stat. 1548); surveys practically completed and original records transferred to the State Engineer at Bismarck.

Oklahoma.—Acquired under the Louisiana Purchase in 1803 and with lands annexed with Texas in 1845, and admitted into the Union November 16, 1907 (34 Stat. 267, 35 Stat. 2160); surveys practically completed and original records filed with the Commissioner of the General Land Office at Washington, D. C.

Ohio.—Included in the territory of the original thirteen States and admitted into the Union April 30, 1802 (2 Stat. 173); sur-

veys practically completed and original records transferred to the Auditor of State at Columbus.

Oregon.—Included in the Oregon territory, title to which was established in 1846, and admitted into the Union February 14, 1859 (11 Stat. 383); surveys in progress; United States Public Survey Office at Portland.

South Dakota.—Included in the territory of the original thirteen States, and with lands acquired under the Louisiana Purchase in 1803, and admitted into the Union November 2, 1889 (25 Stat. 676, 26 Stat. 1549); surveys practically completed and original records transferred to the Commissioner of School and Public Lands at Pierre.

Utah.—Ceded by Mexico in 1848 and admitted into the Union January 4, 1896 (28 Stat. 107, 29 Stat. 876); surveys in progress; United States Public Survey Office at Salt Lake City.

Washington.—Included in the Oregon territory, title to which was established in 1846, and admitted into the Union November 11, 1889 (25 Stat. 676, 26 Stat. 1552); surveys in progress; United States Public Survey Office at Olympia.

Wisconsin.—Included in the territory of the original thirteen States and admitted into the Union May 29, 1848 (9 Stat. 233); surveys practically completed and original records transferred to the Commissioners of Public Lands at Madison.

Wyoming.—Included with lands acquired under the Louisiana Purchase in 1803, with lands annexed with Texas in 1845, with lands included in the Oregon territory, title to which was established in 1846, and with lands ceded by Mexico in 1848, and admitted into the Union July 10, 1890 (26 Stat. 222); surveys in progress; United States Public Survey Office at Cheyenne.

District of Alaska.—Ceded by Russia in 1867; surveys in progress; United States Public Survey Office at Juneau.

2. After the admission of the States into the Union the United States continued to hold title to the unappropriated lands and to administer its public-land laws with reference thereto, and it is expressly provided, as one of the conditions set forth in the various enabling acts, that the title to unappropriated lands within the State shall remain in the United States. The lands in the Territories not appropriated by competent authority before they were acquired are in the first instance the exclusive property of the United States, to be disposed of to such per-

sons, at such times, in such modes, and by such titles as the Government may deem most advantageous to the public. Congress alone has the power, derived from Article IV, section 3, of the Constitution, of disposing of the public domain and making all needful rules and regulations in respect thereto.

3. Under the laws of the United States the navigable waters have always been and shall forever remain common highways, and below mean high water the same are not subject to survey and disposal. This reservation includes all tidewater streams, and other important permanent bodies of water whose natural and normal condition at the date of the admission of a State into the Union was such as to classify the same as navigable water. (See sec. 2476, R. S.)

4. The act of Congress approved March 2, 1849 (9 Stat. 352), granted to the State of Louisiana all the swamp and overflowed lands within the limits of the State for the purpose of aiding in the reclamation of said lands, and the act of Congress approved September 28, 1850 (9 Stat. 519), extended the grant to the other public-land States then in the Union. The grant was also extended to the States of Minnesota and Oregon by the act of Congress approved March 12, 1860 (12 Stat. 3). The provisions of the aforementioned grants apply to the zone situated below the uplands wherein the lands are of such a character that without the construction of suitable levees and artificial drainage systems the same would be wet and unfit for agricultural purposes. The swamp-land grants apply to all swamp and overflowed lands within the beneficiary States which were unappropriated at the dates of the acts of Congress and whose character *at that time* would bring them within the provisions of said grants. A notable exception to the swamp-land laws is found in the Arkansas compromise act approved April 29, 1898 (30 Stat. 367), by virtue of which all right, title, and interest to the remaining unappropriated swamp and overflowed lands within the State of Arkansas reverted to the United States.

5. It comes within the province of the Department of the Interior to consider and determine what are public lands, what lands have been surveyed, what are to be surveyed, what have been disposed of, what remain to be disposed of, and what are reserved, and it is a well-settled principle of law that the United

States, through the Department of the Interior, has the right to extend the surveys as may be necessary to include lands omitted from earlier surveys. It is an important duty of the engineer in the field to discriminate between what are and what are not public lands of the United States, and to subdivide the former in accordance with the regulations imposed by law.

LAWS RELATING TO SURVEYS.

6. The rectangular surveying system is based upon existing law and was devised with the object of marking upon the ground

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

and fixing for all time legal subdivisions for purposes of description and disposal of the public domain under the general land laws of the United States.

7. The rectangular system of survey of the public lands was inaugurated by a committee appointed by the Continental Congress. On the 7th of May, 1774, this committee reported "An ordinance for ascertaining the mode of locating and disposing of lands in the western territory, and for other purposes therein mentioned." The ordinance as finally passed on the 20th of May, 1775, provided for townships 6 miles square, containing 36 sections of 1 mile square. The first public surveys were made under this ordinance. The townships 6 miles square, were laid out in ranges extending northward from the Ohio

River, the townships being numbered from south to north, and the ranges from east to west. The region embraced by the surveys under this law forms a part of the State of Ohio. In these initial surveys only the exterior lines of the townships were surveyed, but the plats were marked by subdivisions into sections of 1 mile square, and mile corners were established on the township lines. The sections were numbered from 1 to 36, and the surveys were made under the direction of the geographer of the United States.

The act of Congress approved May 18, 1796, provided for the appointment of a surveyor general and directed the survey of the lands northwest of the Ohio River and above the mouth of the Kentucky River, "in which the titles of the Indian tribes have been extinguished." Under this law it was provided that "the sections shall be numbered, respectively, beginning with the number one in the northeast section and proceeding west and east alternately through the township, with progressive numbers till the thirty-sixth be completed." This method of numbering sections, as shown by the accompanying diagram, is still in use.

The act of Congress approved May 10, 1800, required the "townships west of the Muskingum, which * * * are directed to be sold in quarter townships, to be subdivided into half sections of three hundred and twenty acres each, as nearly as may be, by running parallel lines through the same from east to west and from south to north at the distance of one mile from each other, and marking corners at the distance of each half mile on the lines running from east to west and at the distance of each mile on those running from south to north. * * *

And the interior lines of townships intersected by the Muskingum, and of all the townships lying east of that river, which have not been heretofore actually subdivided into sections shall also be run and marked. * * *

And in all cases where the exterior lines of the townships thus to be subdivided into sections or half sections shall exceed, or shall not extend, six miles, the excess or deficiency shall be specially noted and added to or deducted from the western and northern ranges of sections or half sections in such townships, according as the error may be in running the lines from east to west or from south to north."

The act of Congress approved February 11, 1805, directs the subdivision of the public lands into quarter sections and pro-

vides that all the corners marked in the public surveys shall be established as the proper corners of sections, or subdivisions of sections, which they were intended to designate, and that corners of half and quarter sections not marked shall be placed as nearly as possible "equidistant from those two corners which stand on the same line." This act further provides that "The boundary lines actually run and marked * * * shall be established as the proper boundary lines of the sections or subdivisions for which they were intended; and the length of such lines as returned by * * * the surveyors * * * shall be held and considered as the true length thereof, and the boundary lines which shall not have been actually run and marked as aforesaid shall be ascertained by running straight lines from the established corners to the opposite corresponding corners; but in those portions of the fractional townships where no such opposite or corresponding corners have been or can be fixed, the said boundary lines shall be ascertained by running from the established corners due north and south or east and west lines, as the case may be, to the * * * external boundary of such fractional township."

The act of Congress approved April 25, 1812, provided "That there shall be established in the Department of the Treasury an office to be denominated the General Land Office, the chief officer of which shall be called the Commissioner of the General Land Office, whose duty it shall be, under the direction of the head of the department, to superintend, execute, and perform all such acts and things touching or respecting the public lands of the United States, and other lands patented or granted by the United States, as have heretofore been directed by law to be done or performed in the office of the Secretary of State, of the Secretary and Register of the Treasury, and of the Secretary of War, or which shall hereafter by law be assigned to the said office."

The act of Congress approved April 24, 1820, provides for the sale of public lands in half-quarter sections, and requires that "in every case of the division of a quarter section the line for the division thereof shall run north and south * * * and fractional sections, containing one hundred and sixty acres and upward, shall, in like manner, as nearly as practicable, be subdivided into half-quarter sections, under such rules and regulations as may be prescribed by the Secretary of the Treasury;

but fractional sections containing less than one hundred and sixty acres shall not be divided."

The act of Congress approved May 29, 1830 (secs. 2412, 2413, R. S.), provides for the fine and imprisonment of any person obstructing the survey of the public lands, and for the protection of surveyors, in the discharge of their official duties, by the United States marshal, with sufficient force, whenever necessary.

The act of Congress approved April 5, 1832, directed the subdivision of the public lands into quarter quarters; that in every case of the division of a half-quarter section the dividing line should run east and west; and that fractional sections should be subdivided under rules and regulations prescribed by the Secretary of the Treasury. Under the latter provision the Secretary directed that fractional sections containing less than 160 acres, or the residuary portion of a fractional section, after the subdivision into as many quarter-quarter sections as it is susceptible of, may be subdivided into lots, each containing the quantity of a quarter-quarter section as nearly as practicable, by so laying down the line of subdivision that they shall be 20 chains wide, which distances are to be marked on the plat of subdivision, as are also the areas of the quarter quarters and residuary fractions.

The last two acts above mentioned provided that the corners and contents of half-quarter and quarter-quarter sections should be ascertained, as nearly as possible, in the manner and on the principles directed and prescribed in the act of Congress approved February 11, 1805.

The act of Congress approved July 4, 1836, provided for the reorganization of the General Land Office, and that the executive duties of said office "shall be subject to the supervision and control of the Commissioner of the General Land Office under the direction of the President of the United States." The repealing clause is, "That such provisions of the act of the twenty-fifth of April, in the year one thousand eight hundred and twelve, entitled 'An act for the establishment of a General Land Office in the Department of the Treasury,' and of all acts amendatory thereof, as are inconsistent with the provisions of this act, be, and the same are hereby, repealed."

From the wording of this act it would appear that the control of the General Land Office was removed from the Treasury Department, and that the commissioner reported directly to the President; but, as a matter of fact, the Secretary of the Treasury still had supervisory control, for the act of Congress approved March 3, 1849, by which the Department of the Interior was established, provided, "That the Secretary of the Interior shall perform all the duties in relation to the General Land Office, of supervision and appeal, now discharged by the Secretary of the Treasury * * *." By this act the General Land Office was transferred to the Department of the Interior, where it still remains.

8. The following comprises so much of the general laws relating to the survey of the public domain as it is deemed necessary to incorporate in this volume, reference being made by chapter and section to the codification of the Public Land Laws, prepared pursuant to acts of Congress approved March 3, 1879, and June 16, 1880, and by section number to the Revised Statutes of the United States.

SEC. 32. The Commissioner of the General Land Office shall perform, under the direction of the Secretary of the Interior, all executive duties appertaining to the surveying and sale of the public lands of the United States, or in any wise respecting such public lands; and, also, such as relate to private claims of lands, and the issuing of patents for all grants of land under the authority of the Government. (R. S. 453.)

SEC. 61. The Commissioner, under the direction of the Secretary of the Interior, is authorized to enforce and carry into execution every part of the public land laws not otherwise specially provided for. (R. S. 2478.)

SEC. 99. First. The public lands shall be divided by north and south lines run according to the true meridian, and by others crossing them at right angles, so as to form townships of six miles square, unless where the line of an Indian reservation, or of tracts of land heretofore surveyed or patented, or the

course of navigable rivers, may render this impracticable; and in that case this rule must be departed from no further than such particular circumstances require.

Second. The corners of the townships must be marked with progressive numbers from the beginning; each distance of a mile between such corners must be also distinctly marked with marks different from those of the corners.

Third. The township shall be subdivided into sections, containing as nearly as may be, six hundred and forty acres each, by running through the same, each way, parallel lines at the end of every two miles¹; and by making a corner on each of such lines at the end of every mile. The sections shall be numbered, respectively, beginning with the number one in the northeast section, and proceeding west and east alternately through the township with progressive numbers till the thirty-six be completed.

Fourth. The deputy surveyors, respectively, shall cause to be marked on a tree near each corner established in the manner described, and within the section, the number of such section, and over it the number of the township within which such section may be; and the deputy surveyors shall carefully note, in their respective field books, the names of the corner trees marked and the numbers so made.

Fifth. Where the exterior lines of the townships which may be subdivided into sections or half sections exceed, or do not extend six miles, the excess or deficiency shall be specially noted, and added to or deducted from the western and northern ranges of sections or half sections in such townships, according as the error may be in running the lines from east to west, or from south to north; the sections and half sections bounded on the northern and western lines of such townships shall be sold as containing only the quantity expressed in the returns and plats, respectively, and all others as containing the complete legal quantity.

Sixth. All lines shall be plainly marked upon trees, and measured with chains, containing two perches of sixteen and

¹Authority for the establishment of section lines at intervals of 1 mile is found in the act of Congress approved May 10, 1800, previously quoted.

one-half feet each, subdivided into twenty-five equal links; and the chain shall be adjusted to a standard to be kept for that purpose.³

Seventh. Every surveyor shall note in his field book the true situations of all mines, salt licks, salt springs, and mill seats which come to his knowledge; all water courses over which the line he runs may pass; and also the quality of the lands.

Eighth. These field books shall be returned to the surveyor general, who shall cause therefrom a description of the whole lands surveyed to be made out and transmitted to the officers who may superintend the sales. He shall also cause a fair plat to be made of the townships and fractional parts of townships contained in the lands, describing the subdivisions thereof, and the marks of the corners. This plat shall be recorded in books to be kept for that purpose; and a copy thereof shall be kept open at the surveyor general's office for public information, and other copies shall be sent to the places of the sale and to the General Land Office. (Acts of May 18, 1796, and May 10, 1800, and R. S. 2395.)

SEC. 100. The boundaries and contents of the several sections,

Boundaries and contents of public lands, how ascertained.

half sections, and quarter sections of the public lands shall be ascertained in conformity with the following principles:

First. All the corners marked in the surveys returned by the surveyor general shall be established as the proper corners of sections, or subdivisions of sections, which they were intended to designate, and the corners of half and quarter sections, not marked on the surveys, shall be placed as nearly as possible equidistant from two corners which stand on the same line.

Second. The boundary lines, actually run and marked in the surveys returned by the surveyor general, shall be established as the proper boundary lines of the sections or subdivisions for which they were intended, and the length of such lines as returned shall be held and considered as the true length thereof.

³The superior results obtained by the use of modern steel ribbon tapes, in contrast with the obsolete link chain, have led to the abandonment of the latter, except that the "chain unit," which is peculiarly adapted to land surveying, has always been employed.

And the boundary lines which have not been actually run and marked shall be ascertained by running straight lines from the established corners to the opposite corresponding corners; but in those portions of the fractional townships, where no such opposite corresponding corners have been or can be fixed, the boundary lines shall be ascertained by running from the established corners due north and south or east and west lines, as the case may be, to the water course, Indian boundary line, or other external boundary of such fractional township.

Third. Each section or subdivision of section, the contents whereof have been returned by the surveyor general, shall be held and considered as containing the exact quantity expressed in such return; and the half sections and quarter sections, the contents whereof shall not have been thus returned, shall be held and considered as containing the one-half or the one-fourth part, respectively, of the returned contents of the section of which they may make part. (Act of Feb. 11, 1805, and R. S. 2396.)

Sec. 101. In every case of the division of a quarter section the line for the division thereof shall run north and south, and the corners and contents of half-quarter sections which may thereafter be sold shall be ascertained in the manner and on the principles directed and prescribed by the section preceding, and fractional sections containing one hundred and sixty acres or upwards shall in like manner, as nearly as practicable, be subdivided into half-quarter sections, under such rules and regulations as may be prescribed by the Secretary of the Interior, and in every case of a division of a half-quarter section, the line for the division thereof shall run east and west, and the corners and contents of quarter-quarter sections, which may thereafter be sold, shall be ascertained, as nearly as may be, in the manner and on the principles directed and prescribed by the section preceding; and fractional sections containing fewer or more than one hundred and sixty acres shall in like manner, as nearly as may be practicable, be subdivided into quarter-quarter sections, under such rules and regulations as may be prescribed by the Secretary of the Interior. (R. S. 2397.)

Lines of division of half-quarter sections, how run.

SEC. 106. The public surveys shall extend over all mineral lands, and all subdividing of surveyed lands into lots less than one hundred and sixty acres may be done by county and local surveyors at the expense of claimants; but nothing in this section contained shall require the survey of waste or useless lands. (R. S. 2406.)

SEC. 118. Each surveyor general, when thereunto duly authorized by law, shall cause all confirmed private land claims within his district to be accurately surveyed, and shall transmit plats and field notes thereof to the Commissioner of the General Land Office for his approval. When publication of such surveys is authorized by law, the proof thereof, together with any objections properly filed, and all evidence submitted either in support of or in opposition to the approval of any such survey, shall also be transmitted to said commissioner. (R. S. 2447.)

SEC. 120. Every person who in any manner, by threat or force, interrupts, hinders, or prevents the surveying of the public lands, or of any private land claim which has been or may be confirmed by the United States, by the persons authorized to survey the same, in conformity with the instructions of the Commissioner of the General Land Office, shall be fined not less than fifty dollars, nor more than three thousand dollars, and be imprisoned not less than one nor more than three years. (R. S. 2412.)

SEC. 121. Whenever the President is satisfied that forcible opposition has been offered, or is likely to be offered, to any surveyor or deputy surveyor in the discharge of his duties in surveying the public lands, it may be lawful for the President to order the marshal of the State or district, by himself or deputy, to attend such surveyor or deputy surveyor with sufficient force to protect such officer in the execution of his duty, and to remove force should any be offered. (R. S. 2413.)

9. More recent legislation has brought about (a) authority for the purchase of metal or other equally durable monuments, to be employed in place of native material to mark public land corners; (b) penalty for the destruction of monuments of the public-land surveys; (c) authority for necessary resurveys; (d) authority for the employment of a permanent corps of United States cadastral engineers; (e) authority for the reorganization of the public survey offices; and (f) authority for the discontinuance of the public survey offices when no longer necessary, and transfer of certain records to the States.

The act of Congress approved May 27, 1908, provided "for the purchase of metal monuments to be used for public land survey corners wherever practicable." (35 Stat. 347.) This authority was amplified by the act of Congress approved June 25, 1910, making appropriation for sundry civil expenses for the fiscal year ended June 30, 1911, and has been continued from year to year to the present time.

The act of Congress approved March 4, 1909, entitled "An act to codify, revise, and amend the penal laws of the United States," provides a penalty for the unauthorized alteration or removal of any Government survey-monument or marked trees, as follows:

"Whoever shall willfully destroy, deface, change, or remove to another place any section corner, quarter-section corner, or meander post, on any Government line of survey, or shall willfully cut down any witness tree or any tree blazed to mark the line of a Government survey, or shall willfully deface, change, or remove any monument or bench mark of any Government survey, shall be fined not more than \$250, or imprisoned not more than six months, or both." (35 Stat. 1099, sec. 57.)

The act of Congress approved March 3, 1909, entitled "An act authorizing the necessary resurvey of public lands," as amended by joint resolution approved June 25, 1910, provides as follows:

"That the Secretary of the Interior may, in his discretion, cause to be made, as he may deem wise under the rectangular

system now provided by law, such resurveys or retracements of the surveys of public lands as, after full investigation, he may deem essential to properly mark the boundaries of the public lands remaining undisposed of: *Provided*, That no such resurvey or retracement shall be so executed as to impair the bona fide rights or claims of any claimant, entryman, or owner of lands affected by such resurvey or retracement: *Provided further*, That not to exceed 20 per centum of the total annual appropriation for surveys and resurveys of the public lands shall be used for the resurveys and retracements authorized hereby." (35 Stat. 845, 36 Stat. 884.)

The act of Congress approved September 21, 1918, entitled "An act authorizing the resurvey or retracement of lands heretofore returned as surveyed public lands of the United States under certain conditions" provides authority for the resurvey by the Government of townships heretofore held to be ineligible for resurvey under existing regulations of the Department of the Interior by reason of disposals in excess of fifty per centum of the total area thereof. The act provides:

"That upon the application of the owners of three-fourths of the privately owned lands in any township covered by public-land surveys, more than fifty per centum of the area of which township is privately owned, accompanied by a deposit with the United States surveyor general for the proper State, or if there be no surveyor general of such State, then with the Commissioner of the General Land Office, of the proportionate estimated cost, inclusive of the necessary (office) work, of the resurvey or retracement of all the privately owned lands in said township, the Commissioner of the General Land Office, subject to the supervisory authority of the Secretary of the Interior, shall be authorized in his discretion to cause to be made a resurvey or retracement of the lines of said township and to set permanent corners and monuments in accordance with the laws and regulations governing surveys and resurveys of public lands; that the sum so deposited shall be held by the surveyor general or commissioner when ex officio surveyor general and may be expended in payment of the cost of such survey, including field and office work, and any excess over the cost of such

survey and the expenses incident thereto shall be repaid pro rata to the persons making said deposits or their legal representatives; that the proportionate cost of the field and office work for the resurvey or retracement of any public lands in such township shall be paid from the current appropriation for the survey and resurvey of public lands, in addition to the portion of such appropriation otherwise allowed by law for resurveys and retracements; that similar resurveys and retracements may be made on the application, accompanied by the requisite deposit, of any court of competent jurisdiction, the returns of such resurvey or retracement to be submitted to the court; that the Secretary of the Interior is authorized to make all necessary rules and regulations to carry this act into full force and effect." (40 Stat. 965.)

The act of Congress approved June 25, 1910 (36 Stat. 703, 740), making appropriation for sundry civil expenses for the fiscal year ended June 30, 1911, provided, under "Surveying the Public Lands": "The surveys and resurveys to be made by such competent surveyors as the Secretary of the Interior may select, * * *." This provision of law brought to a close the practice of letting contracts for the making of the public-land surveys, which had been followed from the beginning. The field work is now performed by a permanent corps of engineers who are employed under civil service regulations.

The act of Congress approved March 3, 1925, provided for the reorganization of the public survey offices as follows:

"The office of surveyor general is hereby abolished, effective July 1, 1925, and the administration of all activities theretofore in charge of surveyors general, including the necessary personnel, all records, furniture, and other equipment, and all supplies in their respective offices, are hereby transferred to and consolidated with the Field Surveying Service, under the jurisdiction of the United States Supervisor of Surveys, who shall hereafter administer same in association

Administration, etc.,
transferred to Field
Surveying Service.

with the surveying operations in his charge and under such regulations as the Secretary of the Interior may provide." (43 Stat. 1144.)

The act of Congress approved May 28, 1926, entitled "An act to provide for the transfer of certain records of the General Land Office to States, and for other purposes," provides as follows:

"That whenever the last United States land office in any State has been or hereafter may be abolished

On abolishment of land offices in State records, etc., thereof may be transferred thereto.

the Secretary of the Interior be, and he is hereby, authorized to transfer to the State within which such United States land office was or is situated such transcripts, documents, and records of the office aforesaid as may not be required for use of the United States and which the State may desire to preserve.

SEC. 2. That when the public surveys in any State have been so far completed that in the opinion of the Secretary of the Interior it is no longer necessary to maintain a public survey office in said State, he may turn over to the State the field notes, maps, plats, records, and all other papers appertaining to land titles in such public survey office that may not be needed by the United States and which the State may elect to receive.

Field notes, etc., of surveys, may be turned over to the State.

SEC. 3. The transcripts, documents, records, field notes, maps, plats, and other papers mentioned in sections 1 and 2 of this act shall in no case be turned over to the authorities in any State until such State has provided by law for the reception and safekeeping of same as public records, and for the allowance of free access to the same by the authorities of the United States." (44 Stat. 672.)

The laws (1) in reference to the reorganization of the public survey offices (43 Stat. 1144, March 3, 1925, effective July 1, 1925), and (2) in reference to the transfer to the States of the field notes and plats on the completion of the surveys (44 Stat. 672, May 28, 1926), superseded certain long established

and important provisions of the Public Land Laws, of which the following sections of the Revised Statutes are given here for the information bearing upon former practices:

SEC. 77. There shall be appointed by the President, by and with the advice and consent of the Senate, a surveyor general for the States and Territories herein named, embracing, respectively, one surveying district, namely: Louisiana, Florida, Minnesota, Kansas, California, Nevada, Oregon, Nebraska and Iowa, Dakota, Colorado, New Mexico, Idaho, Washington, Montana, Utah, Wyoming, Arizona. (R. S. 2207.)

SEC. 87. Whenever the surveys and records of any surveying district are completed the surveyor general thereof shall be required to deliver over to the secretary of state of the respective States, including such surveys, or to such other officer as may be authorized to receive them, all the field notes, maps, records, and other papers appertaining to land titles within the same; and the office of surveyor general in every such district shall thereafter cease and be discontinued. (R. S. 2218.)

SEC. 88. In all cases of discontinuance, as provided in the preceding section, the authority, powers, and duties of the surveyor general in relation to the survey, resurvey, or subdivision of the lands therein, and all matters and things connected therewith, shall be vested in and devolved upon the Commissioner of the General Land Office. (R. S. 2219.)

SEC. 89. Under the authority and direction of the Commissioner of the General Land Office any deputy surveyor or other agent of the United States shall have free access to any such field notes, maps, records, and other papers for the purpose of taking extracts therefrom or making copies thereof without charge of any kind; but no transfer of such public records shall be made to the authorities of any State until such State has provided by law for the recep-

tion and safekeeping of such public records, and for the allowance of free access thereto by the authorities of the United States. (R. S. 2220, 2221.)

GENERAL RULES.

10. From the foregoing synopsis of congressional legislation it is evident—

First. That the boundaries and subdivisions of the public lands as surveyed under approved instructions by the duly appointed engineers, the physical evidence of which survey consists of monuments established upon the ground, and the record evidence of which consists of field notes and plats duly approved by the authorities constituted by law, are unchangeable after the passing of the title by the United States.

Second. That the physical evidence of the original township, section, quarter-section, and other monuments must stand as the true corners of the subdivisions which they were intended to represent, and will be given controlling preference over the recorded directions and lengths of lines.

Third. That quarter-quarter-section corners not established in the process of the original survey shall be placed on the line connecting the section and quarter-section corners, and midway between them, except on the last half mile of section lines closing on the north and west boundaries of the township, or on other lines between fractional or irregular sections.

Fourth. That the center lines of a regular section are to be straight, running from the quarter-section corner on one boundary of the section to the corresponding corner on the opposite section line.

Fifth. That in a fractional section where no opposite corresponding quarter-section corner has been or can be established, the center line of such section must be run from the proper quarter-section corner as nearly in a cardinal direction to the meander line, reservation, or other boundary of such fractional section, as due parallelism with section lines will permit.

Sixth. That lost or obliterated corners of the approved surveys must be restored to their original locations whenever it is possible to do so. Actions or decisions by surveyors, Federal, State,

or local, which may involve the possibility of changes in the established boundaries of patented lands, are subject to review by the State courts upon suit advancing that issue.

THE MANUAL.

11. Various regions of the United States have been surveyed under different sets of instructions issued at periods ranging from 1785 to the present time. The earliest rules were given to surveyors in manuscript or in printed circulars. Regulations more in detail, improving the system for greater accuracy, permanency, and uniformity, were issued in book form in Manuals of 1855, 1881, 1890, 1894, and 1902. The current Manual will be known as the Manual of 1930. Advance sheets of the first six chapters of the Manual of 1930 were promulgated June 16, 1919; a manuscript edition of Chapter IX was put into effect March 1, 1928.

The Manual of Surveying Instructions has been revised with a view to harmonizing the printed instructions furnished to the engineers with recent legislation and current surveying practice. The use of iron-post corner monuments adds much to the permanency of the evidence of the surveys, but this has called for little change in rules except to outline the standard practice. A growing necessity for resurveys to identify and restore original surveys actually made, but poorly monumented, or to supersede grossly erroneous or fraudulent original surveys—"to properly mark the boundaries of the public land remaining undisposed of"—has demanded a full discussion of the subject in this revision of the Manual.

The change from the contract system, including the reorganization of the public-survey offices, has involved necessary changes in the administrative practice, but without departure from the established technical procedure. In this connection it will be noted throughout the Manual that references to the administrative practice are purposely stated in very general terms; this is done in order to avoid diverting the attention from a strictly technical treatment of the surveying subjects.

Modern methods have been made an integral part of the public-land surveying practice in so far as adaptable, for which purpose it has been necessary to include a full instructive text

on the subjects of measurements of lines, field observations for the determination of time, latitude, and azimuth, and the running of the true latitudinal curve, an understanding of which is essential to the making of large-scale rectangular surveys.

Owing to many changes in the character of the work, there is much need for Manual treatment of the subjects of subdivision of sections, restoration of lost or obliterated corners, resurveys, the many types of special surveys, and the detail of the production of plats, which have not been included in any previous Manual. These subjects, by their growing importance, reflect the change in the character of the work from that principally of marking the original subdivisions to that which is largely concerned in the identification and perpetuation of the boundaries already created.

The instructions contained in this Manual are to be observed by every engineer engaged in the execution of the public-land surveys. All other surveyors, including those who have at times been employed in the surveying service of the General Land Office, should bear in mind that in their private capacities they are acting under somewhat different rules of law from those governing original surveys, and surveyors should discriminate between the provisions of the statute which control original surveys and those which apply to the retracement of lines that have been officially established and approved.

STANDARD FIELD TABLES.

12. There has been published by the General Land Office, in the shape of a pocket field book, a compendium of tables and formulas entitled "Standard Field Tables." The volume embraces the data peculiarly useful to engineers engaged in subdividing the public lands. The Standard Field Tables are issued as a supplement to the Manual, and as such the former are a part of the latter, with contents as follows:

1. Units of linear measure, units of area, expansion of steel tapes, and conversion tables, chains to feet and feet to chains.
2. Reduction in latitude to south boundary of township, and corrections for convergency within a township.
3. Traverse table, for the correction of random lines.
4. Traverse tables.

5. Correction of error in stadia wire interval.
6. Stadia coefficients, vertical rod.
7. Natural sines and cosines.
8. Natural tangents and cotangents.
9. Logarithmic sines, cosines, tangents, and cotangents.
10. Logarithms of numbers.
11. Convergency of meridians, and differences of latitude and longitude.
12. Azimuths of the tangent to the parallel.
13. Offsets from the tangent to the parallel.
14. Azimuths of the secant.
15. Offsets from the secant to the parallel.
16. Lengths of arcs of the earth's surface.
17. Apparent time of sunrise and sunset.
18. Conversion tables, degrees to time, and time to degrees.
19. Sidereal conversions, and reductions to the local mean time of upper culmination of Polaris.
20. Mean refractions in zenith distance.
21. Coefficients to apply to mean refractions for variations in barometer and temperature.
22. Coefficients for computing errors in azimuth due to small errors in declination or latitude.
23. Mean refractions in polar distance.
24. Trigonometric formulas for the solution of plane triangles.
25. Trigonometric formulas for the solution of stadia measurements, observations for time, latitude and azimuth, and problems in convergency.

EPHEMERIS OF THE SUN AND POLARIS, AND TABLES OF AZIMUTHS AND ALTITUDES OF POLARIS.

13. The above title has been given to a second supplement to the Manual which is published each year, a convenience which serves to supply the engineers with all necessary data relating to the daily positions of the sun and Polaris without requiring frequent revision of the text of the Manual or the Standard Field Tables. As a supplement to the Manual the data contained in the Ephemeris will be employed in preference to that contained in other publications over which the General Land Office has no control either as to accuracy or fitness for use in the public-land surveys.

CHAPTER II.

INSTRUMENTS AND METHODS.

MEASUREMENTS.

14. The law prescribes the chain as the unit of linear measure for the survey of the public lands, and all returns of measurements are to be made in true horizontal distances, in miles, chains and links. The chain unit is known as the invention of Edmund Gunter, an English astronomer of the seventeenth century, and is especially convenient in computing areas, in the unit of acres, one acre being equal to 10 square chains.

Units of linear measure.

1 chain=100 links.

=66 feet.

1 mile=80 chains.

=5,280 feet.

Units of area.

1 acre=10 square chains.

=43,560 square feet.

1 square mile=640 acres.

15. Each engineer will be provided with a standard and an assortment of 1, 2, 5 or 8-chain steel tapes. The standard tape will be employed for comparison with the field tapes, in order that errors in the latter may be noted and corrected. Before chainmen are intrusted with their actual duties they should be instructed by the chief of party, and required to measure over one or more trial lines of level and mountainous surface, to secure accuracy and uniformity of results.

16. It is essential to the record of a survey to state briefly at the beginning of the field notes, with every set of returns, the general manner of making measurements in the survey, and as topographical

difficulties are encountered making it necessary to depart from the stated general method, it is desirable to record the plan of special measurement adopted. The field notes thus exhibit the manner of making all measurements, and the record should be such that another engineer retracing any line can substantially duplicate the exact procedure adopted in the original survey.

The following paragraphs are illustrative of the record to be made in the field notes:

"Unless otherwise specified all measurements are made with a Chicago 1-chain steel tape compared with a Chesterman standard steel tape and found correct."

"Unless otherwise specified all measurements are made with a Lallie 2-chain steel tape found correct by comparison with a Lufkin standard steel tape."

"Unless otherwise specified all measurements are made with a Lufkin steel tape 8 chains in length compared with a Chesterman standard steel tape and found correct. The measurements are made on the slope, the vertical angle determined, and the slope measurements properly reduced to true horizontal distances."

THE LONG STEEL TAPE.

17. The most approved method of measurement involves the use of steel ribbon tapes from 2 to 8 chains in length; in its use in the public-land surveys the tape is properly alined and stretched, and the measurements are made on the slope at any convenient distance up to the length of the tape as limited by the topography. The vertical angles of the lesser slopes are determined by the use of clinometers in the hands of the chainmen, while the vertical angles of the particularly sharp slopes are determined with the transit operated by the engineer. The slope distances are then reduced to true horizontal distances and the entire operation suitably recorded. It is not considered necessary to exhibit in the official field notes any but the true horizontal distances, omitting details, except where precise measurements are made of various bases for special use.

18. The following is an example of both field and final record for the use of the long steel tape and clinometer, and reductions by the use of the traverse tables (see Table 4, Standard Field Tables):

Field record.					Final field notes.	
Mean vertical angle.	Distance on slope.	True horizontal distance.	Intermediate measurement.	Difference in elevation.		
	<i>Chains.</i>	<i>Chains.</i>	<i>Chains.</i>	<i>Chains.</i>	<i>Chains.</i>	
-12½°	4.50	4.398		-0.95		North, bet. secs. 19 and 24. Desc. 155 ft. over NW. slope, through scattering timber and dense undergrowth.
-17½°	2.20	2.098		-.66		
	6.70	6.496	3.80	-.75	10.30	Dry gulch, course W.; asc. 295 ft. over SW. slope.
+ 8½°	8.00	7.917		+ .75 +1.15		
+10½°	14.70 6.20	14.413 5.835		+2.10		
+ 7½°	20.90 3.30	20.248 3.270		+ .44		
	24.20	23.518	0.00		23.50	Spur, slopes W.; desc. 185 ft. to 1/4 sec. cor., over NW. slope. Wagon road, bears E. and W. Leave undergrowth.
			1.20		24.70	
			1.90		25.40	
- 6½°	8.00	7.949		-0.91		
	32.20	31.467	1.15		32.60	Enter heavy timber, bears NW. and SE.
-10½°	3.70	3.641		-.66		
-14°	35.90 5.00	35.108 4.851		-1.21		
0°	40.90 .04	39.959 .04				
	40.94	40.00				
	40.00	40.00			40.00	Set an Iron post, etc.

19. A simplification of the reduction of measurements on the slope is obtained by the use of two diagrams constructed on cross-section paper, as follows: The first with the vertical lines representing intervals of 20 links measurement on the slope to 2, 5 or 8 chains to suit the length of tape used; the horizontal lines representing the correction in links to be made from the measurement on the slope to obtain the true horizontal distance; slanting lines are drawn to represent various degrees of slope scaled to the proper

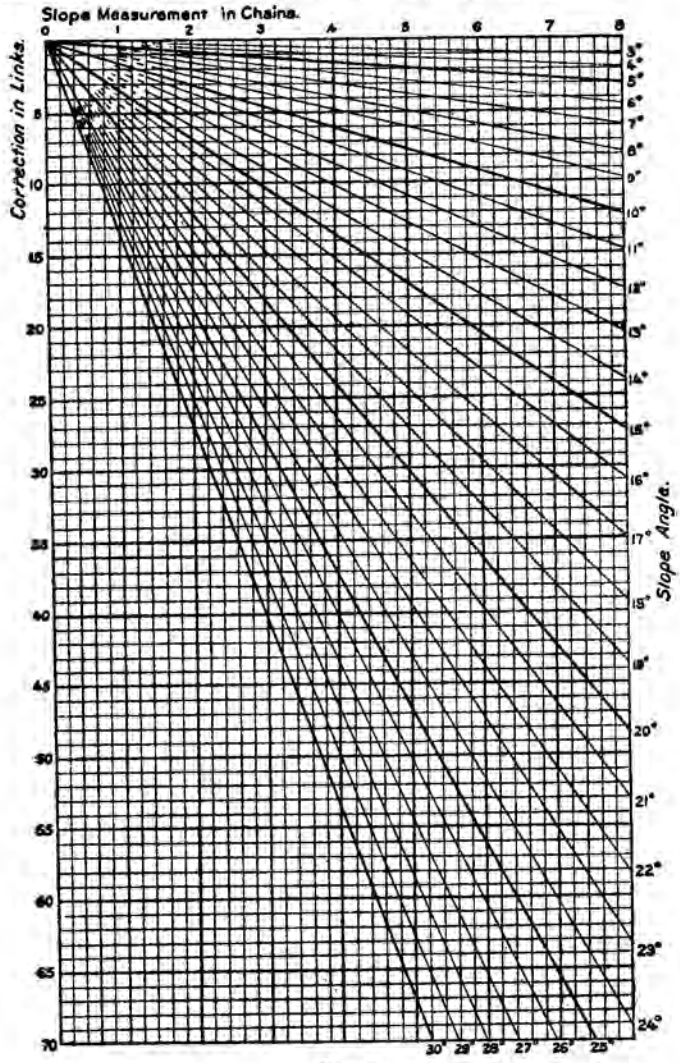


Fig. 1.

Reduction from the slope to the horizontal.

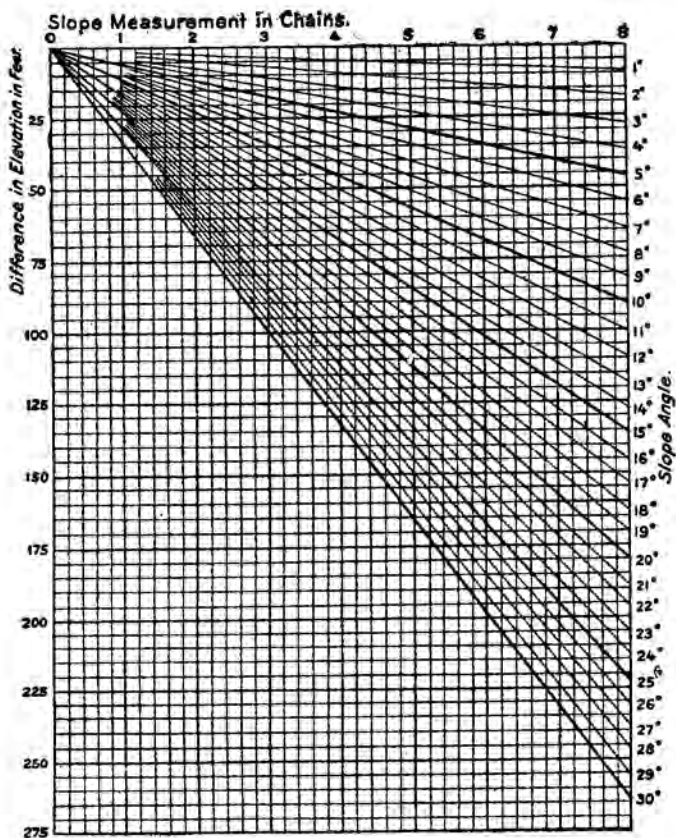


Fig. 2.

Reduction for difference of elevation.

points for the correction for the full length of the tape. The second diagram is constructed with the vertical lines representing similarly the measurement on the slope in the *chain* unit; the horizontal lines in this diagram representing the difference in elevation in *feet*, at intervals of 5 feet; slanting lines are drawn to represent various degrees of slope scaled to the proper points for the differences of elevation for the full length of the tape. (See figs. 1 and 2.)

20. The following is an example of record for the use of the long steel tape and clinometer, and reductions by the use of the reduction diagrams:

Field record.					Final field notes.	
Mean vertical angle.	Distance on slope.	Correction to horizontal.	Intermediate measurement.	Difference in elevation.		
	<i>Chains.</i>	<i>Chains.</i>	<i>Chains.</i>	<i>Feet.</i>	<i>Chains.</i>	
-12½°	4.50	0.10		- 60		North, bet. secs. 19 and 24. Desc. 155 ft. over NW. slope, through scattering timber and dense undergrowth.
-17½°	2.20	.10		- 45		
	6.70	0.20	3.80	- 50	10.30	Dry gulch, course W.; asc. 295 ft. over SW. slope.
+ 8½°	8.00	.08		+ 50 + 75		
+19½°	14.70	0.28		+ 140		
	6.20	.37				
+ 7½°	20.90	0.65		+ 30		
	3.30	.03				
	24.20	0.68	0.00		23.50	Spur, slopes W.; desc. 185 ft. to ¼ sec. cor., over NW. slope. Wagon road, bears E. and W. Leave undergrowth.
			1.20		24.70	
			1.90		25.40	
- 8½°	8.00	.05		- 60		
	32.20	0.73	1.15		32.60	Enter heavy timber, bears NW. and SE.
-10½°	3.70	.06		- 45		
	35.90	0.79				
-14°	5.00	.15		- 80		
	40.90	0.94				
0°	.04	.00				
	40.94	0.94				
	40.00	0.00			40.00	Set an iron post, etc.

21. By skillful use of the long steel tape on the slope, with correct determinations of the vertical angle, and proper reductions from the slope to the true horizontal distance, the engineer obtains one of the most rapid and reliable methods of measurement. It is essential to make all reductions for distance as the work progresses, but the additional information regarding the amount of the ascents and descents is readily obtainable from the record at the convenience of the engineer.

STADIA MEASUREMENTS.

22. Under proper safeguards the stadia method of measurement affords a useful and reliable means of overcoming the difficulties of obtaining correct distances across water and over precipitous slopes that can not be reached with the tape. It is required that the wire interval or ratio be determined in the field by frequent tests under working conditions in comparison with steel tape measurement, solving the formula given in the Standard Field Tables (p. 221) for the value of the wire ratio with the horizontal distance known. The record of the stadia tests should be given in the field notes. It is essential to accurate stadia work that rods of approved construction be used, together with two targets and a properly adjusted rod level to secure true vertical readings; the readings at all times must be restricted to suitable atmospheric conditions and to distances permitting exact bisections of the targets. Possible criticism of the use of the stadia method is found in the failure to observe proper details and not in the reliability of the method if skillfully followed.

23. It is desirable to state briefly at the beginning of the field notes, with every set of returns, the general plan of making stadia measurements. The following paragraphs are illustrative of the character of such record:

"All stadia measurements are made with fixed stadia wires with a ratio of $1 : 132 \pm$, as exhibited by the tests shown in the field notes; the focal constant of the instrument is 1.2 links; the rod used is a standard Philadelphia level rod graduated to feet and equipped with two targets and a rod level; all readings are made with a vertical rod."

"All stadia measurements are made with fixed stadia wires with a ratio of $1 : 100 \pm$, as exhibited by the tests shown in the field notes; the focal constant of the instrument is 1.2 links; the rod used is a standard Troy level rod graduated to feet and equipped with two targets and a rod level; all readings are made with a vertical rod."

24. Notation used in stadia measurements:

Hor. dist.: The true horizontal distance from the center of the instrument to the rod.

Diff. elev.: The true vertical distance from the height of the instrument to the center point between the two targets of the rod.

" r ": Vertical rod reading.

" v ": Observed vertical angle.

" K ": The wire interval or ratio.

" c ": Distance from the center of the instrument to the object glass.

" f ": Distance from the plane of the cross-wires to the object glass.

Hor. dist. = $K r \cos^2 v + (c+f) \cos v$.

Diff. elev. = $K r \frac{1}{2} \sin 2v + (c+f) \sin v$.

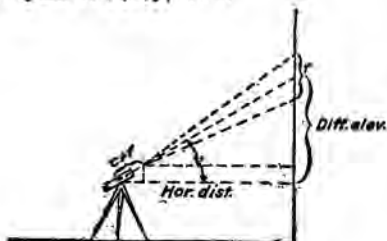


Fig. 3

25. In Table 6, Standard Field Tables, the natural functions " $\cos^2 v$ " and " $\frac{1}{2} \sin 2v$ " are tabulated by intervals of $2'$ for all angles from $0^\circ 0'$ to $28^\circ 0'$; these values become natural coefficients of the rod reading in the use of the vertical rod. In the same table are tabulated the natural products " $(c+f) \cos v$ " and " $(c+f) \sin v$," for three values of " $(c+f)$ " which may be considered as expressed in either the link or foot unit as convenient.

26. In public-land surveying it is convenient to have fixed stadia wires with a ratio of 1:132, so that the sum of two rod readings in feet will be equivalent to a ratio of 1:66, or a reduced distance in chains; it is also convenient to reduce the error in the wire interval to the error in 10 chains, and to eliminate the error by applying to the reduced distance the proper correction taken from the table of proportional parts (Table 5, Standard Field Tables).

27. Example of test of stadia wire interval, the approximate ratio being 1:132, and the focal constant 1.2 links:

Field record.			Vertical rod reading.	Final field notes
Measurement of base by steel tape and clinometer.				
Mean vertical angle.	Distance on slope.	True horizontal distance.		
	<i>Chains.</i>	<i>Chains.</i>	<i>Feet.</i>	June 11, 1911, I make the following test of the stadia wire interval: Horizontal length of base = 14.066 chs. Mean of 10 rod readings = 6.9985 ft. Vertical angle of test = $-0^{\circ} 40'$ $K = 132.551$ Reduced error in 10 chs. = -4.1 lks. All corrections to be added to the distances given by the stadia.
$-4\frac{1}{2}^{\circ}$	3.90	3.888	6.992	
$-1\frac{1}{2}^{\circ}$	8.00	7.998	6.998	
$+7\frac{1}{2}^{\circ}$	2.20	2.180	7.002	
Total base		= 14.066	6.995	
Focal constant		= .012	7.003	
Stadia base		= 14.054 chs.	7.004	
" "		= 927.564 ft.	6.997	
Mean rod reading		=	6.995	
Coefficient for $0^{\circ} 40'$		= 0.9999;	7.001	
0.0001×6.9985		=	6.998	
$r \cos^2 r$		=	6.9985	
$K = \frac{927.564}{6.9978} = 132.551$.0007	
Measured base			6.9978	
$\left. \begin{array}{l} 6.9985 \\ 6.9985 \end{array} \right\} = \text{mean rod reading.}$				
13.997 = equivalent 1:66,				
$\left. \begin{array}{l} 13.997 \times 0.9999 = 13.996 \\ (c+f) = .012 \end{array} \right\}$			14.008 chs.	
Error in 14.008 chs. by stadia			= 0.058 chs.	
Error in 10.00 chs. by stadia			= 0.041 chs.	

28. The error of the wire interval having been determined for a distance of 10 chains, the proportional error for any distance from 1 to 20 chains may be taken from Table 5, Standard Field Tables, thus eliminating all complex steps from the ordinary reductions of field observations.

Emphasis is placed upon the necessity for the above tests for accurate stadia work, and attention is directed to the probability that successive tests will show slightly increasing or decreasing values of the wire interval. It is not considered necessary to record in the official field notes any but the basic elements of stadia observations, omitting the details of the reductions.

29. The following example of record, with reductions added, is adapted to the instrument showing the above test of the wire inter-

val, ratio 1:132 with an error of 4.1 links in 10 chains, and focal constant 1.2 links.

Field record.	Final field notes.	
	<i>Chains.</i>	N. 0° 02' W., bet. secs. 15 and 16. Descend gradually over mountainous land.
3.194 3.212	12.60	Rim of canon, bears NW. and SE.; precipitous descent of 170 ft. Stadia to left bank of creek: 3.194 and 3.212 ft., -26° 44'. Stadia to right bank of creek: 3.448 and 3.432 ft., -24° 10'. Stadia to right rim of canon: 4.914 and 4.895 ft., +4° 58'.
6.406 × 0.7976 = 5.109 Error + .021 (c+f) cos v + .011	12.60 + 5.14 chs.	-17.74
12.60	+5.14 chs.	Left bank of creek, 62 lks. wide, course NW.
Diff. elev. 6.406 × 0.4018 = 2.574 chs. -170 ft.	3.448 3.432	
6.880 × 0.8324 = 5.727 Error + .024 (c+f) cos v + .011	12.60 + 5.76 chs. 5.14 chs.	-18.36
Width of creek -0.62 chs.	4.914 4.895	Right bank of creek; precipitous ascent of 225 ft. to rim of canon.
9.809 × 0.9925 = 9.735 Error + .040 (c+f) cos v .012	12.60 + 9.79 chs.	-22.35
9.809 × 0.0863 = 0.847 chs. = 56 ft. +170 ft.	Diff. elev. -226 ft.	Rim of canon, bears NW. and SE.; asc. gradually.

30. Attention is directed to the fact that in making the above reductions in the chain unit, wire ratio 1:132, the process is at once resolved into taking the sum of the two rod readings in feet multiplied by the proper coefficient for vertical angle, to which product are applied the corrections for the error in the wire interval and for the horizontal value of the focal constant. As two rod readings should always be taken, one as a check upon the other, the entire

operation becomes very simple. It should also be noted that in computing the difference of elevation no correction has been made for the height of the instrument above the ground, nor for the mean height of the rod reading; these corrections are compensating and ordinarily may be neglected, but in precise reductions must be considered. Therefore, in ordinary work in computing differences of elevation by the stadia method it is permissible to neglect the height of the instrument above the ground, the mean height of the rod reading, the error in the wire interval, and the term " $(c+f) \sin v$."

31. Many engineers prefer the conventional stadia wire ratio 1:100 generally adopted in miscellaneous surveying practice, using a rod graduated to feet. With an instrument so fitted for public-land surveys, in which the chain unit of horizontal distance is stipulated by law, the reduction is simplified by ascertaining the logarithm of " $\frac{K}{66}$ ", rod in feet and horizontal distance in chains, accomplishing the reduction of " $K r \cos^2 v$ " by logarithmic functions.

32. Example of test of stadia wire interval, the approximate ratio being 1:100, and the focal constant 1.2 links:

Field record.			Vertical rod reading.	Final field notes.
Measurement of base by steel tape and clinometer.				
Mean vertical angle.	Distance on slope.	True horizontal distance.		
	<i>Chains.</i>	<i>Chains.</i>	<i>Feet.</i>	
- 37°	6.40	6.386 chs.	9.515	July 7, 1915, I made the following test of the stadia wire interval: Horizontal length of base = 14.160 chs. Mean of ten rod readings = 9.5200 ft. Vertical angle of test = +1°54' $K = 98.193$ $\log \frac{K}{66}$, rod in feet and horizontal distance in chains = 0.172537
- 4½°	2.70	2.692	9.518	
+ 12½°	5.20	5.082	9.522	
			9.519	
Total base	= 14.160		9.527	
($c+f$)	= .012		9.513	
Stadia base	= 14.148 chs.		9.524	
" "	= 933.768 ft.		9.521	
			9.520	
Mean rod reading	=		9.5200	
Coefficient for 1°54'	= 0.9989;			
0.0011 × 9.5200	=		.0105	
$r \cos^2 v$	=		9.5095	
	$K = \frac{933.768}{9.5095} = 98.193$			
log $K = 1.992081$				
" $\frac{K}{66} = 1.819544$				
" $\frac{K}{66} = 0.172537$				

33. The following example of record, with reductions added, is adapted to the instrument showing the above test of the wire interval, ratio 1:98.193 and focal constant 1.2 links.

Field record.	Final field notes.	
	<i>Chains.</i>	North, bet. secs. 31 and 36. Over level land.
	14.20	Commence gradual ascent of 40 ft. to base of cliff. Stadia to top of cliff: mean 8.472 ft., +16° 40'.
	24.50	Base of cliff, bears N. 65° W. and S. 65° E.; ascend 190 ft. to top.
$\log \frac{K}{66} = 0.172537$ $" 8.472 = 0.927986$ $" \cos^2 16^\circ 40' = \begin{array}{r} 9.981361 \\ 9.981361 \\ \hline 1.063245 \end{array}$		
$\text{nat} \frac{K}{66} \cos^2 r = 11.568$ $(c+f) \cos v = .012$ 14.20 + 11.58 chs.	25.78	Top of cliff; thence over level mesa.
$\log K = 1.992081$ $" 8.472 = 0.927986$ $" 0.2748 = 9.439017$ $\hline 2.359084$		
Diff. elev. = 228 ft. To bluff = 40 \hline Cliff = 188 "		

34. Most of the General Land Office surveying instruments are equipped with fixed stadia wires of the ratio 1:132, which has been found well adapted to all practical purposes for which used, and enables the use of standard double target level rods graduated to feet. A few instruments have been provided with fixed stadia wires of the ratio 1:100, at special request, but rods graduated to links can not be furnished except upon special order, and are not purchased because they are useless except for the one purpose. Engineers can not expect to accomplish the best results where they graduate their own rods to suit a particular instrument or personal equation.

In authorizing the use of the stadia method in the public-land surveys it is not contemplated that the same will be made a substitute for steel tape measurement where the latter is practicable, but rather that the stadia method may be used as an expedient where natural obstacles are encountered over which the distance may be more accurately measured by the stadia than otherwise, provided that every safeguard is duly observed.

TRIANGULATIONS.

35. In making all triangulations for the purpose of obtaining measurements across water or over precipitous slopes, the engineer is expected to exercise his best judgment in the selection of the measured base, and he is required to adopt the best possible geometric proportions of the sides and angles of the triangle. A complete record of the measurement of the base, the determination of the angles, the location and direction of the sides, and any other essential details of the problem will be required in the field notes, together with a small diagram to graphically represent the triangulation, but it is not considered necessary to include in the official field notes the process of the solution. The method of triangulation at all times must be sufficiently refined to produce reliable results, and when necessary to determine the value of an angle of a triangle with a precision of less than the least reading of the instrument, the method of repetitions will be employed.

36. In its simplest form the method of repeating an angle consists in sighting upon a station, A, with the vernier of the horizontal circle set at zero; the angle is then turned to the second station, B; the *lower clamp* is now loosened and the telescope again set upon station A with the lower tangent motion *without disturbing the angle first turned*, after which the *upper clamp* is loosened and the angle turned a second time to station B. The angle is thus "repeated" two, three, or more times, and finally the multiple angle is read, which, when divided by the repeating factor, gives a value for the angle much closer than the least reading of the instrument. For example, assume an instrument reading to single minutes of arc, and that a certain angle has been repeated five times with a resulting reading of $124^{\circ} 32'$; this gives a value of $24^{\circ} 54' 24''$ for the angle, which if skillfully done is unquestionably closer than a single reading. In surveys which may require even greater precision both verniers are read and the angle is repeated as nearly as practicable to one complete turn of 360° , when both verniers are again read. The observer then reverses the telescope, and duplicates the process by turning

the angle in the opposite direction, to eliminate instrumental errors, and finally takes a mean of the resulting four readings, which is divided by the proper factor. It is occasionally necessary in public-land surveying to repeat angles by the latter method, but the former method is of more general use and will be found dependable and quickly executed.

37. The base lines for triangulations are to be carefully measured, even to tenths of links if necessary, and the sum of the angles should be balanced to 180° , or redetermined if the disagreement is found to exceed $1'$ of arc.

38. The following examples, with the reductions added, are designed to illustrate the form of record of triangulations best suited for the official field notes:

(a) Field record.	Final field notes.	
<p style="text-align: center;"><i>Angles.</i> $50^\circ 35'$ $93 \quad 20$ $36 \quad 05$</p>	<p><i>Chains.</i> 40.00 72.20</p>	<p>S. $89^\circ 58'$ W., on random line bet. secs. 19 and 30. Set temp. $\frac{1}{4}$ sec. cor. Top of precipitous bluff; vertical angle to flag on random line—$32^\circ 47'$; auxiliary flag bears S. $39^\circ 21'$ W.; from flag on random line the auxiliary flag bears S. $3^\circ 16'$ W., 12.80 chs. dist.; all bearings checked by direct reading of the solar, and all angles checked by deflection:</p>
$180^\circ 00'$		
Hor. meas. of base by one chain tape=12.80 chs.		<p>Dist. on random line = 72.20 chs. Dist. by triangulation = 9.76</p>
Dist. = 12.80 $\frac{\sin 36^\circ 05'}{\sin 60^\circ 35'}$		<p>81.96</p>
log 12.80 = 1.107210		<p>Dist. by return meas. = 2.84</p>
" $\sin 36^\circ 05'$ = 9.770087		<u>79.12</u>
" $\sin 50^\circ 35'$ = 0.877207		<p>70.12 Intersect W. bdy. of Tp., 14 lks. S. of the cor. of secs. 19, 24, 25 and 30.</p>
" 9.76 = 0.989371		<p>Thence S. $89^\circ 58'$ E., on a true line bet. secs. 19 and 30.</p>
Dist. by tri. = 9.76 chs.		<p>Ascend gradually in valley. Base of bad-land bluff, bears N. and S.; precipitous ascent of about 400 ft.</p>
log hor. dist. = 0.989371		<p>1.75 6.92 Top of bad-land bluff, bears N. and S.; thence over level prairie.</p>
" 06 = 1.819544		
" $\tan 32^\circ 47'$ = 9.808916		
" 415 = 2.617831		
Diff. elev. = 415 ft.		

(b) Field record.	Final field notes.
NOTE.—Stadia wire ratio, 1:132.551; (c+f)=1.2 lks.	At the meander cor. at 57.30 chs. bet. secs. 16 and 17, a flag on Indian Island bears N. 18° 41' W.; a point on a rock in the lake bears S. 82° 08' W., stadia base to this point: 9.827 and 9.839 ft., level, measured base impracticable; from point on island, flag on rock in lake bears S. 14° 22' W.; all bearings checked by direct reading of the solar, and all angles checked by deflection:
9.827 9.839	Length of base = 19.76 chs. From meander cor. to island = 33.54 chs.
19.666 Error = +.082 (c+f) = +.012	
Base = 19.76	
Angles.	
79° 11'	
33 03	
67 46	
180° 00'	
Dist. = 19.76 $\frac{\sin 67^\circ 46'}{\sin 33^\circ 03'}$	
log 19.76 = 1.295787	
" sin 67° 46' = 9.966447	
1.262274	
" sin 33° 03' = 9.736692	
" 33.54 = 1.525542	
Dist. by tri. = 33.54 chs.	
	<p>At the above point on Indian Island from which the meander cor. at 57.30 chs. bet. secs. 16 and 17, bears S. 18° 41' E., 33.54 chs. dist.; I</p> <p>Set a limestone, 28x10x6 ins., 21 ins. in the ground, for auxiliary meander cor. in sec. 8, mkd. S 8 on N., and A M C on S. face; from which</p> <p>A spruce, 14 ins. diam., bears N. 42½° E., 69 lks. dist., mkd. T 67 N R 43 W S 8 A M C B T.</p> <p>A fir-balsam, 9 ins. diam., bears N. 14½° W., 38 lks. dist., mkd. T 67 N R 43 W S 8 A M C B T.</p>

(c) Field record.	Final field notes.
	<p>Chains. 5th Guide Meridian West, through T. 14 N., between Rs. 20 and 21 W., North, bet. secs. 13 and 15. Descend 225 ft. over NW. slope, through heavy timber and dense undergrowth.</p> <p>Difference between measurement of 27.80 chs., by two sets of chainmen, is 4 lks.; position of middle point</p> <p>by 1st set = 27.78 chs., by 2d " = 27.82 " , the mean of which is</p>

(c) Field record, con.

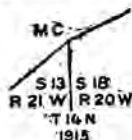
$$\begin{aligned} \text{At } A &= \frac{54^{\circ} 29'}{3} = 18^{\circ} 09' 40'' (-02'') \\ \text{" } B &= \frac{245^{\circ} 13'}{3} = 81^{\circ} 44' 20'' (-09'') \\ \text{" } C &= \frac{240^{\circ} 19'}{3} = 80^{\circ} 06' 20'' (-09'') \\ & \quad \quad \quad 180^{\circ} 00' 20'' (-20'') \end{aligned}$$

Dist.	= 16.427	$\frac{\sin 80^{\circ} 06' 11''}{\sin 18^{\circ} 09' 38''}$
log 16.427		= 1.215558
" sin 80° 06' 11"		= 9.963483
		1.209048
" " 18° 09' 38"		= 9.493710
		-1.715336
" 51.92		
+ 27.80		
		79.72

Final field notes, con.

27.80

The south shore of Grand Lake, bears N. 82° E. and S. 48° W.
Set an iron post, 3 ft. long, 1 in. diam., 28 ins. in the ground, for meander cor. of frac. secs. 13 and 18, with brass cap mkd.



from which

A pine, 8 ins. diam., bears N. 84½° E., 105 lks. dist., mkd. T 14 N R 20 W S 18 M C B T.

A pine, 10 ins. diam., bears S. 26½° W., 49 lks. dist., mkd. T 14 N R 21 W S 13 M C B T.

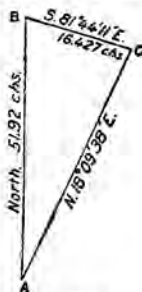
To make a triangulation across the lake I designate the above meander cor. point *A* and set a flag *B* at point for meander cor. on north shore of lake, also a flag *C* on the north shore which from point *A* bears N. 18° 09' 38" E.; the base *BC* bears S. 81° 44' 11" E., 16.427 chs. dist., the mean by two sets of chainmen,

by 1st set = 16.425 chs.,

by 2d " = 16.429 "

longer base impracticable; the angle subtended at point *C* = 80° 06' 11"; all angles by three repetitions with error of 0' 20" balanced to 180°.

Distance across lake = 51.92 chs.



79.72

The north shore of lake, bears S. 82° E. and N. 75° W.

39. In practical field work triangulations are made only to overcome physical difficulties of measurement, and under the conditions generally presented a right-angled triangle is likely to be less desirable than an oblique triangle as the latter may be selected to fit the best topography for the base line. A stadia base may likewise be superior to a measured base as, for example, in extremely rough mountainous regions where possibly no obstruction would interfere with a good stadia determination even though a steel tape measurement of the same base might be almost impossible, or involve great delay and expense. Under some conditions a double triangulation by independent bases may be highly desirable, one result as a check upon the other, whereby the mean of the two would be a better value than either result alone. True efficiency demands a choice of the best methods to suit the peculiar conditions encountered in each circumstance, and this must be left to the judgment of the engineer.

The subject of measurements is incomplete without a suggestion that each engineer should devise a system of signals by means of which numbers and directions may be readily communicated from one member of a party to another; such signals will be found especially useful in long steel tape and stadia measurements and triangulations.

INSTRUMENTS AND REQUIREMENTS AS TO THEIR ADJUSTMENT.

40. The direction of all lines of the public-land surveys will be determined with reference to the true meridian as defined by the axis of the earth's rotation. No departure from this rule is authorized. Beginning with the Manual of 1890 the use of the magnetic needle was prohibited except in subdividing and meandering, and then only in localities free from local attraction and with the use of suitably constructed needle instruments. The Manual of 1894 required that all surveys of the public lands of the United States, embracing all classes of lines, be made with reference to the true meridian, independently of the magnetic needle, and this prohibition against the use of the magnetic needle was even more pronounced in the Manual of 1902. In the modern instruments the length of the needle and other details relating to its construction are sacrificed in favor of the vastly more important details of design of the transit and solar attachment, and it is not presumed that the needle of the modern solar transit will give results even as reliable

as those of a well-constructed needle compass. Many years' use of the solar transit and of the solar compass have proven that comparatively few localities are free from some local magnetic attraction. The needle has some value as a check and for approximate reference purposes under certain conditions, which need not be discussed in the Manual, but the use of the needle as a means of determining the direction of lines of the public-land surveys is now unqualifiedly prohibited.

41. Each engineer will be supplied with one or more instruments of approved construction suited to the conditions to be encountered in his field work. It is considered desirable to include in the record of every survey, at the beginning of the first book of field notes of every set of returns, a description of the instrument used and the general method by which the azimuth determinations were accomplished. The following paragraphs suggest the form of record to be made:

"Survey commenced August 1, 1915, and executed with a Buff 'Rocky Mountain Favorite' solar transit No. 9936, 1915 model, with U-shaped standards, $4\frac{1}{2}$ -inch horizontal circle, 4-inch vertical circle, and improved Smith solar attachment; all azimuth determinations are accomplished with the solar attachment except the special observations upon Polaris and the sun for meridian upon which to test the solar apparatus as stated in the field notes."

"Survey commenced July 28, 1909, and executed with a Young & Sons mountain transit, No. 8070, 1907 model; the instrument is equipped with a full vertical circle and the Smith solar attachment; unless otherwise specified all azimuth determinations are accomplished with the solar attachment."

"Survey commenced May 7, 1906, and executed with a Burt solar compass made by W. & L. E. Gurley, 1905 model; unless otherwise specified all azimuth determinations are accomplished with the solar compass. The Polaris observations in camp are made with a Keuffel & Esser mountain transit No. 9699, 1903 model."

42. The proper supervising officer will carefully examine all instruments to see that they are in first-class condition for field work, but the burden of the final test is placed upon the engineer who uses the instrument, as in every case the approval of an instrument will be made conditional upon satisfactory field test, the record of which will be stated in the field notes.

43. The record of the field test of the instrument should embrace a comprehensive statement of fact as to date, locality, and condi-

tion of the instrumental adjustments. The data relative to the independent observations for meridian should be included in the record, and the functions of apparent time, latitude and sun's declination will always be given in connection with the meridional tests of solar instruments. Various forms of record will be found in connection with the examples of observations and reductions given on the following pages.

44. When a transit without solar attachment is employed, Polaris observations, or direct altitude observations upon the sun, necessary to execute the work in accordance with existing law and the requirements of these instructions will be insisted upon. Observations upon Polaris, or direct altitude observations upon the sun, at frequent intervals, will be necessary to secure accuracy in the projection of transit reference lines, when solar apparatus is not used. The method of transferring the azimuth determined by the meridional observations to the surveyed lines will distinctly appear in the field notes.

45. Engineers using instruments with solar apparatus will be required to make azimuth observations on Polaris, or direct altitude observations upon the sun, at the beginning of every survey, to test the accuracy of the solar apparatus, and subsequent tests will be required at least at the beginning of the subdivision of every township.

46. A test at the conclusion of a survey is necessary in order to prove the continued proper projection of transit lines or the continued satisfactory adjustment of the solar apparatus during the survey. A book of field notes of the survey of standard lines, or of township exteriors, will therefore show preliminary and final azimuth observations for the projection of transit lines, or preliminary and final observations and tests for the adjustment of the solar apparatus, and intermediate tests to comply with the requirements of the preceding paragraphs. The satisfactory condition of the solar apparatus at the conclusion of the subdivision of a township executed with the solar apparatus may, if so desired, be shown by specific reference to the next succeeding test preliminary to commencing the subdivision of another township included in the same series of books of subdivisional notes. A careful engineer will make a sufficient number of tests to satisfy himself at all times of the accuracy of his alinement, but it is not intended to burden the engineer or the field notes with superfluous evidence in this particular matter.

GENERAL STATEMENT, TIME, LATITUDE, AND AZIMUTH.

47. When considering the following treatment of field methods of determination of time, latitude and azimuth, the engineer should bear in mind that a small error, either in assumed latitude or azimuth, produces only a slight effect in time, and when all are unknown the order of sequence in their determination should be that of time, latitude, and azimuth. Time may be readily determined by the engineer with an error not to exceed 10 seconds, while latitude and azimuth are readily determined with an error not to exceed 1' 00"; the stated limits of error are not unreasonable where *any* of the methods herein described and authorized are employed; small errors in assumed longitude may be neglected in the determination of time, latitude, and azimuth.

The following methods are limited to observations upon the sun and the north star, Polaris, and are arranged to facilitate the engineer's work under all conditions encountered in the field without involving more than a practical understanding of astronomical technology. The tables and formulas published in the Standard Field Tables, and the complete daily ephemeris of the sun and Polaris and the tables of azimuths of Polaris, published in the "Ephemeris," are designed primarily for the convenience of the public-land engineers in the field, thus encouraging a general use of approved modern methods, consistent at all times with the engineer's clear understanding of underlying principles involved.

All reference to tables and formulas, or to the daily functions of the sun or Polaris, that follow herein, relate to the above supplements to the Manual, and when necessary to use conventional notation in the demonstrations that follow, the same agrees with that shown in detail in the Standard Field Tables.

With relation to the subject of records of observations as the same should appear in the official field notes of a survey, it must be granted that it is absolutely necessary to state all of the special basic functions of an observation, but it is quite unnecessary to include the process of reduction, except in unusual cases; thus the field notes should be complete in every respect, and it is the purpose to insist upon this requirement without involving that which is unessential to the record. In general also, no attempt is warranted by which the engineer may endeavor to make his results by analytical reduction appear to be more accurate than justified by the refinements of the observation upon which a determination is based; but

it is good practice not to discard the various small elements, fractions or decimal parts of the record value of a function until the result is ascertained, whereupon the insignificant figures may be disposed of.

ANALYTICAL NOTATION, DECLINATION AND REFRACTION.

48. \approx : The symbol for approximation; this symbol signifies inequality, but it is used in a relation representing an inequality which approaches equality.

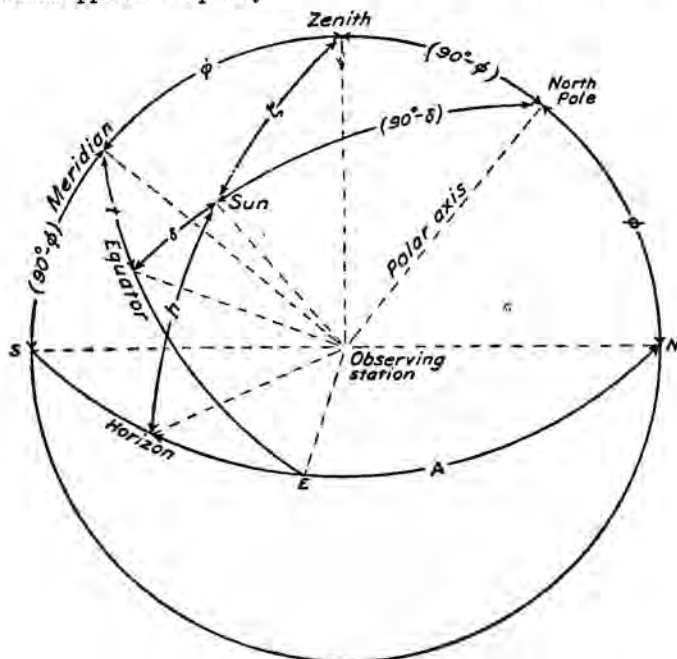


Fig. 4.

The "pole-zenith-sun" triangle as viewed from outside of the celestial sphere.

49. v : Observed vertical angle; in altitude observations on the sun, the reductions to the sun's center both vertically and horizontally, as well as instrumental errors, are eliminated by taking direct and reversed observations on the opposite limbs of the sun, and the mean observed vertical angle to the sun's center will be designated v in the notation. In single observations the vertical reduction to the sun's

center=16'; a refinement is had by referring to the "Ephemeris" for the value of the sun's semi-diameter for the date of observation.

50. h : True vertical angle to the sun's center, or to Polaris, in altitude observations, after correction for refraction: $h = v - \text{refraction in zenith distance}$; a refinement is had in altitude observations on the sun by adding the value of the sun's parallax = $8''.9 \cos v$, opposite in effect to refraction, which results from the observer's position above the center of the earth.

51. ζ : Zeta: true zenith distance of the sun's center:

$$\zeta = 90^\circ - h.$$

Examples of the relative use of v , refraction, parallax, h and ζ .

Field record.					Sun's limbs.	Final field notes.
Telescope.	Watch time.	Horizontal angle.	Vertical angle.			
Dir.	3 ^h 56 ^m 58 ^s	65° 0' 0''	25° 20' 0''	☉	☽	Mar. 18, 1910, I make an altitude observation upon the sun for time and azimuth, making two observations, one each with the telescope in direct and reversed positions, observing opposite limbs of the sun. Mean watch time of observation, 3h 57m 53s p. m. Mean horizontal angle from flag S. to sun S.W., 64° 52' 30''. Mean observed vertical angle 25° 25' 30''.
Rev.	3 58 48	64 45 0	25 31 0			
Mean	3 ^h 57 ^m 53 ^s	64° 52' 30''	25° 25' 30''			
		$v =$	25° 25' 30''			
		Refraction =	- 2' 0''			
		Parallax =	+ 0' 8''			
		$h =$	25° 23' 38''			
		$\zeta =$	64° 36' 22''			
			90° 0' 0''			

Example of vertical reduction to the sun's center.

Field record.			Sun's limbs.	Final field notes.
Sun's lower limb		-25° 20' 0''	☉	Mar. 18, 1910, I make an altitude observation upon the sun for time, observing the sun's lower limb only; failing to observe the sun's upper limb in the reversal of the transit on account of clouds. Watch time of observation, 3h 56m 58s p. m. Observed vertical angle to sun's lower limb, 25° 20' 0'', corrected to the sun's center = 25° 36' 6''.
Reduction to sun's center		- +16' 6''		
Sun's center,	v	-25° 36' 6''		
		$v =$		
		Refraction =	- 2' 0''	
		Parallax =	+ 0' 8''	
		$h =$	-25° 34' 14''	
		$\zeta =$	-64° 25' 48''	
			90° 0' 0''	

52. ϕ : Phi: Latitude of the station of observation.

53. λ : Lambda: Longitude of the station of observation.

54. δ : Delta: Declination of the sun or Polaris; to be taken from the Ephemeris for the date of observation; the declination of the sun is to be corrected in hourly difference to the longitude of the station and to the time of observation; north declinations are treated as positive and south declinations as negative; a northerly hourly motion is treated as positive and a southerly hourly motion is treated as negative; in the use of the solar attachment the declination of the sun is to be corrected for refraction in polar distance, always north.

Examples of computation of the sun's declination.

(a) It is desired to compute the value of the sun's declination for the above altitude observation upon the sun for time and azimuth. Longitude of the station of observation, $5^{\text{h}} 8^{\text{m}}$ W.; apparent time of observation, $3^{\text{h}} 42^{\text{m}}$ p. m.:

Declination of the sun at Greenwich apparent noon

Mar. 18, 1910 = $1^{\circ} 11' 3''$ S.

Difference in time from Greenwich apparent noon
to apparent time of observation: $^{\circ}$

For longitude = $5^{\text{h}} 8^{\text{m}}$

For time, p. m. = $+3 42$

$8.83^{\text{h}} = 8^{\text{h}} 50^{\text{m}}$

Hourly difference in declination = $+59''.28$

Difference in declination from Greenwich apparent
noon to apparent time of observation:

$8.83 \times 59.28 = 523''$ = $8' 43''$ N.

True declination of the sun

$1^{\circ} 2' 20''$ S.

(b) It is desired to prepare, by computation, a table of hourly declinations of the sun, corrected for refraction in polar distance, for use with the solar attachment, for a date March 14, 1912, and for a station in latitude $33^{\circ} 10' \text{ N.}$, and longitude $7^{\text{h}} 47^{\text{m}} \text{ W.}$

$2^{\circ} 33' 28''.6$ S. = Declination of the sun at Greenwich apparent noon, Mar. 14, 1912.

Difference in time from Greenwich apparent noon to 7 a. m., local app. time:

For longitude = $7^h 47^m$

For time, a. m., $12^h - 7^h 0^m = (-) 5 0$

$2.78^h = 2^h 47^m$

Hourly difference in declinations = $+59''.2$.

$2' 44''.5$ N. = Difference in declination from Greenwich apparent noon to 7 a. m., local apparent time: $2.78 \times 59.2 = 164''.5$.

$2^{\circ} 30' 44''.1$ S. = True declination of the sun, 7 a. m., local apparent time.

Local apparent time.	True declination.	Refraction.	Declination setting.
7 a. m.	$2^{\circ} 30' 44''$ S.	$2' 41''$ N.	$2^{\circ} 28' 3''$ S.
7½	2 30 14	1 48	2 28 26
8	2 29 45	1 22	2 28 23
9	2 28 46	0 58	2 27 48
10	2 27 47	0 47	2 27 0
11 a. m.	2 26 48	0 43	2 26 5
Noon	2 25 49	0 41	2 25 8
1 p. m.	2 24 50	0 43	2 24 7
2	2 23 51	0 47	2 23 4
3	2 22 52	0 58	2 21 54
4	2 21 53	1 22	2 20 31
4½	2 21 28	1 48	2 19 35
5 p. m.	2 20 54	2 41	2 18 13

(c) It is desired to prepare, by computation, a table of hourly declinations of the sun, corrected for refraction in polar distance, for use with the solar attachment, for a date August 12, 1912, and for a station in latitude $47^{\circ} 10'$ N., and longitude $7^h 24^m$ W.

$15^{\circ} 1' 6''$ N. = Declination of the sun at Greenwich apparent noon, Aug. 12, 1912.

Difference in time from Greenwich apparent noon to 6 a. m., local app. time:

For longitude = $7^h 24^m$

For time a. m.,

$12^h - 6^h 0^m = (-) 6 0$

$1.4^h = 1^h 24^m$

Hourly difference in declination = $-45''.1$.

$1' 3''$ S. = Difference in declination from Greenwich apparent noon to 6 a. m., local apparent time: $1.4 \times 45.1 = 63''$.

$15^{\circ} 0' 3''$ N. = True declination of the sun, 6 a. m., local apparent time.

Local apparent time.	True declination.	Refraction.	Declination setting.
6 a. m.....	15° 0' 3" N.	3' 29" N.	15° 3' 32" N
6½.....	14 59 40	2 22	15 2 2
7.....	14 59 18	1 46	15 1 4
8.....	14 58 33	1 9	14 59 42
9.....	14 57 48	0 52	14 58 40
10.....	14 57 3	0 42	14 57 45
11 a. m.....	14 56 18	0 39	14 56 57
Noon.....	14 55 33	0 37	14 56 10
1 p. m.....	14 54 48	0 39	14 55 27
2.....	14 54 3	0 42	14 54 45
3.....	14 53 18	0 52	14 54 10
4.....	14 52 33	1 9	14 53 42
5.....	14 51 48	1 46	14 53 34
5½.....	14 51 26	2 22	14 53 48
6 p. m.....	14 51 3	3 29	14 54 32

(d) A graphic method for ascertaining the changing declinations of the sun, corrected for refraction in polar distance, for use with the solar attachment, is obtained by the use of a diagram constructed on cross-section paper for each date, as follows:

The horizontal lines may be used to represent each hour of the day, and the vertical lines may represent intervals of 1' in declination. It is convenient to use the right-hand side of the sheet to represent N., and the left-hand side of the sheet to represent S., or to have N. declinations increase numerically to the right-hand side of the sheet, and S. declinations increase numerically to the left-hand side of the sheet. The vertical lines are numbered to suit the range of declination of the sun for the date. Two points are marked on the diagram to agree with the true declination of the sun; the first point is marked with the argument of declination agreeing with the declination of the sun taken from the Ephemeris for Greenwich apparent noon and with the argument of time agreeing with the local apparent time corresponding to Greenwich noon; the second point is marked agreeing with the proper declination and time 10 hours later; the straight line determined by the two points agrees with the sun's true declination for the date for the local apparent time. The proper refractions in polar distance are then scaled from the straight line to the N. for each tabulated refraction, a. m. and p. m., taken from Table 23, Standard Field Tables, appropriate to the latitude of observation and declination of the sun; the locus of the latter points is a smooth curve representing graphically the declinations of the sun, corrected for refraction in polar distance, for use with the solar attachment. The scale of the refractions must equal the scale of the intervals of 1' in declination, and the refractions are laid off along or parallel to the horizontal lines and *not* normal to the line of

true declination. At any time throughout the day the proper declination for use with the solar attachment is obtained by reference to the curve at the point corresponding to the time of observation. To obtain any true value of the sun's declination for use in the reduction of *altitude observations* reference may be made to the straight line of true declination at the point corresponding to the time of observation.

The advantage of the diagram method is found in the practical elimination of errors of computation, and the ease with which it is checked, together with the fact that in the use of the diagram actual values are obtained at any time without any process of interpolation.

The following diagrams have been prepared to illustrate the method:

DIAGRAM OF THE SUN'S DECLINATIONS.

Date, Mar. 20, 1912.

Station: Lat. = $37^{\circ} 30' N.$

Long. = $7^h 30^m W.$

Declination.

Greenwich noon = $0^{\circ} 11' 14'' S.$ = $4^h 30^m a. m.$

Diff. $10^h, +593'' = \underline{09\ 53\ N.}$

$0^{\circ} 01' 21'' S.$ = $2^h 30^m p. m.$

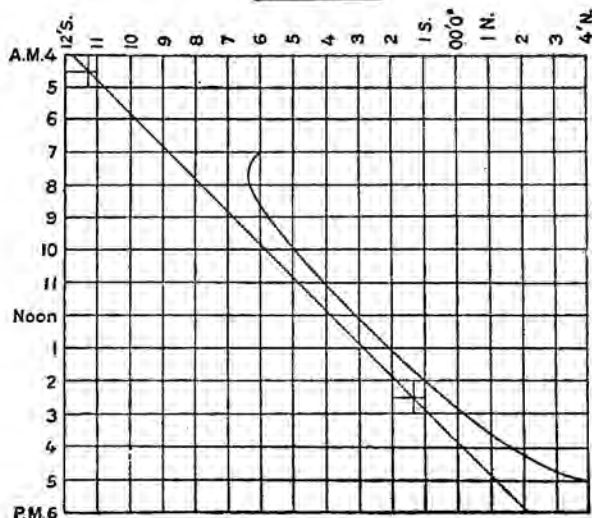


Fig. 5.

DIAGRAM OF THE SUN'S DECLINATIONS.

Date, Sept. 23, 1913.

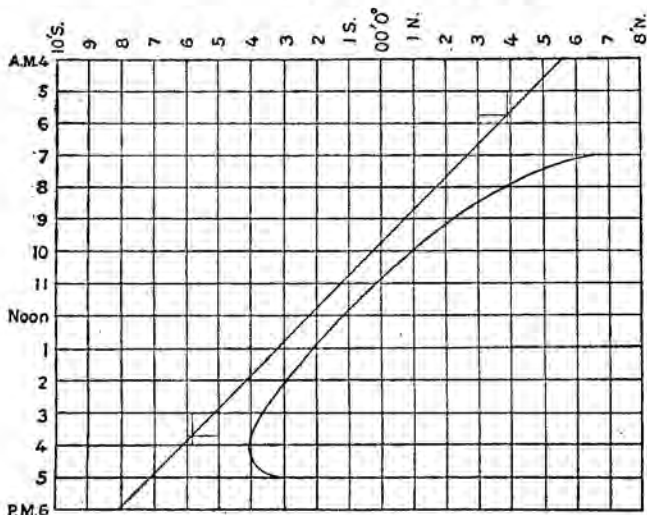
Station: Lat. = $47^{\circ} 30' N.$ Long. = $6^h 18^m W.$ Greenwich noon = $0^{\circ} 03' 55'' N.$ = $5^h 42^m a. m.$ Diff. $10^h, -585'' = 9\ 45\ S.$ $0^{\circ} 05' 50'' S.$ = $3^h 42^m p. m.$ 

Fig. 6.

55. A: Azimuth angle from the true meridian to Polaris, or to the sun's center; in the following analytical examples A is referred to the north point unless otherwise noted, and the reductions are symmetrical either east or west of the meridian; all determinations for azimuth imply the recording of horizontal angles from a fixed reference point to Polaris or to the sun, or that a point has been marked on the ground to define the direction of observation; the mean horizontal angle in the first case, or the mean point in direction in the second instance, being used.

In the first of the foregoing examples of the relative use of v , h and ζ , is shown the record of certain observed horizontal angles from a fixed reference point to the sun's limbs, and now for the purpose of clearly stating the use of the notation A , the final reduction of that observation is here anticipated, in which the following result is obtained:

Sun's azimuth.

Referred to the N. point, $A=N. 114^{\circ} 07' 28'' W.$

Referred to the S. point, $A=S. 65^{\circ} 52' 32'' W.$

Recorded mean horizontal

angle from flag S. to the

sun SW. = S. $64^{\circ} 52' 30'' W.$

True bearing of flag..... = S. $1^{\circ} 00' 02'' W.$

In general in altitude observations upon the sun it is convenient to record horizontal angles from a fixed reference point to the sun's limbs; this method is preferable in view of the rapid motion of the sun and the advantage of minimizing the period of the observation. In observations upon Polaris the same method is often convenient, and at other times it may be more convenient to mark points upon the ground to define the direction of observation, taking a proper mean of the several points to define the true line of sight to Polaris.

Under adverse conditions an altitude observation upon the sun for azimuth may fail in the reversal of the transit on account of clouds or error in reading one of the angles of a series of observations, in which case it may be desirable to reduce the single observation upon the sun's limbs to equivalent corrected readings to the sun's center. In single observations on the sun, the reduction to the sun's center in azimuth = $\frac{16'}{\cos v}$; a refinement in the value of the sun's semi-diameter is had by referring to the Ephemeris for the date of observation.

An example of reduction to the sun's center in both vertical and horizontal angles follows:

Field record.	Final field notes.
ϕ Vertical angle to sun's lower limb $= -25^{\circ} 20' 00''$ Sun's semi-diameter for reduction to center $= + 16' 06''$ <hr/> Sun's center, v $= -25^{\circ} 36' 06''$ <hr/> Hor. angle from flag S. to sun's right limb, SW. $= 65^{\circ} 00' 00''$ Reduction to sun's center, $\frac{18.1}{\cos 25^{\circ} 36'} = 17.9$ $= 17' 54''$ <hr/> Hor. angle from flag S. to sun's center, SW. $= 64^{\circ} 42' 06''$ <hr/>	Mar. 18, 1910, I make an altitude observation upon the sun for azimuth, observing the sun's lower and right limbs only; failing to observe the sun's upper and left limbs in the reversal of the transit on account of clouds: Apparent time of observation, 3h 42m p. m. Observed vertical angle to sun's lower limb, $25^{\circ} 20' 00''$, corrected to the sun's center $= 25^{\circ} 36' 06''$. Observed horizontal angle to sun's right limb from flag S. to sun SW., $65^{\circ} 00' 00''$, corrected to the sun's center $= 64^{\circ} 42' 06''$.

56. Tables of mean refractions both in zenith and polar distance appear in the Standard Field Tables, arranged to meet the requirements of field use; see Tables 20 and 23. A table of coefficients to apply to mean refractions in zenith or polar distance for variations in atmospheric pressure and temperature to obtain true values of refractions is given to meet occasional necessity for its use, see Table 21. In the absence of a barometric instrument to determine the atmospheric pressure, the argument "approximate elevation above sea level" may usually be safely substituted. The differences between the true and the tabulated refractions are generally small and negligible excepting for the combined effect of low apparent altitude of observation with great elevation above sea level or extremes of temperature. The following example of reduction illustrates the method to be employed in all reductions from the tabulated refractions:

Tabulated refraction $= 6' 45'' = 6'.75$; elevation above sea level $= 10,000$ feet, for which elevation the coefficient is 0.70; temperature at the time of observation $= 82^{\circ}$ F., for which temperature the coefficient is 0.94; true refraction $= 0.70 \times 0.94 \times 6'.75 = 4'.44 = 4'26''$.

TIME.

57. The element of time enters into all azimuth determinations to such an extent that the engineer should be able to arrive at the exact apparent time of all observations upon the sun and the exact local mean time of all observations upon Polaris. The sun's declination varies with the apparent time and the longitude west from $1990^{\circ} - 31 - 5$

Greenwich, and enters directly into all observations upon the sun for azimuth; thus the apparent time and longitude should be known to a degree of accuracy commensurate with the refinement necessary in computing the sun's declination. The azimuth of Polaris varies with the local mean time of observation, which must be known to a degree of accuracy consistent with the result wanted in the determination of the true meridian. In observations upon Polaris at elongation precision in local mean time is unnecessary, but in hour angle observations upon Polaris it will be noted that at upper or lower culmination, in latitude 40° for example, Polaris varies $1'$ in azimuth in about 2.5 minutes of time; this interval of time slowly increases toward elongation and in the latter position more than 30 minutes of time are required for a change of $1'$ in azimuth.

58. Conversion of standard time into local mean time: watch reading \pm watch error in standard time by comparison \pm correction for longitude; the correction for longitude is additive east and subtractive west of the standard meridian of the time belt; the conversion table "degrees to time" (Table 18, Standard Field Tables) is convenient in this reduction.

Example of conversion of standard time into local mean time; longitude $77^\circ 01' 37''.5$ W.:

Watch time of observation	$= 6^h 26^m 40^s$ p. m.
Watch slow of 75th meridian standard time by comparison with a standard clock	$= +1^m 22^s$
Correction for longitude of station ($77^\circ 01' 37''.5$ W. $= 5^h 08^m 06.5^s$)	$= -8^m 06^s$
Local mean time of observation	$= \underline{\underline{6^h 19^m 56^s}}$ p. m.

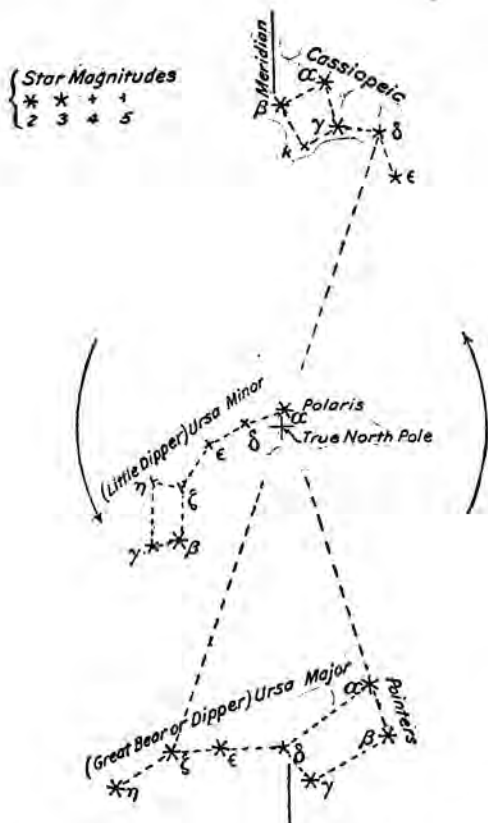
59. Conversion of apparent time into local mean time: apparent time of observation \pm the equation of time; the equation of time is to be taken from the Ephemeris for the date of observation and corrected for the longitude and time of observation, conveniently interpolated as the interval from Greenwich noon to the time of observation; the watch error in local mean time is then found by taking the difference between the watch reading at the epoch of the observation and the reduced local mean time of observation.

Example of conversion of apparent time into local mean time; longitude $77^\circ 01' 37''.5$ W.:

Mar. 18, 1910, apparent time of altitude observation upon sun	=	3 ^h 42 ^m 11 ^s	p. m.
Equation of time, Greenwich apparent noon	+8 ^m 23.4 ^s		
Interpolation for longitude of station 5 ^h 08 ^m W., and time of observation 3 ^h 42 ^m , p. m., 8 ^h 50 ^m after Greenwich noon, or 8.83/24 of change (17.64 ^s) in 24 hours	=	- 6.5 ^s	
Equation of time	+8 ^m 16.9 ^s	+8 ^m 17 ^s	
Local mean time of observation		=	3 ^h 50 ^m 28 ^s
Watch time of observation		=	3 ^h 57 ^m 53 ^s
Watch fast of local mean time		=	7 ^m 25 ^s

TIME IN ITS RELATION TO POLARIS OBSERVATIONS.

60. Polaris, a star of the second magnitude, occupies a position in the northern heavens a little more than 1° from a line defined by the axis of the earth's rotation, and on account of its brightness and proximity to the polar axis it ranks to the engineer as the most useful circumpolar star. It will be assumed that the engineer has learned how to identify the north star among its associates in the clear starlit heavens, especially with reference to the "pointers" in the constellation of the "Great Bear," which is popularly called the "Dipper." Polaris (α Ursæ Minoris) is nearly on a line (or great circle) determined by the pole and the star " δ Cassiopeix," and both stars are located in the same direction from the pole. The same line (or great circle) passes near the star " ζ Ursæ Majoris" (another star of the "Dipper"), but the latter star is located on the *opposite* side of the pole. The engineer may note the relative position of the three stars aforementioned, if it is a clear night, and this will give an immediate indication of the approximate position of Polaris in its diurnal circle at such time of observation. The novice should secure field demonstration in these details from an experienced observer. The three stars named are all of about the same brightness. Instructions will follow (sec. 99) regarding the positive identification of Polaris by instrumental methods during the twilight period, before the star is visible to the naked eye, and the same process may



NAKED-EYE IDENTIFICATION OF POLARIS.

About noon March 23rd.

About 6 a. m. June 22nd.

About midnight September 22nd.

About 6 p. m. December 22nd.

be employed for verification of night observations, if there should be any doubt as in case the neighboring constellations are obscured by clouds.

A skillful engineer can readily observe Polaris at sunset or sunrise without artificial illumination, and with a very clear atmosphere can perform the observation when the sun is as much as 20 or 30 minutes above the horizon. At any time that Polaris is visible any one of the various methods of Polaris observation for meridian, properly followed, is superior to any form of observation upon the sun for the same purpose. In general, in public-land surveying, the best of all practices is found in the proper use of a solar instrument adjusted to the true meridian as established by Polaris observation.

Polaris has a diurnal circle about the earth's polar axis similar to the diurnal circle of other stars, though Polaris has the smallest circle of any naked-eye star. The daily circuit of Polaris is covered in one sidereal day of 24 sidereal hours, or an equivalent of 23 hours 56 minutes 4.09 seconds of mean solar time. In its diurnal circle Polaris crosses the meridian twice, once at upper culmination, or above the polar axis, and once at lower culmination, or below the polar axis.

The direction of the apparent motion of Polaris is suggested by the following diagram:

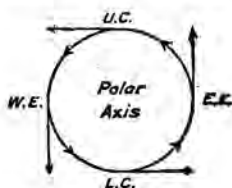


Fig. 7.

The pointings of the arrows on the above circle indicate the direction of the apparent motion of Polaris in its diurnal path, while the pointings of the arrows on the lines tangent to the circle show the direction of travel at the epochs of culmination and elongation. If the engineer has any doubt in regard to the quadrant occupied by Polaris in its diurnal circle at the time of an observation, he may set the intersection of the telescope cross-wires exactly upon the star, then, without moving the instrument, note the direction of the star's motion and compare with the diagram.

The position of Polaris in its diurnal circle at any time may be determined by reference to the mean time interval *from* upper culmination to any observed position *west* of the meridian, or by reference to the mean time interval *from* any observed position *east* of the meridian to the succeeding upper culmination.

61. The Greenwich mean time of upper culmination of Polaris is tabulated in the Ephemeris for every day in the year, arranged for the ordinary civil date, a. m. or p. m.

62. Local mean time of upper culmination of Polaris: the Greenwich mean time of upper culmination of Polaris is to be taken from the Ephemeris for the date of observation; the amount to be subtracted from the Greenwich mean time of upper culmination of Polaris to obtain the local mean time of upper culmination, in which the argument is the longitude west from Greenwich, is obtained from the table of sidereal conversions without computation; see Table 19, Standard Field Tables.

Example of reduction from the Greenwich mean time of upper culmination of Polaris to the local mean time of upper culmination of Polaris, longitude $111^{\circ} 15' W.$:

Aug. 12, 1910, Gr. U. C. of Polaris = $4^h 08.3^m$ a. m.

Red. to long. $111^{\circ} 15' W.$, $1^m 13^s = - 1.2$

L. M. T. of U. C. of Polaris = $4^h 07.1^m$ a. m.

63. The Greenwich mean time of elongation of Polaris, latitude 40° , is tabulated in the Ephemeris for every day in the year, arranged for the ordinary civil date, a. m. or p. m.

64. Local mean time of elongation of Polaris: the mean time of elongation of Polaris, Greenwich meridian, latitude 40° , is to be taken from the Ephemeris for the date of observation; the amount to be subtracted from the mean time of elongation of Polaris, Greenwich meridian, latitude 40° , to obtain the mean time of elongation of Polaris, local meridian, latitude 40° , in which the argument is the longitude west from Greenwich, is obtained from the table of sidereal conversions (Table 19, Standard Field Tables) without computation. The amount to apply to the local mean time of elongation of Polaris latitude 40° to obtain the local mean time of elongation of Polaris at the *latitude of observation* is tabulated in the Ephemeris in connection with the table of azimuths of Polaris at elongation.

Examples of reduction from the Greenwich mean time of elongation of Polaris, latitude 40° , to the local mean time of elongation of Polaris, latitude $64^{\circ} 30' N.$, and longitude $146^{\circ} 30' W.$:

EASTERN ELONGATION.

Sept. 9, 1910, Gr. E. E. of Polaris, Lat. $40^{\circ}=8^{\text{h}} 19.6^{\text{m}}$ p. m.	
Red. to long. $146^{\circ} 30' \text{ W.}, 1^{\text{m}} 36^{\text{s}}$	$= - 1.6$
Red. to lat. $64^{\circ} 30' \text{ N.}$	$= + 5.8$
	<hr/>
L. M. T. of E. E. of Polaris	$8^{\text{h}} 23.8^{\text{m}}$ p. m.
	<hr/> <hr/>

WESTERN ELONGATION, SAME STATION.

Oct. 16, 1910, Gr. W.E. of Polaris, lat. $40^{\circ}=5^{\text{h}} 48.5^{\text{m}}$ a. m.	
Red. to long. $146^{\circ} 30' \text{ W.}, 1^{\text{m}} 36^{\text{s}}$	$= - 1.6$
Red. to lat. $64^{\circ} 30' \text{ N.}$	$= - 5.8$
	<hr/>
L. M. T. of W. E. of Polaris	$=5^{\text{h}} 41.1^{\text{m}}$ a. m.
	<hr/> <hr/>

65. Conversion of a mean time interval into a sidereal time interval, or vice versa: The amount to apply to one time interval to obtain the other time interval is found in the table of sidereal conversions (Table 19, Standard Field Tables) without computation.

Example of conversion of a mean time interval into a sidereal time interval:

Mean time hour angle of Polaris for an assumed observation in Alaska $= 7^{\text{h}} 32.6^{\text{m}}$

	$= 7^{\text{h}} 32^{\text{m}} 36^{\text{s}}$
Conversion into equivalent sidereal hour angle	$= + 1 14$
	<hr/>
Sidereal hour angle	$= 7^{\text{h}} 33^{\text{m}} 50^{\text{s}}$
	<hr/> <hr/>
$7^{\text{h}} = 105^{\circ}$	
$33^{\text{m}} = 8^{\circ} 15'$	
$50^{\text{s}} = 12' 30''$	
	<hr/>
	$= 113^{\circ} 27' 30''$
	<hr/> <hr/>

66. Hour angles of Polaris: a mean time hour angle of Polaris west of the meridian is the mean time interval from the local mean time of the last preceding upper culmination to the local mean time of observation of Polaris; a mean time hour angle of Polaris east of the meridian is the mean time interval from the local mean time of observation to the local mean time of the next succeeding upper culmination of Polaris.

The above application of the term "hour angle" is a departure from conventional usage, which has been employed in order to sim-

ply the text. By this means one confusing step in the problem relating to hour angles for positions of Polaris east of the meridian is avoided. Polaris crosses the meridian at lower culmination at an hour angle of $11^{\text{h}} 58^{\text{m}} 02^{\text{s}}$, and in the arrangement of the various examples, the observations west of the meridian have been referred to the last preceding upper culmination, and those east of the meridian have been referred to the next succeeding upper culmination, thus avoiding the introduction of any hour angles exceeding $11^{\text{h}} 58^{\text{m}} 02^{\text{s}}$.

Examples of computing hour angles of Polaris; all taken out for longitude $117^{\circ} 15' \text{ W.}$:

West of the meridian, p. m. obsn., U. C. in p. m.



L. M. T. of obsn., Feb. 18, 1911		$= 5^{\text{h}} 20.1^{\text{m}}$ p. m.
Gr. U. C. same date	$= 3^{\text{h}} 36.5^{\text{m}}$ p. m.	
Red. to long. $117^{\circ} 15' \text{ W.}$	$= -1.3$	$= 3 35.2$ p. m.
Hour angle of Polaris, west		$= 1^{\text{h}} 44.9^{\text{m}}$

West of the meridian, p. m. obsn., U. C. in a. m.



L. M. T. of obsn., May 14, 1911		$= \left\{ \begin{array}{l} +12 \\ 7^{\text{h}} 12.4^{\text{m}} \text{ p. m.} \end{array} \right.$
Gr. U. C. same date	$= 10^{\text{h}} 02.1^{\text{m}}$ a. m.	
Red. to long. $117^{\circ} 15' \text{ W.}$	$= -1.3$	$= 10 0.8$ a. m.
Hour angle of Polaris, west		$= 9^{\text{h}} 11.6^{\text{m}}$

West of the meridian, a. m. obsn., U. C. in p. m.



L. M. T. of obsn., Nov. 3, 1911		+12
Gr. U. C., Nov. 2	= 10 ^h 43.9 ^m p. m.	= 6 ^h 31.6 ^m a. m.
Red. to long. 117° 15' W.	-1.3	= 10 42.6 p. m.
Hour angle of Polaris, west		<u>= 7^h 49.0^m</u>

West of the meridian, a. m. obsn., U. C. in a. m.



L. M. T. of obsn., Aug. 11, 1911		= 5 ^h 05.9 ^m a. m.
Gr. U. C., same date	= 4 ^h 13.6 ^m a. m.	
Red. to long. 117° 15' W.	-1.3	= 4 12.3 a. m.
Hour angle of Polaris, west		<u>= 0^h 53.6^m</u>

East of the meridian, p. m. obsn., U. C. in p. m.



Gr. U. C., Dec. 20, 1911		= 7 ^h 34.8 ^m p. m.
Red. to long. 117° 15' W.		= -1.3
L. M. T. of U. C., Dec. 20		= 7 33.5 p. m.
L. M. T. of obsn., same date		= 4 35.1 p. m.
Hour angle of Polaris, east		<u>= 2^h 58.4^m</u>

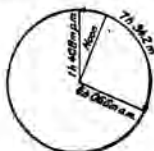
East of the meridian, p. m. obsn., U. C. in a. m.



Gr. U. C., Sept. 2, 1911
 Red. to long. $117^{\circ} 15' W$.
 L. M. T. of U. C., Sept. 2
 L. M. T. of obsn., Sept. 1
 Hour angle of Polaris, east

$$\begin{array}{r}
 = 2^h 47.4^m \text{ a. m.} \\
 = -1.3 \\
 \hline
 = 2 46.1 \text{ a. m.} \\
 \left\{ \begin{array}{l} +12 \\ \hline \end{array} \right. \\
 = 6 34.0 \text{ p. m.} \\
 \hline
 = 8^h 12.1^m \\
 \hline
 \hline
 \end{array}$$

East of the meridian, a. m. obsn., U. C. in p. m.



Gr. U. C., Mar. 19, 1911
 Red. to long. $117^{\circ} 15' W$.
 L. M. T. of U. C., Mar. 19
 L. M. T. of obsn., same date
 Hour angle of Polaris, east

$$\begin{array}{r}
 = 1^h 42.1^m \text{ p. m.} \\
 = -1.3 \\
 \hline
 = 1 40.8 \text{ p. m.} \\
 \left\{ \begin{array}{l} +12 \\ \hline \end{array} \right. \\
 = 6 06.6 \text{ a. m.} \\
 \hline
 = 7^h 34.2^m \\
 \hline
 \hline
 \end{array}$$

East of the meridian, a. m. obsn., U. C. in a. m.



Gr. U. C., May 18, 1911
 Red. to long. $117^{\circ} 15' W$.
 L. M. T. of U. C., May 18
 L. M. T. of obsn.
 Hour angle of Polaris, east

$$\begin{aligned}
 &= 9^{\text{h}} 46.4^{\text{m}} \text{ a. m.} \\
 &= \underline{\quad -1.3 \quad} \\
 &= 9 \ 45.1 \text{ a. m.} \\
 &= 4 \ 42.9 \text{ a. m.} \\
 &= \underline{\underline{5^{\text{h}} 02.2^{\text{m}}}}
 \end{aligned}$$

67. By reference to the preceding diagram showing the direction of motion of Polaris in its diurnal circle, the motion at western elongation is shown to be vertically downward, and at eastern elongation the motion is shown to be vertically upward. At the epoch of either western or eastern elongation the motion of Polaris in azimuth is zero.

At the equator, if Polaris could be observed, the hour angle of Polaris at elongation would be $90^{\circ} 0' 0'' = 6^{\text{h}} 0^{\text{m}} 0^{\text{s}}$ sidereal hour angle = $5^{\text{h}} 59^{\text{m}} 1.02^{\text{s}}$ mean time hour angle, but as stations of observation are occupied in the higher latitudes the hour angle of Polaris at elongation decreases progressively. The reason for this is found in the fact that all vertical planes intersect at the zenith, and the point of tangency of a vertical plane with the diurnal circle of Polaris occurs at points corresponding to decreasing hour angles with the higher latitudes. The "spread" of the two vertical planes intersecting Polaris at eastern and western elongation increases with the higher latitudes, giving increasing azimuths at elongation with the more northern latitudes.

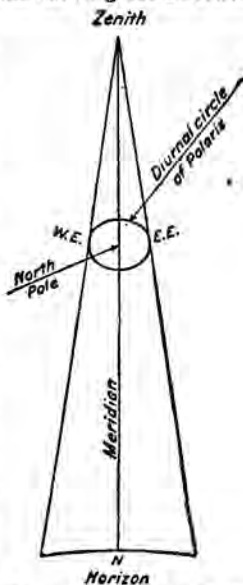


FIG. 8.—The meridian and vertical planes tangent to the diurnal circle of Polaris as viewed from inside of the celestial sphere.

68. Mean time hour angle of Polaris at elongation: t = the sidereal hour angle in angular measure; this converted into time measure, and this in turn converted from a sidereal time interval into a mean time interval gives the mean time hour angle of Polaris at elongation:

$$\cos t = \cotan \delta \tan \phi$$

Example of computing the mean time hour angle of Polaris at elongation, April 3, 1915, in latitude $65^{\circ} 0' N.$, on which date the declination of Polaris = $88^{\circ} 51' 20'' N.$:

$\phi = 65^{\circ} 0'$;	$\log \tan \phi$	= 0.331327
$\delta = 88^{\circ} 51' 20''$;	" $\cotan \delta$	= 8.300530
	" $\cos t$	= 8.631857
Sidereal hour angle		= $87^{\circ} 32' 41''$
		<hr style="width: 50%; margin: 0 auto;"/>
		87° = 5 ^h 48 ^m
		32' = 2 ^m 08 ^s
		41'' = 3 ^s
		<hr style="width: 50%; margin: 0 auto;"/>
		= 5 ^h 50 ^m 11 ^s
Reduction to mean time hour angle		= -0 ^m 57 ^s
		<hr style="width: 50%; margin: 0 auto;"/>
Mean time hour angle at elongation		= 5 ^h 49 ^m 14 ^s
		<hr style="width: 50%; margin: 0 auto;"/>

ALTITUDE OBSERVATION OF THE SUN FOR APPARENT TIME.

69. Altitude observation of the sun for apparent time: t = hour angle from apparent noon in angular measure; reverse the signs of δ for south declinations:

$$\tan \frac{1}{2} t = \sqrt{\frac{\sin \frac{1}{2} (\zeta + \phi - \delta) \sin \frac{1}{2} (\zeta - \phi + \delta)}{\cos \frac{1}{2} (\zeta + \phi + \delta) \cos \frac{1}{2} (\zeta - \phi - \delta)}}$$

70. An altitude observation of the sun for time is made by determining the correct altitude of the sun's center and recording the watch time at the epoch of observation. The following order of procedure is recommended for the elimination of instrumental errors, reduction to the sun's center, and practical elimination of differential refraction:

A. M. OBSERVATION.

Thoroughly level the transit.

Observe the sun's upper limb, recording the watch time of observation and vertical angle.

Reverse the transit.

Observe the sun's lower limb, recording the watch time of observation and vertical angle.

The mean vertical angle is equivalent to the vertical angle to the sun's center corresponding to the mean epoch of the watch readings.

P. M. OBSERVATION.

Thoroughly level the transit.

Observe the sun's lower limb, recording the watch time of observation and vertical angle.

Reverse the transit.

Observe the sun's upper limb, recording the watch time of observation and vertical angle.

The mean vertical angle is equivalent to the vertical angle to the sun's center corresponding to the mean epoch of the watch readings.

Example of altitude observation of the sun for apparent time:

Final field notes.

August 24, 1909, in latitude $37^{\circ} 16' 50''$ N., and longitude $102^{\circ} 12'$ W., I make an altitude observation upon the sun for time, making two observations, one each with the telescope in direct and reversed positions, observing opposite limbs of the sun:

Mean observed vertical angle = $19^{\circ} 39' 30''$

Mean watch time of observation = $4^{\text{h}} 56^{\text{m}} 04^{\text{s}}$ p. m.

Watch slow of local mean time = $0^{\text{m}} 56^{\text{s}}$

Field record.

Telescope.	Sun's limbs.	Watch time.	Vertical angle.
Direct.....	\odot	4 55 22	$19^{\circ} 33' 00''$
Reversed.....	\ominus	4 56 46	19 46 00
Mean.....		4 56 04	$19^{\circ} 39' 30'' = v$
Refraction.....			- - 2 40
Parallax.....			- + 0 08
			$h = 19^{\circ} 36' 58''$

True vertical angle = $h = 19^{\circ}37'$ Zenith distance = $\zeta = 70^{\circ}23'$ Sun's declination = $\delta = 11^{\circ}05'N.$ $\zeta = 70^{\circ}23'$ $\phi = 37\ 17$ $\zeta = 70^{\circ}23'$ $\phi = 37\ 17$ $(\zeta + \phi) = 107^{\circ}40'$ $\delta = 11^{\circ}05' (+)$ $(\zeta - \phi) = 33^{\circ}06'$ $\delta = 11^{\circ}05' (+)$ $\frac{1}{2}$ values = $(\zeta + \phi + \delta) = 118^{\circ}45'$ $59^{\circ}22'30''$ $22^{\circ}05'30''$ $(\zeta - \phi + \delta) = 44^{\circ}11'$ $(\zeta + \phi) = 107^{\circ}40'$ $\delta = 11\ 05 (+)$ $(\zeta - \phi) = 33^{\circ}06'$ $\delta = 11\ 05 (+)$ $(\zeta + \phi - \delta) = 96^{\circ}35'$ $48^{\circ}17'30''$ $11^{\circ}00'30''$ $(\zeta - \phi - \delta) = 22^{\circ}01'$ log sin $\frac{1}{2}(\zeta + \phi - \delta) = 9.873054$ " sin $\frac{1}{2}(\zeta - \phi + \delta) = 9.575291$ " cos $\frac{1}{2}(\zeta + \phi + \delta) = 9.707073$ 9.448345 " cos $\frac{1}{2}(\zeta - \phi - \delta) = 9.991934$ 9.699007 9.699007 " $\tan^2 \frac{1}{2}t = 9.749338$ " $\tan \frac{1}{2}t = 9.874669$ $\frac{1}{2}t = 36^{\circ}50'42''$ $t = 73^{\circ}41'24''$ $73^{\circ} = 4^h 52^m$ $41' = 2^m 44^s$ $24'' = 2^s$ $t = 4^h 54^m 46^s$ Apparent time of observation = $4^h 54^m 46^s$ p. m.Equation of time = $+2\ 14$ Local mean time of observation = $4^h 57^m 00^s$ p. m.Watch time of observation = $4\ 56\ 04$ p. m.Watch slow of local mean time = $0^m 56^s$

MERIDIAN OBSERVATION OF THE SUN FOR APPARENT NOON.

71. *Meridian observation of the sun for apparent noon.*—With the telescope in the meridian elevated to the sun's altitude, the watch times of transit of the sun's west and east limbs are noted, the mean of which is the watch time of apparent noon; if the observation fails for either limb the reduction to the sun's center is accomplished by adding or subtracting 68 seconds; a refinement in the amount of this time is had by referring to the Ephemeris for the time of the sun's

semi-diameter passing the meridian for the date of observation; the setting for the approximate altitude of the sun's center is:

$$v \approx 90^\circ - \phi \pm \delta$$

OBSERVING PROGRAM.

Determine the meridian by the best means at hand and compute the altitude setting for the sun.

Level the transit, place the instrument in the meridian, and elevate the telescope to the altitude of the sun's center.

Note the watch time of the sun's west limb tangent to the vertical wire.

Note the watch time of the sun's east limb tangent to the vertical wire.

Take the mean of the readings for the watch time of apparent noon from which to compute the watch error local mean time.

Example of meridian observation of the sun for apparent noon:

Final field notes.

August 14, 1909, in latitude $37^\circ 16' N.$, and longitude $102^\circ 16' W.$, with the telescope in the meridian and elevated to the sun's altitude, I observe the sun's transit for time, noting the watch time of transit of each limb:

Mean watch time of apparent noon = $12^h 00^m 27^s$

Watch slow of local mean time = $4^m 06^s$

Field record.

$$\begin{aligned} \text{Setting:} & \quad 90^\circ 00' \\ \phi & \approx (-) 37^\circ 16' N. \\ \delta & \approx (+) 14^\circ 25' N. \\ & \quad \hline v & \approx \quad 67^\circ 09' \end{aligned}$$

\ominus Watch time of transit, W. limb = $11^h 59^m 22^s$

\oplus Watch time of transit, E. limb = $12 \quad 01 \quad 32$

Watch time of apparent noon = $12^h 00^m 27^s$

Apparent noon = $12^h 00^m 00^s$

Equation of time = $+ 4 \quad 33$

Local mean time of apparent noon = $12 \quad 04 \quad 33$

Watch slow of local mean time = $\quad \quad 4^m 06^s$

The above form of meridian observation of the sun for apparent noon is by far the most convenient reliable method of time observation.

TIME FROM THE SOLAR ATTACHMENT.

72. Several of the approved forms of solar apparatus, including principally the Smith solar attachment and the Burt solar compass, have a graduated arc or circle mounted normal to the polar axis to indicate the apparent time of observation. The reading of the time arc is most conveniently checked by comparison with the above form of meridian observation of the sun for apparent noon. An error in the reading of the time arc or hour circle may be corrected by adjusting the circle, or allowed for as an index error. The reading of the hour circle may then be safely accepted as giving correct apparent time for use in computing or taking out required declinations of the sun for the various forms of solar observations. A proper reading of the hour circle may be safely accepted to indicate apparent time at which moment the watch reading may be noted, and the watch error *local mean time* determined as shown in the preceding example of conversion of apparent time into local mean time; this result derived for the *watch error local mean time* may then be safely used in observations on Polaris at *elongation*, but for observations upon Polaris by the *hour angle method* the time should be determined by one of the more refined methods already given.

LATITUDE.

73. It is absolutely necessary in the operation of any solar attachment to employ the correct latitude of the station, and in general in altitude observations upon the sun for azimuth or time the latitude must be well determined. In the public-land surveying practice all determinations of either time or latitude are an important part of the program of operations only so far as these functions finally enter into the establishment of the true meridian; all classes of observations given in the Manual have been arranged to facilitate the performance of solar instruments, and for this purpose a definite knowledge of the true latitude is highly important. No lack of reasonable precision should be allowed in the accepted latitude. The various forms of observations for latitude are very simple and a considerable series should be taken in every group of surveys, all reduced to the township boundaries for comparison, until a satisfactory mean has been obtained.

MERIDIAN ALTITUDE OBSERVATION OF THE SUN FOR LATITUDE.

74. *Meridian altitude observation of the sun for latitude.*—Reverse the sign of δ for south declinations:

$$\phi = 90^\circ + \delta - h$$

The following observing program is recommended:

Thoroughly level the transit and place the telescope in the meridian elevated to the sun's approximate altitude at noon.

Observe the altitude of the sun's lower limb with the sun slightly east of the meridian.

Reverse the transit.

Observe the altitude of the sun's upper limb with the sun slightly west of the meridian.

Take the mean observed vertical angle for the altitude of the sun's center at apparent noon.

The following is an example of meridian altitude observation of the sun for latitude:

Final field notes.

October 5, 1909, in approximate latitude $37^{\circ} 20' N.$, and longitude $102^{\circ} 04' W.$, I make a meridian altitude observation of the sun for latitude, observing the altitude of the sun's lower limb with the telescope in direct position, reversing the transit and observing the sun's upper limb:

Apparent time of observation, noon	$=12^h 00^m 00^s$
Mean observed altitude	$=47^{\circ} 59' 45''$
Reduced latitude	$=37^{\circ} 19'.3 N.$

Field record.

Setting:	$90^{\circ} 00'$
$\phi \neq (-)$	$37^{\circ} 20' N.$
$\delta \neq (-)$	$4^{\circ} 42' S.$
$v \neq$	$47^{\circ} 58'$
Lower limb	$47^{\circ} 42'$
Upper limb	$48^{\circ} 14'$

\odot Observed alt., lower limb, tel. dir. $=47^{\circ} 43' 00''$

\ominus Observed alt., upper limb, tel. rev. $=48^{\circ} 16' 30''$

Mean observed altitude, v	$=47^{\circ} 59' 45''$
Refraction	$- 0 52$
Parallax	$+ 0 06$

$$h = 47^{\circ} 58' 59''$$

$$\delta = 4 41 42 S.$$

$$\phi = 37^{\circ} 19'.3 N. = 90^{\circ} - \delta - h = 37 19 19$$

$$\underline{\underline{90^{\circ} 00' 00''}}$$

75. The above-described observation is conveniently combined with the meridian observation of the sun for time, by observing simultaneously the sun's lower and west limbs, recording the watch time and the vertical angle and reversing the transit in the interval of about 2 minutes, and then observing simultaneously the sun's upper and east limbs. The settings for the approximate altitudes of the sun's lower and upper limbs, respectively, are:

$$v \approx 90^\circ - \phi \pm \delta \mp 16'$$

Example of meridian observation of the sun for time and latitude:

Final field notes.

June 8, 1910, in approximate latitude $38^\circ 54'$ N., and longitude $77^\circ 01'.6$ W., I make a meridian observation of the sun for time and latitude, observing simultaneously the altitude of the sun's lower limb and the transit of the sun's west limb, reversing the telescope and observing simultaneously the altitude of the sun's upper limb and the transit of the sun's east limb:

Mean observed altitude	$= 73^\circ 55' 30''$
Reduced latitude	$= 38^\circ 53'.7$ N.
Mean watch time of observation	$= 12^h 06^m 40^s$
Watch fast of local mean time	$= 7^m 58^s$

Field record.

Setting:	$90^\circ 00'$
$\phi \approx$	$(-) 38^\circ 54'$ N.
$\delta =$	$(+) 22^\circ 49'$ N.
$v \approx$	$73^\circ 55'$
Lower limb	$73^\circ 39'$
Upper limb	$74^\circ 11'$

Position of telescope.	Position of sun.	Watch time transit.	Observed vertical angle.
Direct.....	☉	$12^h 05^m 37^s$	$73^\circ 42' 30''$
Reversed.....		☽	$12 07 42$
Mean.....		$12^h 06^m 40^s$	$73^\circ 55' 30''$
Refraction.....			$= -16$
Parallax.....			$= +02$
h			$= 73^\circ 55' 16''$
$\delta = 22^\circ 49' 00''; 90^\circ + \delta$			$= 112 49 00$
$\phi = 38^\circ 53'.7$ N. $= 90^\circ + \delta - h$			$= 38^\circ 53' 44''$

Watch time of apparent noon.....	=	12 ^h	06 ^m	40 ^s
Apparent noon.....	=	12 ^h	00 ^m	00 ^s
Equation of time..	=	- 1	18	
<hr/>				
Local mean time of apparent noon.	=	11	58	42
<hr/>				
Watch fast of local mean time.....	=		7 ^m	58 ^s
<hr/>				

The known latitude of the above station is $38^{\circ} 53' 40''$, but it can not be assumed that any one altitude observation of the sun will always give a result so close to the true latitude. In general a better determination of the latitude by this method is possible only by making a series of observations on successive days, or by combining the result with Polaris observations for latitude.

For the purpose of a test as to the accuracy of the above time observation, the same watch was compared with a Western Union telegraph clock as follows:

75th meridian time of comparison..	=	12 ^h	00 ^m	00 ^s
Correction for longitude $77^{\circ} 1.6'$...	=	- 08	06	
<hr/>				
Local mean time of comparison...	=	11 ^h	51 ^m	54 ^s
Watch time of comparison.....	=	11	59	56
<hr/>				
Watch fast of local mean time.....	=		8 ^m	02 ^s
<hr/>				

ALTITUDE OBSERVATION OF POLARIS FOR LATITUDE.

76. *Altitude observation of Polaris at upper culmination for latitude:*

$$\phi = h + \delta - 90^{\circ}$$

Altitude observation of Polaris at lower culmination for latitude:

The mean time hour angle of Polaris at lower culmination is 11 hours 58 minutes 2 seconds:

$$\phi = h + 90^{\circ} - \delta$$

The settings for the approximate altitude of Polaris at upper and lower culminations, respectively, are:

$$v \approx \phi \pm (90^{\circ} - \delta)$$

The following program is recommended in altitude observations of Polaris at culmination for latitude.

Compute the local mean time and watch time of culmination.

Thoroughly level the transit.

About four minutes before culmination observe the altitude of Polaris with the telescope in direct position.

Reverse the transit and observe the altitude of Polaris.

Again level the transit.

Observe the altitude of Polaris with the telescope in the reversed position.

Reverse the transit to the direct position of the telescope and again observe the altitude of Polaris.

Take the mean observed altitude to use in the reduction.

Example of altitude observation of Polaris at lower culmination for latitude:

Final field notes.

June 19, 1910, in approximate latitude $38^{\circ} 54' N.$, and longitude $77^{\circ} 01'.6 W.$, I make an altitude observation on Polaris at lower culmination for latitude, making four observations, two each with the telescope in direct and reversed positions:

Watch fast of 75th meridian	
standard time by comparison =	0 ^m 24 ^s
Mean watch time of observation =	7 ^h 44 ^m 37 ^s p. m.
Mean observed vertical angle =	37° 44' 00''
Reduced latitude =	38° 53'.4 N.

Field record.

$$\begin{array}{r}
 \text{Setting: } 90^{\circ} 00' \\
 \delta \approx 88^{\circ} 49' \\
 \hline
 90^{\circ} - \delta \approx 1^{\circ} 11' \\
 \phi \approx 38^{\circ} 54' \\
 \hline
 v \approx 37^{\circ} 43' = \phi - (90^{\circ} - \delta)
 \end{array}$$

Gr. U. C. of Polaris, June 19, 1910	=	7 ^h 39.7 ^m a. m.
Reduction to longitude $77^{\circ} 1.6' W.$	=	-0.8
Reduction to lower culmination	=	+11 58.0

7^h 36.9^m p. m.

L. M. T. of L. C. of Polaris, June 19	=	7 ^h 36 ^m 54 ^s p. m.
---------------------------------------	---	--

Watch fast of 75th meridian standard time by comparison with a Western Union telegraph clock	= +	0 24
--	-----	------

Correction for longitude $77^{\circ} 01'.6 W.$	= +	8 06
--	-----	------

Computed watch time of lower culmination	=	<u>7^h 45^m 24^s p. m.</u>
--	---	--

Telescope.	Watch time.	Vertical angle.
Direct.....	7 ^h 40 ^m 14 ^s	37° 42' 30"
Reversed.....	7 42 45	37 44 30
Reversed.....	7 46 39	37 45 30
Direct.....	7 48 50	37 43 30
Mean.....	7 ^h 44 ^m 37 ^s	37° 44' 00"
Refraction.....		-1 15
		$h=37^{\circ} 42' 45''$
$\delta=88^{\circ} 49' 20''; 90^{\circ}-\delta$		- 1 10 40
$\phi=38^{\circ} 53'.4 \text{ N.} \rightarrow h+(90^{\circ}-\delta)$		$=38^{\circ} 53' 25''$

76-A. To find the latitude by an altitude observation of Polaris at any hour angle, see section 133-A, page 131.

AZIMUTH.

THE SOLAR ATTACHMENT.

77. The solar attachment to the engineer's transit has been designed for instrumentally setting off the sides of the "pole-zenith-sun" triangle in agreement with their angular values at the station and time of observation. The sun's image may be brought into the line of collimation of an auxiliary telescope by orientation of the transit to the position where the instrumental parts are made parallel to the respective sides of the celestial triangle, whereupon the vertical plane of the "pole-zenith" arc of the solar attachment will coincide with the true meridian. Skillfully handled, the solar attachment will give at once close approximations to the true meridian comparing favorably for accuracy with direct observations. The advantage in the proper use of the solar attachment is found in its rapid and close determinations of the meridian in heavy timber, dense undergrowth, and strong wind, in low swamp or on high mountain ascents, and under nearly all other difficult physical situations encountered in the field, avoiding in its proper use accumulative errors incident to the prolongation and deflection of transit lines, and deviations in the azimuth of latitudinal lines. On the public-land surveys, the Smith solar attachment, designed in 1880 by Benjamin H. Smith, a United States surveyor of Colorado, has given the most general satisfaction. The later models, as perfected,

have been adopted as the standard instrument of the General Land Office cadastral surveying service.

A description of the standard model of the Smith solar attachment is here given in order to preface a discussion of the theory, adjustment, test, and use of the instrument. A description of only one other solar instrument is included owing to the wide differences of design, and the impossibility of a general treatment of the adjustments, test, and use, without an elaboration of the subject beyond the purpose of the Manual. If nonstandard instruments are supplied to the engineers, the proper supervising officer will furnish suitable instructions regarding their adjustment and use.

DESCRIPTION.

78. The working parts of the Smith solar attachment consist of five fundamental features, each performing its own distinctive function. The principles involved have been adapted to various types of construction, and the efficiency of the different designs is related directly to the perfection which may be attained in making a proper adjustment in the field, the stability of the adjustments when made, and the compactness of the design, considering protection to the working parts and proper distribution of weight. The five fundamental working parts consist of:

1. An auxiliary telescope whose line of collimation is the polar axis of the solar attachment; the telescope may be revolved in collar bearings which are securely mounted on a vertical limb.
2. The vertical limb is mounted on a horizontal axis and has a graduated latitude arc in its vertical plane.
3. A plane mirror at the objective end of the auxiliary telescope with an axis normal to the line of collimation, and an arm leading to a graduated declination arc.
4. An hour circle on the auxiliary telescope mounted normal to the line of collimation.
5. A set of equatorial wires parallel to the axis of the reflector.

In all the forms of construction of the Smith solar attachment the auxiliary telescope is mounted in a vertical plane parallel to the transit telescope. Thus, if the instrument is in proper adjustment and oriented to the true meridian, the polar axis of the solar attachment may be made parallel to the earth's polar axis by setting off the true latitude of the station. The sun's rays are brought into the auxiliary telescope by means of the mirror, due allowance being

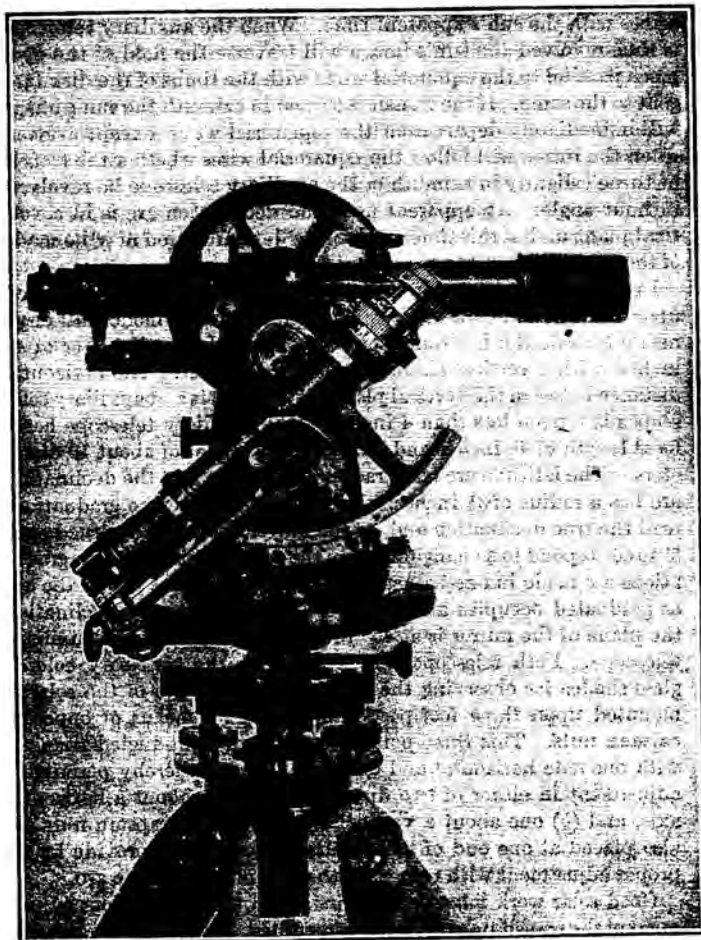


FIG. 9.—The solar transit as it appears in use.

made for the sun's declination north or south of the equator, but to bring the sun's image into the auxiliary telescope the latter must be revolved in its collar bearings until the reading of the hour circle agrees with the sun's apparent time. When the auxiliary telescope is thus revolved the sun's image will traverse the field of the eyepiece parallel to the equatorial wires with the limbs of the disk tangent to the same. If the transit is turned in azimuth the sun's image will immediately depart from the equatorial wires, except at noon when the image will follow the equatorial wires whether the transit be turned slightly in azimuth or the auxiliary telescope be revolved in hour angle. At apparent noon the declination arc is in a vertical plane and at this time an absolute determination may be made of the correctness of the reading of this arc.

In the modern construction the solar attachment is mounted upon the east standard of a regular light mountain model full engineer's transit, the horizontal circle of which has a diameter of $4\frac{1}{2}$ inches, with a vertical circle of 4 inches diameter. The horizontal distance between the vertical planes of the transit and auxiliary telescopes is a trifle less than 4 inches. The auxiliary telescope has a focal length of $4\frac{1}{2}$ inches and a magnifying power of about 10 diameters. The latitude arc has a radius of 3 inches, and the declination arc has a radius of $3\frac{1}{2}$ inches. Upon the latter arc the graduations read the true declination and, as the mirror needs to be turned only 5° to correspond to a change of 10° in the sun's declination, the graduations are made in one-half space, i. e., an interval of 10° on the arc as graduated occupies a segment of only 5° . At zero declination the plane of the mirror is at 45° to the line of sight of the auxiliary telescope. Both telescopes are fitted with the necessary colored glass shades for observing the sun. The base plate of the solar is mounted upon three foot posts, adjustable by means of opposing capstan nuts. This three-point base forms a right-angled triangle, with one side horizontal and one side vertical, thereby permitting adjustment in either of two directions: (a) One about a horizontal axis, and (b) one about a vertical axis. Suitable capstan nuts are also placed at one end of the auxiliary telescope to provide for its proper adjustment with respect to the axis of the latitude arc.

Good solar work must depend first of all upon the proper adjustment of the transit upon which it is mounted, with great care in keeping every working part cleaned, suitably oiled to work smoothly, and

protected from adverse weather and injury. The same precautions are due the solar attachment. It will give very efficient meridional performance if properly adjusted and operated; nothing less can be conceded.

Before starting in with the adjustments it should be determined that the auxiliary telescope revolves smoothly in its collar bearings, neither too tight nor too loose; that there is free and smooth motion to the latitude and declination arcs; that the clamps are positive and the tangent motions smooth and free in either direction; that the eye-piece is carefully focused upon the cross wires; and that the objective is carefully focused upon any quite distant object, then secured in this position. The eye-piece turns freely and has a pin-which travels in a guide slot; this pin is not a clamp. The objective may be moved by first loosening, then pushing the screw, which will be found to travel in a guide slot near the lower (or left hand) collar bearing.

ADJUSTMENT.

79. The field adjustments of the solar attachment should be considered in the following order:

1. The equatorial wires must be made parallel to the axis of the reflector.

2. The line of sight of the auxiliary telescope must lie in its true turning axis.

3. The polar axis, or line of sight of the auxiliary telescope, must be normal to the axis of the latitude arc, describe a true vertical plane when turning on said axis, and said vertical plane must be parallel to the vertical plane of the transit telescope.

4. The latitude arc should read zero when the auxiliary telescope is horizontal.

5. The declination arc should at all times read the true declination of the sun plus the refraction in polar distance.

6. The hour circle should read the sun's apparent time.

There are two or more methods of testing each and every adjustment, but those stated below are without doubt the simplest, and most rapid and reliable of all field methods. The true meridian should be established by Polaris or other independent observation, upon which to test the solar, but otherwise it plays only a small part in the adjustments of the solar attachment. The true latitude of the station must be definitely known. There should be a clear view to a

distant object in the horizon, but if an object less than a mile away must be utilized due allowance may be made for the horizontal distance between the vertical planes of the transit and auxiliary telescopes.

1. *The equatorial wires.*—Set up the instrument as in a regular solar observation, setting off the known latitude, declination and apparent time, and bring the sun's image accurately between the equatorial wires by orienting the transit approximately to the meridian, in which position the instrument should be clamped. (See fig. 9.) Turn the auxiliary telescope in hour angle, causing the sun's image to travel across the field from side to side. If the image follows the equatorial wires accurately the latter are parallel to the axis of the reflector as required. If the sun's image departs materially from the equatorial wires, the capstan screws which hold the diaphragm should be loosened and the reticle may be rotated until the equatorial wires are made to agree with the path of the sun's image across the field, then return each capstan screw to a proper seat.

2. *Collimation of the auxiliary telescope.*—Swing the mirror to give a direct view through the auxiliary telescope. (See fig. 10.) Set the line of sight on a distant point and clamp the instrument. Revolve the auxiliary telescope 12 hours in hour angle. If the line of sight remains fixed on the distant point it agrees with the turning axis as required. If after revolution, the line of sight appears to be above or below, or to the right or left, of the distant point, one-half of the differences should be taken up with the capstan screws which control the diaphragm. The test should be repeated until the auxiliary telescope is in perfect collimation.

3. *The polar axis.*—Carefully level the transit and then sight the main telescope to the distant point and clamp the instrument; sight toward the same point with the auxiliary telescope, and place the striding level on the latitude axis. (See fig. 10.) The striding level should be reversed to see if there is any error in the level itself, and if so take the mean position for the true indication of the level. If the latitude axis is not horizontal it may be made so by adjusting the lower pair of capstan nuts on the base frame of the solar attachment. If the line of sight of the auxiliary telescope is not parallel to that of the main telescope it may be made parallel by means of the left-hand upper pair of capstan nuts on the base frame of the solar. After fulfilling the foregoing conditions turn the transit 180° in azimuth and reverse both telescopes so as to sight again to the same distant object,

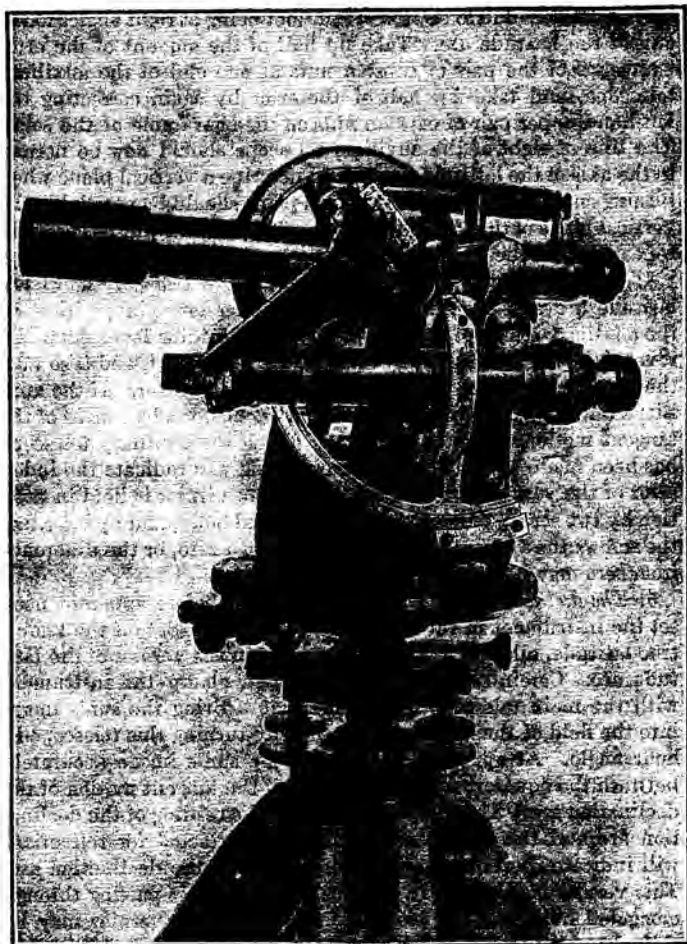


FIG. 10.—Direct sighting through the auxiliary telescope, with the mirror swung to a central position, and showing the striding level on the latitude axis.

setting the main telescope upon the object. (See fig. 11.) If the auxiliary telescope does not again sight upon the distant object, one-half the error is due to its line of sight not being at right angles to the axis of the latitude arc. Take up half of the amount of the error by means of the pair of capstan nuts at one end of the auxiliary telescope, and take up half of the error by again correcting the left-hand upper pair of capstan nuts on the base frame of the solar. The line of sight of the auxiliary telescope should now be normal to the axis of the latitude arc, should describe a vertical plane when turning on said axis, and said vertical plane should be parallel to the vertical plane of the transit telescope. The tests should be carefully repeated until the adjustments are perfected.

4. *The latitude vernier.*—Carefully level the transit, clamp the latitude arc at zero, and place the striding level in position on the auxiliary telescope. (See fig. 12.) The striding level should be reversed to see if there is any error in the level itself, and if so take the mean position for the true indication of the level. If the auxiliary telescope is not horizontal it may be made so by means of the tangent motion of the latitude arc. When the auxiliary telescope has been made truly horizontal the reading will indicate the index error of the vernier of the latitude arc. The vernier is held in position by two screws passing through elongated holes, and by loosening the screws the vernier may be shifted to read zero, or the difference from zero may be carried as an index error.

5. *The declination vernier.*—A few minutes before apparent noon set the instrument in the established meridian. Set off the known true latitude, allowing for any index error in the vernier of the latitude arc. Carefully level the transit and clamp the instrument with the main telescope in the meridian. Bring the sun's image into the field of the auxiliary telescope by turning this telescope in hour angle. At apparent noon bring the sun's image accurately between the equatorial wires by means of the tangent motion of the declination arc. The difference between the reading of the declination arc and the calculated declination (corrected for refraction) will indicate the index error of the vernier of the declination arc. This vernier is also held in position by two screws passing through elongated holes, and by loosening the screws the vernier may be shifted to read the calculated declination for apparent noon of that date, or the difference may be carried as an index error. This test should be made every day the instrument is used. If by some

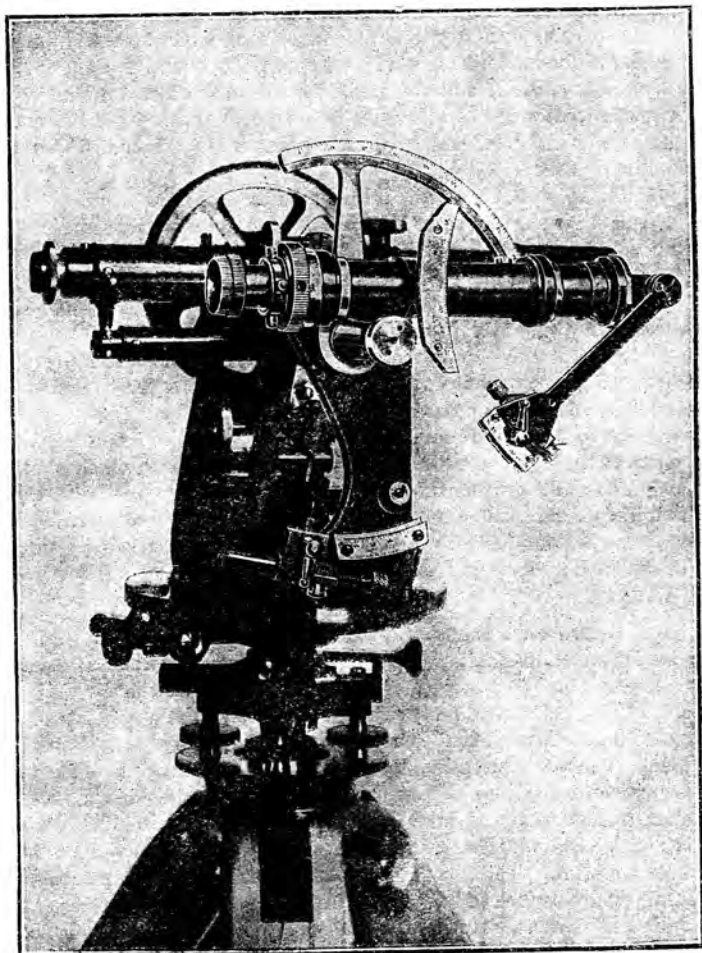


FIG. 11.—The auxiliary telescope in reversed position

failure in the adjustments of the solar attachment a difference of as much as $30''$ from previous tests should be discovered in the noon observation, the new error will generally be found in one of three places: (a) The auxiliary telescope may be out of collimation; (b) the vernier of the latitude arc may have become loose and shifted; or (c) the vernier of the declination arc may have become loose and shifted. Any slight error in the other adjustments, or in the determination of the established meridian, will not appear in the noon test of the declination arc.

6. *The hour circle.*—A few minutes before apparent noon set the instrument in the established meridian. Level the transit and clamp the instrument with the main telescope in the meridian and elevated to the sun's altitude. Set your watch to read 12 o'clock as the sun's center crosses the vertical wire of the main telescope. At any convenient time thereafter set off the proper readings on the latitude and declination arcs, and with the instrument in the meridian, bring the sun's image to the center of the field of the auxiliary telescope and observe the watch time. If the reading of the hour circle agrees with the watch it is in adjustment; if not, it may be made to read apparent time by loosening the set screw which holds the hour circle in position and shifting the circle until the reading agrees with the watch, care being taken not to move the auxiliary telescope in hour angle until after the set screw is again seated. The test may then be repeated as often as desirable.

USE.

80. Before using the solar attachment the latitude of the station and the sun's declination (properly corrected for refraction in polar distance) must be known and accurately set off on the respective arcs. The instrument is carefully leveled and the apparent time set off on the hour circle. The transit is then oriented to the meridian. The plates are generally first set at zero and the sun's image brought into the field of the solar telescope before setting the lower clamp; thereupon the sun's image is brought accurately between the equatorial wires with the lower tangent motion; this gives the solar meridian. The transit may then be used for any normal function. The solar meridian may be tested as many times as may be desirable by simply setting the plates back to zero and turning the auxiliary telescope in hour angle to the apparent time; this brings the sun's image again to the center of the field. The sun's declination is constantly changing at a very slow rate, so that it is necessary

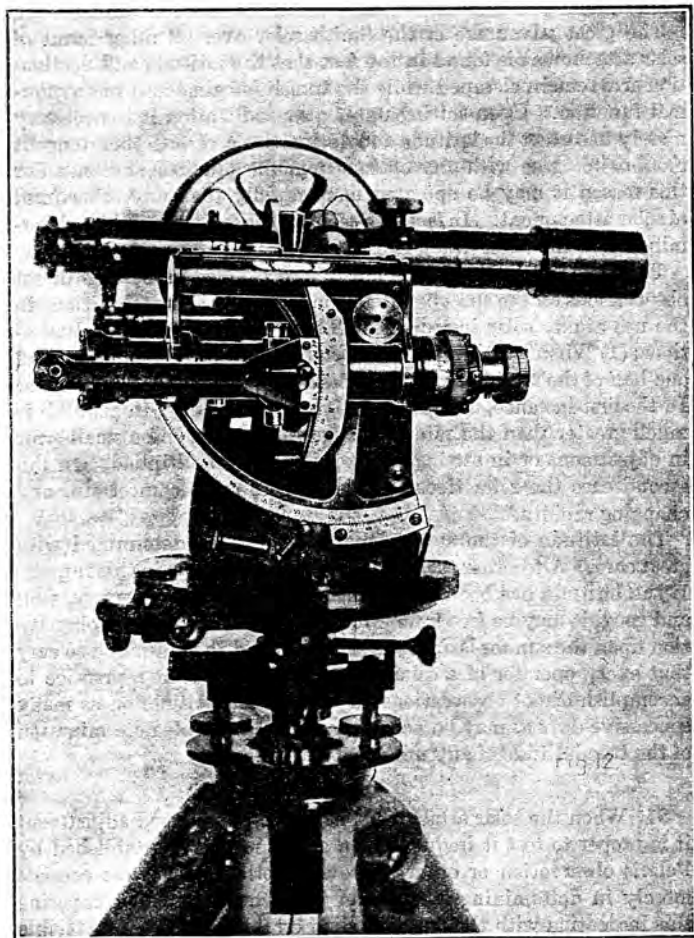


FIG. 12.—The striding level on the auxiliary telescope.

to correct the reading on the declination arc with its tangent motion to agree with the declination of the sun for the apparent time of observation.

The great advantage of the Smith solar over all other forms of solar attachment is found in the fact that the latitude and declination arcs remain clamped while the transit is being used in any normal function. Upon setting up at a second station it is necessary merely to correct the latitude and declination arcs with their tangent motions to agree with any change from the previous station. For this reason it may be operated more rapidly than any other form of solar attachment. In fact, the solar meridian is so quickly determined that the observation is usually repeated at every station.

The same restrictions which must be recognized in making direct observations on the sun operate in the same way as a prohibition in the use of any solar instrument. There are only two such limitations: (1) When the sun is within two hours, or possibly an hour and one-half of the meridian; and (2) when the sun is low in the horizon. In the first instance, the sun's relative rate of change in azimuth is much greater than the rate of change in altitude, and a small error in adjustment or in setting the arcs is greatly multiplied. In the second case the refractions are great, more or less uncertain, and changing rapidly.

The latitude of the station should always be determined with great care. Altogether too many maps are unreliable in this respect. If the latitude has been determined by competent observers, well and good, it may be free from error, but the direct altitude observation upon the sun for latitude is so simple and the reduction so easy that every operator of a solar transit should make it a practice to accomplish direct observations on the sun for latitude on as many successive days as may be necessary to give a reliable determination of the true latitude of any unknown station.

TEST.

81. When the solar attachment has been put in good adjustment it is proper to test it frequently on a true meridian established by Polaris observation or other approved method. The test consists merely in determining a meridian with the solar and comparing this indication with the true meridian established by other reliable method. The test should be repeated in a. m. and p. m. hours at

frequent intervals, and the noon observation should most certainly be taken every day that the solar is used.

The selection of the method of observation to establish the true meridian will be made by the engineer, the facts relative to which are to appear in the final field notes, and the solar attachment may be considered in satisfactory adjustment when all meridional tests during the usual hours of solar work are found to come within $1' 30''$ of the true meridian, whereupon the certificate of the engineer's examination of the adjustments of his instrument will take the following form:

Field record.	Final field notes.
Buff Solar Transl. No. 8028. Sun's declination at Greenwich noon $= 5^{\text{h}} 58^{\text{m}}$ a. m., local app. t. $= 18^{\circ} 32' 04''$ S. Diff. $10^{\text{h}}, -382''$ $= 6 22$ S. $3^{\text{h}} 58^{\text{m}}$ p. m. $= 18^{\circ} 38' 26''$ S.	Nov. 16, 1911, at my station in Sec. 35, T. 11 N., R. 6 E., 5th Prin. Mer., Arkansas, in latitude $35^{\circ} 32.9' N.$, as determined by the mean of altitude observations on the sun on Sept. 26 and 29, 1911, heretofore described, and longitude $90^{\circ} 25' W.$, I examine the adjustments of the instrument and correct all errors. I then test the solar apparatus by comparing its indications hourly with the true meridian established by Polaris observation Sept. 26, 1911, heretofore described. At $9^{\text{h}} 20^{\text{m}}$ a. m., app. t., I set off $35^{\circ} 33' N.$, on the lat. arc; $18^{\circ} 32'.5 S.$, on the decl. arc; and determine a meridian with the solar which I find to agree with the true meridian. At app. noon, with the lat. arc unchanged, I observe the sun on the meridian; the resulting reading of the decl. arc is $18^{\circ} 34'.5 S.$, which agrees with the computed declination of the sun. At $3^{\text{h}} 0^{\text{m}}$ p. m., app. t., with the lat. arc unchanged, I set off $18^{\circ} 36' S.$, on the decl. arc; and determine a meridian with the solar which I find to agree with the true meridian. As all of the solar observations during the usual hours of solar work come within $1' 30''$ of the true meridian, I conclude that the adjustments of the instrument are satisfactory.
* Adjust auxiliary telescope for collimation.	

THE SOLAR COMPASS.

82. The first solar instrument was designed in 1836 by William A. Burt, a United States surveyor, of Michigan. Since its intro-

duction the instrument has been extensively used in public-land surveying; the solar compass has given general satisfaction and is still used to some extent in the public-land surveys, but in recent years it has been largely superseded by the more complete instrument already described. The Burt solar apparatus is designed for mounting upon an open-sight compass, commonly used in the early public-land surveys. A polar axis is fitted in line with the terrestrial sights when the plate verniers are set at zero. The inclination of the polar axis is controlled by a latitude arc mounted in the same vertical plane. Normal to the polar axis there is a revolving arm upon which is mounted a declination arc and two solar lines of collimation, one for north declination of the sun, and one for south declination. Each line of collimation consists of a lens and silver plate or disk mounted upon opposite ends of the revolving arm; parallel equatorial lines are drawn upon each disk symmetrical with the axis of the opposite lens. Two adjustments are peculiar to the Burt solar compass, which are here given for the engineer's reference in the field; these adjustments should be made when the sun is within an hour of the meridian.

(1) *To make the solar lines of collimation parallel.*—The declination arm will be detached and replaced by an auxiliary frame upon which the arm will be laid. Set the latitude and declination arcs approximately correct for the hour, date and station, and bring the sun's image upon either disk as in an orientation to the meridian. Now turn the arm over, without reversing from end to end, and see if the sun's image again comes between the equatorial lines; if not, adjust the disk for half the difference and repeat the test until satisfactory. When this has been accomplished, reverse the arm from end to end for the purpose of adjusting the second disk with respect to the opposite lens. Remove the auxiliary frame and attach the declination arm in place.

(2) *To set the vernier of the declination arc.*—Set the declination vernier to read approximately zero, and bring the sun's image upon either disk as in an orientation to the meridian, changing the elevation of the polar axis as may be necessary to bring the solar line of collimation upon the sun. With the sun's image accurately between the equatorial lines, clamp all other motions and reverse the declination arm on the polar axis, thus bringing into use the second line of collimation. Note if the image of the sun is now squarely between the second pair of equatorial lines; if not, correct half the differ-

ence by movement of the tangent screw of the declination arc. Again orient in azimuth to bring the sun's image accurately between the equatorial lines, clamp and reverse as before, repeating the test until satisfactory. When the lines of collimation have thus been made truly at right angles to the polar axis, the vernier may be shifted to read zero in this position.

The general test of the Burt solar compass, by comparing its indications, resulting from solar observations made during a. m. and p. m. hours, with the true meridian determined by independent method, is similar to the test of the Smith solar attachment except in respect to the test of the latitude arc. No provision is made for independent adjustment of the latitude arc, and in the operation of the Burt solar compass the latitude is used as given by the instrument resulting from a meridian observation on the sun. In this respect therefore the noon observation with the Burt solar compass differs from the noon observation with the Smith solar attachment.

Example of noon observation with the Burt solar compass, in latitude $38^{\circ} 53' 40''$ N., and longitude $77^{\circ} 01.6'$ W.:

"May 6, 1910: At this station I set off $16^{\circ} 26'$ N., on the decl. arc; and, at apparent noon, observe the sun on the meridian; the resulting latitude is $38^{\circ} 54'$ N."

ERRORS IN AZIMUTH, DUE TO SMALL ERRORS IN DECLINATION OR LATITUDE.

83. It may frequently happen with a solar transit, especially at the beginning of a new survey or with an instrument insufficiently tested, that the first meridional trials are made with slight errors in the settings of the latitude and declination arcs, resulting in small errors in azimuth. This may be particularly true with a solar compass prior to a determination of the instrumental latitude. The correction of such errors has been provided for in Table 22, Standard Field Tables, which may be applied to results of single observations with considerable certainty, but not so well to a series of observations as in ordinary line work owing to the changing values (for hours from noon) of the correction coefficients. The explanation with the table gives a key to the direction of the azimuth errors on account of small errors in setting the latitude and declination arcs.

For example, at $9^h 40^m$ a. m., app. t., at a station in latitude assumed to be $46^{\circ} 20'$ N., a test was made with a solar transit whereby the trial indication was found to fall $0^{\circ} 05'$ west of the true meridian. Sub-

sequent determinations of the true latitude of the station and of the correctness of the vernier of the declination arc showed that the actual latitude of the station was $46^{\circ} 21'.5$ N., and that the vernier of the declination arc had an index error which gave readings $0^{\circ} 00'.5$ S. of the calculated declination (i. e. reading $15^{\circ} 19'.5$ N. for a calculated declination of $15^{\circ} 20'$ N.). Thus in the test the latitude arc was set $1'.5$ S. of the correct latitude of the station, and the declination arc was actually set $0'.5$ N. of the value that would have been set had the index error been known.

Table 22 is entered to obtain the correction coefficients:

Latitude.	Hours from noon.			
	2 ^h 0 ^m .	2 ^h 20 ^m .	3 ^h 0 ^m .	
45° 00'	2.83	2.55	2.00	Declination coefficient.
46 21.5	2.62	
50 00	3.11	2.81	2.20	
45 00	2.45	2.10	1.41	Latitude coefficient.
46 21.5	2.16	
50 00	2.60	2.31	1.56	

The corrections are then applied as follows:

Indication of solar in test = S. $0^{\circ} 05'.0$ W.

Correction for declination = 0 01.3 E. = (2.62×0.5)

Correction for latitude = 0 03.2 E. = (2.16×1.5)

Corrected indication of solar = S. $0^{\circ} 00'.5$ W.

The above corrections will often serve to explain the apparent errors of the solar, but these are not intended for use in line work, and can not be accepted in lieu of satisfactory subsequent tests based on correct values.

In the above connection it should be explained that it is not deemed desirable to burden the official record with evidence of correction for index errors found in the verniers of the latitude and declination arcs, other than to state, when such are determined, that the same are forthwith removed or are allowed for in subsequent observations.

POLARIS AT ELONGATION.

84. The engineer having thoroughly considered the theory and use of the solar instrument in its relation to the public-land surveys,

and presumably mastered its operation, his attention is now directed to the approved methods of observation to establish the true meridian with which to make comparisons of the indications of the solar apparatus as a necessary test of such an instrument, or without a solar instrument, the establishment of the true meridian from which to project transit lines and to test the calculated course thereof.

Of the various independent methods of observation to establish the true meridian, the simplest and most reliable is found in the observation upon Polaris at eastern or western elongation.

Azimuth of Polaris at elongation:

$$\sin A = \frac{\cos \delta}{\cos \phi}$$

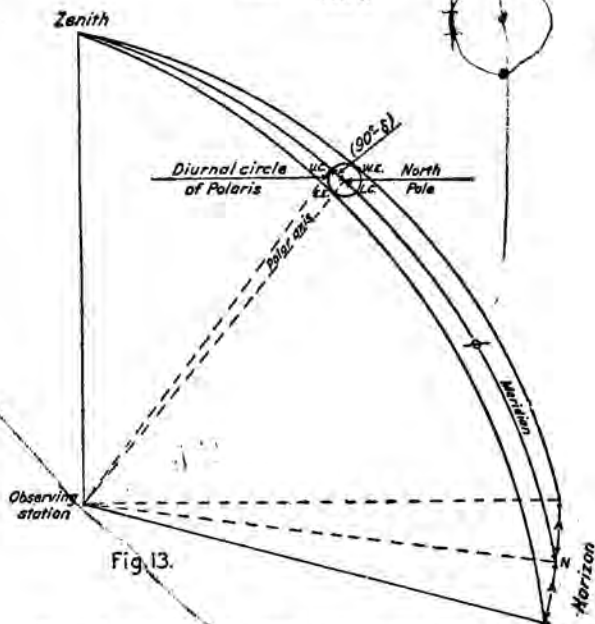


Fig. 13.

The meridian and vertical planes tangent to the diurnal circle of Polaris as viewed from outside of the celestial sphere.

Example of computing the azimuth of Polaris at elongation, October 20, 1910, in latitude $46^{\circ} 20' N.$, on which date the declination of Polaris= $88^{\circ} 49' 48'' N.$:

$$\log \cos \delta = 8.310033$$

$$'' \cos \phi = 9.839140$$

$$'' \sin A = 8.470893$$

$$A = \text{Azimuth of Polaris at elongation} = 1^{\circ} 41' 41''.$$

85. A table of azimuths of Polaris at elongation for latitudes from 25° to $70^{\circ} N.$, appears in the Ephemeris, arguments: declination of Polaris, and latitude of station.

Example in the use of the table of azimuths of Polaris at elongation, same date and station as above, showing the method of interpolation:

Latitude.	Declination.		
	$88^{\circ} 49' 40''$	$88^{\circ} 49' 48''$	$88^{\circ} 49' 50''$
	Azimuths at elongation.		
$46^{\circ} 00'$	$1^{\circ} 41' 15''$	$1^{\circ} 41' 04''$	$1^{\circ} 41' 01''$
$46 20$		$1 41 42$	
$47 00$	$1 43 08$	$1 42 57$	$1 42 54$

By interpolation in the table the required azimuth of Polaris at elongation is therefore found to be $1^{\circ} 41' 42''$.

86. An observation upon Polaris at elongation for azimuth consists in marking upon the ground a point to define the true line of sight to Polaris at the epoch of elongation, from which to lay off the true meridian. An equivalent process is to determine the true horizontal angle by deflection from a fixed reference point to Polaris at the epoch of elongation, by which to determine the true bearing of the reference point.

POLARIS AT ELONGATION, OBSERVING PROGRAM "a."

87. Select the observing station and make suitable provision to mark the line defining the direction of Polaris at elongation; the flag point should be from 5 to 10 chains N. of the transit point, and should be cleared of all obstruction before dark. Determine the local mean and watch time of elongation of Polaris, provide suitable

illumination for both the transit and flag point, and have everything in readiness as much as 15 minutes before the time of elongation.

Thoroughly level the transit.

About six minutes before elongation, with the telescope in direct position, bisect Polaris, note the watch time, and mark the direction of sight.

Reverse the transit, bisect Polaris, note the watch time, and mark the direction of sight.

Again level the transit.

With the telescope in the reverse position bisect Polaris, note the watch time, and mark the direction of sight.

Reverse the transit to the direct position of the telescope, bisect Polaris, note the watch time, and mark the direction of sight.

By daylight determine the mean (*a*) of the first and fourth sights, and (*b*) the mean of the second and third sights; then take the mean of points "*a*" and "*b*" to define the true direction of Polaris at elongation.

The mean of the four watch readings may be taken as the watch time of observation, which if within four or five minutes of correct watch time of elongation, the mean position of Polaris during the observation will be within 1'' or 2'' of true elongation. The proper value of the azimuth of Polaris at elongation having been taken from the table is then used to lay off the true meridian to the east for western elongation or to the west for eastern elongation.

The above program practically eliminates instrumental errors in observation. In laying off the azimuth of Polaris, the angle may be laid off directly, if desired, checked by the method of repetitions, and corrected if necessary; or the azimuth angle may be laid off by the natural tangent method; this should then be checked by reading the angle on the plates.

Example of observation of Polaris at elongation, observing program "*a*."

Field record.		Final field notes.		
Sept. 10, 1911, Gr. E. E. of Polaris, lat. 40° Red. to long. $111^{\circ} 45' W.$ Red. to lat. $43^{\circ} 22' 30'' N.$		Sept. 10, 1911, in camp at the standard cor. of Tps. 1 N., Rs. 39 and 40 E., Boise Mer., in latitude $43^{\circ} 22' 30'' N.$, and longitude $111^{\circ} 45' W.$, at $8^h 16.3^m$ p. m., l. m. t., I observe Polaris at eastern elongation, making four observations, two each with the telescope in direct and reversed positions, and mark the mean point in the line thus determined, on a peg driven firmly in the ground, 5 chs. N.		
	$-8^h 17.0^m$ p. m. -1.2 $+0.5$			
L. M. T. of E. E. of Polaris. Watch slow of l. m. t.		Azimuth of Polaris at eastern elongation— $1^{\circ} 36' 27''$.		
	$-8^h 16.3^m$ p. m. -1.7			
Watch time of E. E.		Sept. 11: I lay off the azimuth of Polaris, $1^{\circ} 36' 30''$, to the west, and mark the meridian thus determined, by a tack in a peg driven firmly in the ground, 5 chs. N.		
	$-8^h 14.6^m$ p. m.			
Telescope.	Watch Time.			
Direct.....	$8^h 08^m 26^s$ p. m.			
Reversed.....	8 11 20			
Reversed.....	8 14 34			
Direct.....	8 16 46			
Mean.....	$8^h 12^m 46^s$ p. m.			
Declination of Polaris— $88^{\circ} 49' 54'' N.$				
Latitude.	Declination.			
	$88^{\circ} 49' 50''$	$88^{\circ} 49' 54''$	$88^{\circ} 49' 60''$	
	Azimuth.			
	$43^{\circ} 00' 00''$	$1^{\circ} 35' 57''$	$1^{\circ} 35' 51''$	$1^{\circ} 35' 43''$
	$43^{\circ} 22' 30''$	1 36 27	1 36 27	
	$44^{\circ} 00' 00''$	1 37 33	1 37 27	1 37 19

The above program of observation of Polaris at elongation is the most convenient method where there is an opportunity to mark the direction of the line of sight. Occasionally conditions obtain where it is impossible to define or mark the direction of the observation; the program may then be altered to the reading of deflection angles as shown in the next method.

POLARIS AT ELONGATION, OBSERVING PROGRAM "b."

88. Select the observing station and mark a point by driving a tack in a peg driven firmly in the ground approximately in the true meridian as determined by the solar before sunset, or choose other suitable reference mark in any direction. The reference point should not be nearer to the transit than 5 chains distant. Deter-

mine the local mean and watch time of elongation of Polaris, provide suitable illumination for both the transit and flag point, and have everything in readiness as much as 10 minutes before the time of elongation.

Thoroughly level the transit.

About 6 minutes before elongation with the transit in direct position, read and note the deflection angle from the reference point to Polaris, noting also the watch time of observation.

Reverse the transit and read and note the deflection angle from the reference point to Polaris, noting also the watch time of observation.

Again level the transit.

With the transit in the reverse position again read and note the deflection angle from the reference point to Polaris and note the watch time of observation.

Reverse the transit to the direct position and again read and note the deflection angle from the reference point to Polaris, and note the watch time of observation.

As the position of Polaris remains within about $0^{\circ} 00' 01''$ of true elongation for a period of about five or six minutes either side of the time of exact elongation, the observation may be considered satisfactory if all of the watch readings fall within the stated period.

The mean of the four horizontal deflection angles may be taken to which must be applied the value of the azimuth of Polaris at elongation taken from the table, to obtain the true bearing of the reference flag, from which the true meridian may be laid off, or the flag may be used as a reference point.

A reference point in any direction may be used in the above method; the direction of the deflection from the reference point to Polaris should always be clearly stated. The insignificant figures of the final result may be discarded if the value of the bearing angle does not enter into another determination that demands great precision. In the example below the true meridian may be laid off by accurately measuring a distance from the reference point, at right angles to the line of sight, found by multiplying the distance from the instrument to the reference point (660 ft.) by the tangent of the bearing angle ($\text{nat tan } 0^{\circ} 00' 44'' = 0.00021$) which gives 0.14 ft. After laying off the true meridian the angle from the reference point may be checked by the method of repetitions.

Example of observation of Polaris at elongation, observing program "b":

Field record.			Final field notes.
Apr. 1, 1911, Gr. W. E. of Polaris, lat. 40°			April 1, 1911, in camp at the cor. of Tps. 5 and 6 N., Rs. 56 and 57 E., Prin. Mer., Montana, in latitude $46^{\circ} 13' N.$, and longi- tude $104^{\circ} 39' W.$, at $6^h 44.0^m$ p. m., l. m. t., I observe Polaris at western elongation, making four observations, two each with the telescope in direct and reversed positions, reading the deflection angle from a tack in a peg driven firmly in the ground, 10 chs. N., west to Polaris: Azimuth of Polaris at west- ern elongation — $1^{\circ} 41' 14''$ Mean deflection angle — $1\ 40\ 30$ True bearing of mark — $N.0^{\circ} 00' 44'' W.$
	— $6^h 46.1^m$ p. m.	— 1.1	
Red. to long. $104^{\circ} 39' W.$	— — 1.0		
" " lat. $46^{\circ} 13' N.$			
L. M. T. of W. E. of Polaris.	— $6^h 44.0^m$ p. m.		
Watch slow of L. M. T.	— — 2.9		
Watch time of W. E	— $6^h 41.1^m$ p. m.		
Telescope.	Watch time.	Deflection angle.	
Direct	$6^h 37^m 22^s$	$1^{\circ} 41' 00''$	
Reversed	$6\ 39\ 40$	$1\ 40\ 30$	
Reversed	$6\ 43\ 14$	$1\ 40\ 00$	
Direct	$6\ 45\ 30$	$1\ 40\ 30$	
Mean	$6^h 41^m 26^s$	$1^{\circ} 40' 30''$	
Declination of Polaris— $88^{\circ} 49' 58'' N.$			
Latitude.	Declination.		
	$88^{\circ} 49' 50''$	$88^{\circ} 49' 58''$	$88^{\circ} 49' 60''$
	Azimuth.		
	$1^{\circ} 41' 01''$	$1^{\circ} 40' 50''$	$1^{\circ} 40' 47''$
	$46\ 13$	$1\ 41\ 14$	
	$47\ 00$	$1\ 42\ 42$	$1\ 42\ 39$

89. Both of the above observing programs require the engineer to compute in advance the correct watch time of elongation, and in so conducting the observation the minimum period is consumed in the observing program; every opportunity is also thus afforded for reversals to eliminate instrumental errors and otherwise to introduce creditable refinement. However, should the watch error be unknown, the observation may be conducted by following the motion of Polaris in azimuth during an ample period preceding elongation to insure that the epoch of the vertical motion of Polaris in its diurnal circle,

or zero motion in azimuth, is taking place, when the engineer marks the direction of sight thus defined.

The rate of horizontal motion for the hour preceding elongation rapidly diminishes, the change in azimuth being to the west for western elongation, or to the east for eastern elongation, when Polaris will follow the vertical cross-wire, after which the motion is reversed at an accelerating rate. This suggests a third, but less refined, observing program.

POLARIS AT ELONGATION, OBSERVING PROGRAM "c."

90. Select the observing station and make suitable provision to mark the line defining the direction of Polaris at elongation; provide suitable illumination for both the transit and flag point, and have everything in readiness as much as an hour before the time of elongation.

Thoroughly level the transit.

Bisect Polaris and note that the motion of the star carries it away from the vertical wire in the proper direction. As long as this motion is discernible continue the bisection of Polaris by the tangent movement. When it can not be discerned in a period of several minutes that the least lateral motion is taking place mark the direction of sight upon the ground.

Reverse and level the transit.

Again bisect Polaris and mark the direction of sight upon the ground.

Verify the position of Polaris in its diurnal circle by again bisecting the star and without changing the tangent motion note the movement of Polaris; the motion should still be nearly vertical, with a scarcely discernible movement in the opposite horizontal direction.

By daylight determine the mean of the sights, and establish the meridian by properly laying off the correct azimuth as described in observing program "a."

AZIMUTH OF POLARIS AT ANY HOUR ANGLE.

91. While no more reliable method is at the command of the engineer for the establishment of the true meridian than the observation upon Polaris at elongation, yet the epoch of elongation may occur at a very inconvenient time and should Polaris be obscured by clouds at the time of elongation the observation must fail. The "hour angle" method admits of observation upon Polaris for azimuth at any time that the star is visible; the precise watch error local mean time must be known, but if this has been determined,

the hour angle method becomes at once the most convenient. The possible accuracy of the result compares favorably in every way with the refinement to be obtained in an observation at elongation.

The determination of the watch error local mean time and the calculation of hour angles having been fully treated on previous pages, it remains only to state that the record of the time observation should appear in the field notes with the record of all observations upon Polaris for azimuth by the hour angle method, as the azimuth observation is incomplete without the time determination. With the meridian observation of the sun for apparent noon, and the use of the azimuth tables contained in the Ephemeris, the entire process becomes so simple and yet so highly refined that the engineer should early become thoroughly familiar with the hour angle method.

92. *Azimuth of Polaris at any hour angle.*—"t"=sidereal hour angle in angular measure; in hour angles exceeding 90° the function " $-\sin \phi \cos t$ " becomes positive by virtue of the cosine of an angle between 90° and 270° being treated as negative in analytical reductions:

$$\text{Tan } A = \frac{\sin t}{\cos \phi \tan \delta - \sin \phi \cos t}$$

Example of computing the azimuth of Polaris, February 23, 1911, at a mean time hour angle of $2^h 37.4^m$, in latitude $33^\circ 20' N.$, on which date the declination of Polaris= $88^\circ 50' 08'' N.$:

Mean time hour angle	= $2^h 37.4^m$		
	= $2^h 37^m 24^s$	$2^h = 30^\circ$	
		$37^m = 9^\circ 15'$	
Red. to sidereal hour angle =	$+26^s 50^s$	=	$12' 30''$
Sidereal hour angle	= $2^h 37^m 50^s$	=	$39^\circ 27' 30''$
log cos ϕ	= 9.921940	log sin ϕ	= 9.739975
" tan δ	= 1.691944	" cos t	= 9.887666
" cos ϕ tan δ	= <u>1.613884</u>	" sin ϕ cos t	= <u>9.627641</u>
nat cos ϕ tan δ	= 41.104	nat sin ϕ cos t	= <u>0.424</u>
nat sin ϕ cos t	= <u>0.424 (-)</u>		
		log sin t	= 9.803127
Algebraic sum =	<u>40.680</u>	" 40.680	= <u>1.609381</u>
		" tan A	= <u>8.193746</u>
Azimuth of Polaris at above hour angle, A	= <u><u><u>$0^\circ 53' 42''$</u></u></u>		

93. A table of azimuths of Polaris at all hour angles, for latitudes from 30° to 50° N., appears in the Ephemeris, arguments: declination of Polaris, mean time hour angle, and latitude of station. For other than the latitudes given in the table the engineer will be required to solve the above equation.

Example in the use of the table of azimuths of Polaris at any hour angle, same date, hour angle and station as above, showing the method of interpolation:

Mean time hour angle.	Azimuth of Polaris.			Correction subtractive for dec- lination $+88^\circ 50' 10''$
	Mean declination. $+88^\circ 50' 05''$			
	Latitude.			
	32°	$33^\circ 20'$	34°	
$2^h 29.6^m$	50'.7	51'.5	51'.9	0'.1
37.4		53.8		0.1
39.6	53.5	54.4	54.8	0.1

By interpolation in the table the required azimuth of Polaris is therefore found to be $0^\circ 53'.8 - 0'.1 = 0^\circ 53' 42''$.

94. Example of computing the azimuth of Polaris, Sept. 11, 1911, at a mean time hour angle of $7^h 25.1^m$, in latitude $42^\circ 54' N.$, on which date the declination of Polaris = $88^\circ 49' 54'' N.$:

Mean time hour angle.....	$= 7^h 25.1^m$	$7^h = 105^\circ$	
	$= 7^h 25^m 06^s$	$26^m = 6^\circ 30'$	
Reduction to sidereal hour angle....	$= +1^m 13^s$	$19^s = 4' 45''$	
Sidereal hour angle.....	$= 7^h 26^m 19^s$	$= 111^\circ 34' 45''$	
$\log \cos \phi$	$= 9.864833$	$\log \sin \phi$	$= 9.832969$
" $\tan \delta$	$= 1.690496$	" $\cos t$	$= 9.565596$
" $\cos \phi \tan \delta$	$= 1.555329$	" $\sin \phi \cos t$	$= 9.398565$
nat $\cos \phi \tan \delta$	$= 35.919$	nat $\sin \phi \cos t$	$= .250$
" $\sin \phi \cos \delta$	$= .250(+)$	$\log \sin t$	$= 9.968441$
Algebraic sum	$= 36.169$	" 36.169	$= 1.558337$
		" $\tan A$	$= 8.410104$
Azimuth of Polaris at above hour angle, A			$= 1^\circ 28' 22''$

95. Example in the use of the table of azimuths of Polaris at any hour angle, same date, hour angle and station as above:

Mean time hour angle.	Azimuth of Polaris.			Correction additive for declination +88° 49'	
	Mean declination. +88° 50' 05''				
	Latitude.				
	42°	42° 54'	44°	60''	50''
7h 18.8m	87'.9	89'.2	90'.7	0'.1	0'.3
25.1		88'.2		0'.1	0'.3
28.8	86'.3	87'.5	89'.1	0'.1	0'.3

By interpolation in the table the required azimuth of Polaris is therefore found to be $1^{\circ} 28'.2 + 0'.2 = 1^{\circ} 28' 24''$.

96. An observation upon Polaris for azimuth by the hour angle method consists in marking upon the ground a point to define the true line of sight to Polaris at any convenient epoch, the watch error local mean time being known, from which line to lay off the true meridian. An equivalent process is to determine the true horizontal angle by deflection from a fixed reference point to Polaris at any convenient epoch, the watch error local mean time being known, by which to determine the true bearing of the reference point.

HOOR ANGLE OBSERVATION OF POLARIS, OBSERVING PROGRAM "a."

97. Select the observing station and make suitable provision to mark the line defining the direction of Polaris; the flag point should be from 5 to 10 chains north of the transit point; provide suitable illumination for both the transit and flag point.

Thoroughly level the transit.

With the telescope in the direct position, bisect Polaris, note the watch time, and mark the direction of sight.

Reverse the transit, bisect Polaris, note the watch time, and mark the direction of sight.

Again level the transit.

With the telescope in the reverse position bisect Polaris, note the watch time, and mark the direction of sight.

Reverse the transit to the direct position of the telescope, bisect Polaris, note the watch time, and mark the direction of sight.



By daylight determine the mean (*a*) of the first and fourth sights, and (*b*) of the second and third sights; then take the mean of

points "a" and "b" to define the true direction of Polaris at the epoch of the average of the watch times of observation.

Treat the reduction as one observation, applying the watch error to the average watch time of observation to obtain the correct local mean time of observation.

Enter the table in the Ephemeris or make the computation to determine the value of the azimuth of Polaris at the epoch of the observation with the stated arguments: declination of Polaris, mean time hour angle and latitude; this value is then used to lay off the true meridian to the east if Polaris is observed west of the meridian or to the west if Polaris is observed east of the meridian.

Example of hour angle observation of Polaris, observing program "a":

Field record.		Final field notes.
Meridian observation of the sun for apparent noon:		Oct. 5, 1910, in camp at the cor. of secs. 5, 6, 31, and 32, on the S. bdy. of T. 31 S., R. 42 W., 6th Prin. Mer., Colo., in latitude $37^{\circ} 17'.6$ N., and longitude $102^{\circ} 11'$ W., I make a meridian observation of the sun for apparent noon: Watch time of obsn. = $12^h 01^m 22^s$. Watch fast of l. m. t. = $12^m 47^s$.
$\phi = 37^{\circ} 18' N.$	$90^{\circ} 00'$	
$\delta = 4^{\circ} 36' S.$	$41^{\circ} 54'$	
$\phi + \delta = 41^{\circ} 54'$	$\nu = 48^{\circ} 06'$	
	Watch time.	
Sun's W. limb 	$-12^h 00^m 18^s$	
" E. " 	$-12^h 02^m 26^s$	
Watch time of app. noon	$-12^h 01^m 22^s$	
App. noon = $12^h 00^m 00^s$		
Equation of time = $-11^m 25^s$		
L. M. T. of apparent noon	$-11^h 48^m 35^s$	
Watch fast of l. m. t.	$12^m 47^s$	
Hour angle observation of Polaris:		
Telescope.	Watch time.	
Direct.....	$5^h 48^m 40^s$ p. m.	
Reversed.....	$5^h 49^m 49^s$	
Reversed.....	$5^h 51^m 36^s$	
Direct.....	$5^h 52^m 54^s$	
Mean.....	$5^h 50^m 45^s$ p. m.	
Watch fast of l. m. t.....	$-12^m 47^s$	
L. M. T. of obsn.....	$5^h 37^m 58^s$ p. m. $5^h 38.0^m$ p. m.	
		At the same station, at $5^h 38.0^m$ p. m., l. m. t., I make an hour angle observation on Polaris east of the meridian, making four observations, two each with the telescope in direct and reversed positions, and mark the mean point in the line thus determined, on a peg driven firmly in the ground, 8 chs. N.

Field record, con.				Final field notes, con.	
Gr. U. C. of Polaris, Oct. 6, 1910 = 0 ^h 32.7 ^m a. m.				Watch time of obsn., mean of four readings = 5 ^h 50 ^m 45 ^s p. m. Oct. 6, I lay off the azimuth of Polaris, 1° 25' 30", to the west, and mark the meridian thus determined, by a tack in a peg driven firmly in the ground, 8 chs. N.	
Red. to long, 102° 11' W. = - 1.1					
L. M. T., U. C. of Polaris, Oct. 6 = 0 ^h 31.6 ^m a. m.					
+ 12					
L. M. T. of obsn., Oct. 5 = 5 38.0 p. m.					
Hour angle of Polaris east of the meridian = 6 ^h 53.6 ^m					
Declination of Polaris = 88° 49' 42" N.					
Mean time hour angle.	Azimuth of Polaris.				Correction additive for declination +88° 49' 40"
	Mean declination. +88° 49' 45"				
	Latitude.				
	36°	37° 18'	38°		
6 ^h 48.9 ^m	84'.5	85'.9	86'.7	0'.1	
53.6		85'.4		0'.1	
58.9	83'.5	84'.9	85'.7	0'.1	
Azimuth of Polaris = 1° 25'.4 + 0'.1 = 1° 25' 30"					

HOOR ANGLE OBSERVATION OF POLARIS, OBSERVING PROGRAM "b."

98. Select the observing station and choose a suitable reference mark in any direction. The reference point should be at least 5 chains distant.

Thoroughly level the transit.

With the telescope in the direct position, read and note the horizontal angle from the reference point to Polaris, noting the watch time at the moment Polaris is properly bisected.

Reverse the transit and read and note the horizontal angle from the reference point to Polaris, noting the watch time at the moment Polaris is properly bisected.

Again level the transit.

With the telescope in the reverse position again read and note the horizontal angle from the reference point to Polaris, noting the watch time at the moment Polaris is properly bisected.

Reverse the transit to the direct position of the telescope and again read and note the horizontal angle from the reference point to Polaris, noting the watch time at the moment Polaris is properly bisected.

Treat the reduction as one observation, applying the watch error to the average watch time of observation to obtain the correct local mean time of observation.

The mean of the four horizontal deflection angles may be taken, to which must be applied the proper value of the azimuth of Polaris at the mean epoch of the observation, to give the true bearing of the reference flag, from which the true meridian may be laid off, or the flag may be used for a reference point.

Example of hour angle observation of Polaris, observing program "b":

Field record.				Final field notes.	
Hour angle observation on Polaris:				March 21, 1910, at a transit point in Washington, D. C., in latitude $38^{\circ} 53' 40''$ N., and longitude $77^{\circ} 1'.6$ W., I find by comparison with a Western Union telegraph clock that my watch is $1^m 22^s$ slow of 75th meridian standard time. At the same station at $6^h 19.9^m$ p. m., l. m. t., I make an hour angle observation on Polaris, west of the meridian, two each with the telescope in direct and reversed positions, reading the horizontal deflection angle from a flag pole about 20 chs. S., in the direction S-W-N to Polaris. Watch time of obsn. — $6^h 26^m 40^s$ p. m. Mean horizontal angle from Polaris to flag — $177^{\circ} 34' 15''$ N-W-S Azimuth of Polaris = $1\ 26\ 24$ W. True bearing of flag — N. $179^{\circ} 00' 39''$ W. — S. $0^{\circ} 59' 21''$ W.	
Telescope.	Horizontal angle from flag to Polaris.	Watch time.			
Direct.....	$177^{\circ} 34' 30''$	$6^h 23^m 37^s$ p. m.			
Reversed.....	$177\ 34\ 30$	$6\ 25\ 29$			
Reversed.....	$177\ 34\ 00$	$6\ 28\ 17$			
Direct.....	$177\ 34\ 00$	$6\ 30\ 17$			
Mean....	$177^{\circ} 34' 15''$	$6^h 26^m 40^s$ p. m.			
Watch slow of 75th mer. stand- ard time		+ 1 22			
Correction for longitude.....		— 8 6			
L. M. T. of obsn. Mar. 21, 1910—		$6^h 19^m 56^s$			
		$6^h 19.9^m$ p. m.			
Gr. U. C. of Polaris, same date.....		$-1^h 33.0^m$ p. m.			
Red. to long. $77^{\circ} 1'.6$ W.....		— 0.9 = $1\ 32.1$ p. m.			
Hour angle of Polaris west of the meridian		$= 4^h 47.8^m$			
Declination of Polaris		$= 88^{\circ} 49' 41''$ N.			
Mean time hour angle.	Azimuth of Polaris.			Correction additive for decli- nation $+88^{\circ} 49' 40''$	
	Mean declination. $+88^{\circ} 49' 45''$				
	Latitude.				
	38°	$38^{\circ} 54'$	40°		
$4^h 39.2^m$	84'.2	85'.3	86'.7	0'.1	
47.8		86.3		0.1	
49.2	85.4	86.5	87.9	0.1	
Azimuth of Polaris = $1^{\circ} 26'.3 + 0'.1 = 1^{\circ} 26' 24''$					

POLARIS AT SUNSET OR SUNRISE.

99. Polaris is conveniently observed for azimuth by the hour angle method at sunset or sunrise without artificial illumination. The preparation for the observation consists in computing in advance the approximate settings in azimuth and altitude in order to find Polaris, and the plan contemplates an approximate reference meridian: With the time of sunset or sunrise assumed as the time of observation, the hour angle " t " and azimuth " A " are ascertained in order to find the position of Polaris in azimuth; the position in altitude is found by the method indicated in section 133-A, the vertical angle being equal to the latitude of the station *plus* the primary adjustment when Polaris is above the pole, or *subtractive* when below, taking this value from the tabulation given in the Ephemeris.

Example of computation of the position of Polaris at sunset, May 6, 1911, at a station in latitude $47^{\circ} 20' N.$, and longitude $102^{\circ} 40' W.$:

From the Ephemeris the declination of the sun is found to be $16^{\circ} 18' N.$, and by entering Table 17, of the Standard Field Tables, the apparent time of sunset is found to be $7^h 15^m$ p. m.

Assumed time of obsn., May 6, 1911	=	7 ^h 15 ^m p. m.
Gr. U. C. of Polaris, May 6	=	10 ^h 33. 5 ^m a. m. +12
Red. to long. $102^{\circ} 40' W.$	-1. 1 =	10 32. 4 a. m.
	<hr style="width: 50%; margin: 0 auto;"/>	<hr style="width: 50%; margin: 0 auto;"/>
Assumed hour angle of Polaris west of the meridian	=	8 ^h 42. 6 ^m
Azimuth of Polaris, W.	≠	1 ^o 17'
Latitude of station = $47^{\circ} 20'$		<hr style="width: 50%; margin: 0 auto;"/>
Primary adjustment to the vertical angle elevation of Polaris, from the table = 46(-)		<hr style="width: 50%; margin: 0 auto;"/>
		<u><u>$v \neq 46^{\circ} 34'$</u></u>

Example of computation of the position of Polaris at sunset, November 6, 1911, at a station in latitude $47^{\circ} 20' N.$, and longitude $102^{\circ} 40' W.$:

From the Ephemeris the declination of the sun is found to be $15^{\circ} 44' S.$, and by entering Table 17, of the Standard Field Tables,

the apparent time of sunrise is found to be $7^h 12^m$ a. m., or of sunset $4^h 48^m$ p. m.

Gr. U. C. of Polaris, Nov. 6, 1911 $= 10^h 28.2^m$ p. m.
 Red. to long. $102^\circ 40' W.$ $= -1.1$

L. M. T. of U. C. of Polaris $= 10^h 27.1^m$ p. m.
 Assumed time of observation $= 4 48$ p. m.

Assumed hour angle of Polaris east of the meridian $= 5^h 39.1^m$

Azimuth of Polaris, E. $\neq 1^\circ 43'$

Latitude of station $= 47^\circ 20'$

Primary adjustment to the vertical angle elevation of Polaris, from the table $= 06 (+)$

$v \neq 47^\circ 26'$

Example of computation of the position of Polaris at sunrise, November 7, 1911, and same station as above:

Assumed time of obsn., Nov. 7, 1911 $= \left\{ \begin{array}{l} 7^h 12^m \text{ a. m.} \\ +12 \end{array} \right.$

L. M. T. of U. C. of Polaris, Nov. 6 $= 10 27.1$ p. m.

Assumed hour angle of Polaris west of the meridian $= 8^h 44.9^m$

Azimuth of Polaris, W. $\neq 1^\circ 16'$

Latitude of station $= 47^\circ 20'$

Primary adjustment to the vertical angle elevation of Polaris, from the table $= 46 (-)$

$v \neq 46^\circ 34'$

Thus at the above station in latitude $47^\circ 20' N.$, and longitude $102^\circ 40' W.$, to observe Polaris by the daylight method an approximate meridian should be established with the solar before sunset, then to find Polaris the following angles are set off:

	Horizontal angle.	Vertical angle.
Sunset May 6, 1911.....	$1^\circ 17' W.$	$46^\circ 34'$
Sunset Nov. 6, 1911.....	$1^\circ 43' E.$	$47^\circ 26'$
Sunrise Nov. 7, 1911.....	$1^\circ 16' W.$	$46^\circ 34'$

The above "settings" are merely approximations, but sufficiently close, however, to bring Polaris reasonably near the center of the field of the telescope where the star will be found in plain view; the telescope should be focused upon a distant object, otherwise, though Polaris may be practically at the center of the field, it might be out of focus and therefore not observable during daylight. When Polaris has been found the above settings have answered their purpose and the observation may proceed in accordance with either observing program "a" or "b" of the hour angle method, the final reductions to be based upon the precise details of the observation. During the reversals of the transit the settings should be made each time. The daylight hour angle method is particularly desirable because the observation, including all instrumental work, marking of points upon the ground, etc., is accomplished without artificial illumination, and sunset is usually a convenient time to devote to this field duty.

To recapitulate, the following general program will be found best adapted to the requirements of public-land surveying practice, and will be used most extensively:

Time: By meridian observation of the sun for apparent noon.

Latitude: By meridian altitude observation of the sun.

Azimuth, true meridian upon which to test the solar apparatus:
By hour angle observation on Polaris at sunset.

Azimuth, on line: By the solar transit properly adjusted to the true meridian.

ALTITUDE OBSERVATION OF THE SUN FOR AZIMUTH.

100. While the methods of observation upon Polaris for azimuth are unquestionably the most desirable in their relation to the theory and practice of public-land surveying, yet a very efficient alternative is found in direct altitude observations upon the sun for azimuth, with a number of equations at the disposal of the engineer to suit his convenience. During the shorter days of the year and even quite often at any season the engineer finds himself at a loss for time and suitable daylight hours in which to make the required tests of his solar attachment; conditions obtain making the required tests impossible if limited to a Polaris meridian in camp, without involving unreasonable delay. It is in such cases that a direct altitude observation upon the sun for azimuth, on the actual line of the survey, finds its most useful application. Presuming the engineer

at work with a standard instrument with solar attachment, the accuracy of its adjustments can, by this method, be readily tested at work on line at any suitable morning or afternoon hour, without appreciable loss of time. Under working conditions any line determined with the solar attachment may be used for reference purposes, while vertical and horizontal angles are recorded to the sun to obtain the necessary data for computing the true bearing of the established solar line. A series of three altitude observations upon the sun, each with the telescope in direct and reversed positions, are required to guard against error; these are readily made in 10 or 12 minutes, while the reductions may be made in the evening without loss of time from the line work.

Other difficulties in the nature of temporary disability of the solar attachment, and cloudy nights preventing Polaris observations, or other adverse conditions may sometimes obtain, during which periods, even for a few days, if the engineer is familiar with the method of direct altitude observation upon the sun for meridian, he can thus establish his lines and possibly realize a saving of the entire time of his party until the trouble is removed. To the engineers who have used this method little more needs to be said in its favor, but to those unfamiliar with it the suggestion is made to practice the observations and reductions until proficiency is attained, and in its application the reward will come many times during an average season's work.

Referring to the description of the standard instrument adopted by the General Land Office it will be noted that it is equipped with a full vertical circle, a colored glass shade in the dust shutter of the eye-piece, and a prismatic eye-piece; these are essential to rapid and accurate altitude observations upon the sun.

101. An altitude observation of the sun for azimuth consists in the simultaneous determination of the true vertical and horizontal angles to the sun's center, the horizontal angle being referred to a fixed point. With the true vertical angle to the sun's center, the declination of the sun, and the latitude of the station all known, one of the following equations is entered and a calculation made of the azimuth of the sun's center at the epoch of observation, as referred to the true meridian; the relation between the sun's calculated azimuth and the recorded angle to the sun's center gives the true bearing of the fixed reference point.

102. *Altitude observation of the sun for azimuth.*—Reverse the signs of “ δ ” for south declinations:

$$\tan \frac{1}{2} A = \sqrt{\frac{\cos \frac{1}{2} (\zeta + \phi + \delta) \sin \frac{1}{2} (\zeta + \phi - \delta)}{\cos \frac{1}{2} (\zeta - \phi - \delta) \sin \frac{1}{2} (\zeta - \phi + \delta)}}$$

The spherical angles “ ζ ”, “ ϕ ”, and “ δ ” appear in this equation combined as in the formula for the reduction of an altitude observation of the sun for apparent time, and when it is desired to reduce for both time and azimuth, the above equation for azimuth is to be preferred to any that follow.

103. *Altitude observation of the sun for azimuth.*—For south declinations the function “ $\sin \delta$ ” becomes negative by virtue of the sine of a negative angle being treated as negative in analytical reductions: If the algebraic sign of the result is positive the azimuth “ A ” is referred to the north point, but if negative, the azimuth “ A ” is referred to the south point:

$$\cos A = \frac{\sin \delta}{\cos \phi \cos h} - \tan \phi \tan h$$

The above equation is very convenient in reducing for azimuth only.

104. *Altitude observation of the sun for azimuth.*—To many surveyors the following equation is familiarly expressed directly in terms of the spherical triangle “pole-zenith-sun:” Reverse the sign of “ δ ” for south declinations:

$$\begin{aligned} \text{Pole to zenith} &= 90^\circ - \phi = \text{colat.}; \\ \text{Pole to sun} &= 90^\circ - \delta = \text{codecl.}; \\ \text{Zenith to sun} &= 90^\circ - h = \text{coalt.}; \\ S &= \frac{1}{2} \text{ sum of the three sides:} \end{aligned}$$

$$\cos \frac{1}{2} A = \sqrt{\frac{\sin S \sin (S - \text{codecl.})}{\sin \text{colat.} \sin \text{coalt.}}}$$

OBSERVING PROGRAM, MORNING.

105. Thoroughly level the transit.

With the telescope in direct position observe and record the horizontal deflection angle from a fixed reference point to the sun’s right limb, and the vertical angle to the sun’s upper limb; these observations must be simultaneous, at the epoch of which the sun will appear as indicated; note the watch time at the epoch of the observation: $\frac{1}{4}$

Reverse the transit.

Observe and record the horizontal deflection angle from the fixed reference point to the sun's left limb, and the vertical angle to the sun's lower limb; these observations must be simultaneous, at the epoch of which the sun will appear as indicated; note the watch time at the epoch of the observation: $\frac{p}{\perp}$

* The mean observed vertical and horizontal angles, and the mean watch time are to be used in the reduction; this program constitutes one complete altitude observation, which is repeated until a series of three complete direct and reversed observations are made.

OBSERVING PROGRAM, AFTERNOON.

106. In the afternoon the program is modified only as to the order in which the sun's limbs are observed, which is as follows:

First observation, telescope direct, observe the sun's right and lower limbs: $\frac{q}{\perp}$

Second observation, telescope reversed, observe the sun's left and upper limbs: $\frac{r}{\perp}$

107. By the above observing programs the horizontal and vertical angles in the direct positions of the telescope will be found of about the same numerical values as in the reversed position of the telescope, by reason of the sun passing in a direction that will carry it across the field of the telescope during the time taken in the reversal and second setting. Differential refraction is therefore practically eliminated, and it is desirable that the corresponding angles in the direct and reversed positions of the telescope be about the same rather than as far apart as would result in any other observing program.

The most suitable hour for this observation is when the sun is moving rapidly in altitude as compared with a relatively small change in azimuth. When the sun has been brought into about the proper position in the field of the telescope the observer by lateral motion of the horizontal tangent screw on the plates keeps the vertical wire tangent to the sun's right or left limb while the upper or lower limb of the sun by the direction of its motion gradually approaches the horizontal wire; at the epoch of proper tangency of the two limbs to the two wires the observation is completed by calling "time" and stopping all motion until the angles are recorded. It is very helpful for an assistant to read the time and to enter all records.

108. Example of direct altitude observation of the sun for azimuth, sun north declination, and both north and south of an east and west line:

Final field notes.

Aug. 2, 1909, at the cor. of Tps. 31 and 32 S., Rs. 43 and 44 W., 6th Prin. Mer., Colo., in latitude $37^{\circ} 17' .5$ N., and longitude $102^{\circ} 18' .6$ W., at 7h 30m. a. m., app. t., I set off $37^{\circ} 17' 30''$ N., on the lat. arc; $17^{\circ} 52'$ N., on the decl. arc; and determine a meridian with the solar, whence I turn 90° to the east and set a flag, about 20 chs. dist.; then to test this indication of the solar I make a series of three altitude observations of the sun for azimuth, each with the telescope in direct and reversed positions, observing opposite limbs of the sun, and reading the horizontal deflection angles from the flag to the sun:

Observation.	Telescope.	Sun.	Watch time.	Vertical angle.	Horizontal angle from flag to sun.
1st	Direct	d	7h 36 ^m 54 ^s	30° 05'	0° 08' 30'' to N.
"	Reversed...	p	7 38 15	29 48	0 33 00 " "
	Mean..	-----		29° 56' 30''	0° 20' 45'' to N.
2nd	Direct	d	7h 41 ^m 20 ^s	30° 58' 00''	0° 32' 00'' to S.
"	Reversed...	p	7 43 00	30 46 30	0 12 30 " "
	Mean..	-----		30° 52' 15''	0° 22' 15'' to S.
3rd	Direct	d	7h 52 ^m 00 ^s	33° 05' 00''	2° 11' 00'' to S.
"	Reversed...	p	7 53 48	32 53 30	1 50 00 " "
	Mean..	-----	7h 52 ^m 54 ^s	32° 59' 15''	2° 00' 30'' to S.

By 1st obsn. flag bears N. $89^{\circ} 58' 57''$ E.

By 2nd obsn. flag bears N. $89^{\circ} 58' 26''$ E.

By 3rd obsn. flag bears N. $89^{\circ} 58' 38''$ E.

Mean true bearing of flag N. $89^{\circ} 58' 40''$ E.

Indicated error of solar
attachment

1' 20''

Field record.

The declination of the sun for the mean period of the three observations = $17^{\circ} 51' 04''$ N.

The following reductions are made to obtain the true vertical angles of the above observations:

	1st obsn.	2nd obsn.	3rd obsn.
v	$=29^{\circ} 56' 30''$	$30^{\circ} 52' 15''$	$32^{\circ} 59' 15''$
Refraction	$= -1\ 40$	$-1\ 36$	$-1\ 28$
Parallax	$= +\ 8$	$+ 8$	$+ 8$
h	<u><u>$=29^{\circ} 54' 58''$</u></u>	<u><u>$30^{\circ} 50' 47''$</u></u>	<u><u>$32^{\circ} 57' 55''$</u></u>

The following examples of reduction are all by the equation:

$$\cos A = \frac{\sin \delta}{\cos \phi \cos h} - \tan \phi \tan h$$

$$\begin{array}{ll} \log \cos \phi = 9.900674 & \log \sin \delta = 9.486493 (+) & \log \tan \phi = 9.881708 \\ \text{" } \cos h = 9.937897 & \text{" } \tan h = 9.759970 & \end{array}$$

$$\begin{array}{ll} \underline{9.838571} & \underline{9.838571} & \log & \underline{9.641678} \end{array}$$

$$\log \quad 9.647922 \quad \text{nat}(-) \quad .43821$$

$$\text{nat}(+) .44455$$

$$(-) .43821$$

$$\cos A = (+) .00634$$

$$A = \text{True bearing of sun} = \text{N. } 89^{\circ} 38' 12'' \text{ E.}$$

$$\text{Angle from sun to flag} = (+) 0\ 20\ 45$$

$$\text{True bearing of flag} = \underline{\underline{\text{N. } 89^{\circ} 58' 57'' \text{ E.}}}$$

$$\begin{array}{ll} \log \cos \phi = 9.900674 & \log \sin \delta = 9.486493 (+) & \log \tan \phi = 9.881708 \\ \text{" } \cos h = 9.933763 & \text{" } \tan h = 9.776132 & \end{array}$$

$$\begin{array}{ll} \underline{9.834437} & \underline{9.834437} & \log & \underline{9.657840} \end{array}$$

$$\log \quad 9.652056 \quad \text{nat}(-) \quad .45482$$

$$\text{nat}(+) .44880 \quad (+) .44880$$

$$\cos A = (-) .00602$$

$$A = \text{True bearing of sun} = \text{S. } 89^{\circ} 39' 19'' \text{ E.}$$

$$\text{Angle from sun to flag} = (+) 0\ 22\ 15$$

$$\text{True bearing of flag} = \text{S. } 90^{\circ} 01' 34'' \text{ E.}$$

$$= \underline{\underline{\text{N. } 89^{\circ} 58' 26'' \text{ E.}}}$$

log cos ϕ = 9.900674	log sin δ = 9.486493(+)	log tan ϕ = 9.881708
" cos h = 9.923762		" tan h = 9.811941
9.824436	9.824436	log 9.693649
	log 9.662057	nat (-) .49391
	nat (+) .45926	(+) .45926
		cos A = (-) .03465
A = True bearing of sun	= S. 88° 00' 52" E.	
Angle from sun to flag	= (+) 2 00 30	
True bearing of flag	= S. 90° 01' 22" E.	
	= N. 89° 58' 38" E.	

The particular convenience of the above equation is noted in the fact that the functions "cos ϕ ", "tan ϕ ", and "sin δ " are constant throughout the entire reduction, the function " h " being the only variable.

109. The third of the above series is selected for an example of reduction by the equation:

$$\cos \frac{1}{2} A = \sqrt{\frac{\sin S \sin (S - \text{codecl.})}{\sin \text{colat.} \sin \text{coalt.}}}$$

90° - ϕ = 90° - 37° 17' 30"	= 52° 42' 30" = colat.	
90° - δ = 90° - 17° 51' 04" (+)	= 72 08 56 = codecl.	
90° - h = 90° - 32° 57' 55"	= 57 02 05 = coalt.	
	2 S = 181° 53' 31"	
	S = 90° 56' 45"	
	codecl. = 90° - δ = 72 08 56	
	S - codecl. = 18° 47' 49"	
log sin S	=	9.999941
" sin (S - codecl.)	=	9.508146
" sin colat.	= 9.900674	9.508087
" sin coalt.	= 9.923762	
	9.824436	9.824436
" cos ² $\frac{1}{2} A$	=	9.683651
" cos $\frac{1}{2} A$	=	9.841825
$\frac{1}{2} A$	=	45° 59' 35"
A = True bearing of sun	= N. 91° 59' 10" E.	
Angle from sun to flag	= (-) 2 00 30	
True bearing of flag	= N. 89° 58' 40" E.	

The above equation is as good as any for the reduction of one observation, but the reduction becomes laborious for a series of three observations.

110. The third of the above series is also selected for an example of reduction by the equation:

$$\tan \frac{1}{2} A = \sqrt{\frac{\cos \frac{1}{2} (\zeta + \phi + \delta) \sin \frac{1}{2} (\zeta + \phi - \delta)}{\cos \frac{1}{2} (\zeta - \phi - \delta) \sin \frac{1}{2} (\zeta - \phi + \delta)}}$$

$$h = 32^{\circ} 57' 55''$$

$$\zeta = 57^{\circ} 02' 05''$$

$$\phi = 37 \quad 17 \quad 30$$

$$\zeta + \phi = 94^{\circ} 19' 35''$$

$$\delta = 17 \quad 51 \quad 04 (+)$$

$$\zeta + \phi + \delta = 112^{\circ} 10' 39''$$

$$\frac{1}{2}(\zeta + \phi + \delta) = 56^{\circ} 05' 20''$$

$$\zeta + \phi = 94^{\circ} 19' 35''$$

$$\delta = 17 \quad 51 \quad 04 (+)$$

$$\zeta + \phi - \delta = 76^{\circ} 28' 31''$$

$$\frac{1}{2}(\zeta + \phi - \delta) = 38^{\circ} 14' 15''$$

$$\log \cos \frac{1}{2}(\zeta + \phi + \delta) =$$

$$\text{“ } \sin \frac{1}{2}(\zeta + \phi - \delta) =$$

$$\text{“ } \cos \frac{1}{2}(\zeta - \phi - \delta) = 9.999941$$

$$\text{“ } \sin \frac{1}{2}(\zeta - \phi + \delta) = 9.508152$$

$$9.508093$$

$$\log \tan^2 \frac{1}{2} A =$$

$$\text{“ } \tan \frac{1}{2} A =$$

$$\frac{1}{2} A = 45^{\circ} 59' 34''$$

$$A = \text{True bearing of sun} = \text{N. } 91^{\circ} 59' 08'' \text{ E.}$$

$$\text{Angle from sun to flag} = (-) 2 \quad 00 \quad 30$$

$$\text{True bearing of flag} = \text{N. } 89^{\circ} 58' 38'' \text{ E.}$$

$$\zeta = 57^{\circ} 02' 05''$$

$$\phi = 37 \quad 17 \quad 30$$

$$\zeta - \phi = 19^{\circ} 44' 35''$$

$$\delta = 17 \quad 51 \quad 04 (+)$$

$$\zeta - \phi + \delta = 37^{\circ} 35' 39''$$

$$\frac{1}{2}(\zeta - \phi + \delta) = 18^{\circ} 47' 50''$$

$$\zeta - \phi = 19^{\circ} 44' 35''$$

$$\delta = 17 \quad 51 \quad 04 (+)$$

$$\zeta - \phi - \delta = 1^{\circ} 53' 31''$$

$$\frac{1}{2}(\zeta - \phi - \delta) = 0^{\circ} 56' 45''$$

$$9.746561$$

$$9.791636$$

$$9.538197$$

$$9.508093$$

$$0.030104$$

$$0.015052$$

111. The above equation is as good as any for the reduction of one observation, but the reduction becomes laborious for a series of three observations. However, the advantage in using the above equation is found when it becomes desirable to reduce the observations for both time and azimuth.

Let it be required to reduce the third observation of the above series for time, making the reduction by the following equation:

$$\tan \frac{1}{2} t = \sqrt{\frac{\sin \frac{1}{2}(\zeta + \phi - \delta) \sin \frac{1}{2}(\zeta - \phi + \delta)}{\cos \frac{1}{2}(\zeta + \phi + \delta) \cos \frac{1}{2}(\zeta - \phi - \delta)}}$$

log sin $\frac{1}{2}(\zeta + \phi - \delta) =$		9.791636
“ sin $\frac{1}{2}(\zeta - \phi + \delta) =$		9.508152
		9.299788
“ cos $\frac{1}{2}(\zeta + \phi + \delta) =$	9.746581	
“ cos $\frac{1}{2}(\zeta - \phi - \delta) =$	9.999941	
	9.746502	9.746502
“ tan $^2 \frac{1}{2} t =$		9.553286
“ tan $\frac{1}{2} t =$		9.776643
“ $\frac{1}{2} t =$	$30^\circ 52' 34''$	
“ $t =$	$61^\circ 45' 08'' = 4^h 07^m 01^s$	

Apparent time of observation	$= 7^h 52^m 59^s$ a. m.
Equation of time	$= +6 05$
	Local mean time of observation $= 7^h 59^m 04^s$ a. m.
Watch time of observation	$= 7 52 54$
Watch slow of l. m. t.	$= 6^m 10^s$

112. Example of direct altitude observation of the sun for azimuth, sun south declination:

Final field notes.

March 18, 1910, at a transit point in Washington, D. C., in latitude $38^\circ 53' 40''$ N., and longitude $77^\circ 01'.6$ W., at $3^h 42^m$ p. m., app. t., I make a series of three altitude observations upon the sun for azimuth, each with the telescope in direct and reversed positions, observing opposite limbs of the sun, and reading the horizontal deflection angle from a flag pole about 20 chs. to the S., SW. to the sun:

Observation.	Telescope.	Sun.	Watch time.	Vertical angle.	Horizontal angle flag to sun.
1st....	Direct.....	☉	3 ^h 56 ^m 58 ^s	25° 20'	65° 00' to SW.
" ...	Reversed....	☽	3 58 48	25 31	64 45 " "
	Mean		3 ^h 57 ^m 53 ^s	25° 25' 30''	64° 52' 30'' " "
2nd....	Direct.....	☉	4 ^h 01 ^m 48 ^s	24° 28'	65° 56' " "
" ...	Reversed....	☽	4 03 10	24 44	65 36 " "
	Mean			24° 36' 00''	65° 46' 00'' " "
3rd....	Direct.....	☉	4 ^h 05 ^m 58 ^s	23° 44'	66° 44' " "
" ...	Reversed....	☽	4 07 30	23 57	66 26 " "
	Mean			23° 50' 30''	66° 35' 00'' " "

By 1st obsn. flag bears S. 1° 00' 02'' W.

" 2nd " " " S. 1 00 20 W.

" 3rd " " " S. 0 59 50 W.

Mean true bearing of flag = S. 1° 00' 04'' W.

Field record.

The declination of the sun for the mean period of the three observations = 1° 02' 16'' S.

The following reductions are made to obtain the true vertical angles of the above observations:

	1st obsn.	2nd obsn.	3rd obsn.
$v =$	25° 25' 30''	24° 36' 00''	23° 50' 30''
Refraction =	-2 00	-2 06	-2 10
Parallax =	+ 08	+ 08	+ 08
$h =$	<u>25° 23' 38''</u>	<u>24° 34' 02''</u>	<u>23° 48' 28''</u>

113. The first of the above series is selected for an example of reduction by the equation:

$$\text{Tan } \frac{1}{2}A = \sqrt{\frac{\cos \frac{1}{2}(\zeta + \phi + \delta) \sin \frac{1}{2}(\zeta + \phi - \delta)}{\cos \frac{1}{2}(\zeta - \phi - \delta) \sin \frac{1}{2}(\zeta - \phi + \delta)}}$$

$$h = 25^\circ 23' 38''$$

$$\zeta = 64^\circ 36' 22''$$

$$\phi = 38 \quad 53 \quad 40$$

$$\zeta + \phi = 103^\circ 30' 02''$$

$$\delta = 1 \quad 02 \quad 16 \quad (-)$$

$$\zeta + \phi + \delta = 102^\circ 27' 46''$$

$$\frac{1}{2}(\zeta + \phi + \delta) = 51^\circ 13' 53''$$

$$\zeta + \phi = 103^\circ 30' 02''$$

$$\delta = 1 \quad 02 \quad 16 \quad (-)$$

$$\zeta + \phi - \delta = 104^\circ 32' 18''$$

$$\frac{1}{2}(\zeta + \phi - \delta) = 52^\circ 16' 09''$$

$$\log \cos \frac{1}{2}(\zeta + \phi + \delta) =$$

$$\text{“ } \sin \frac{1}{2}(\zeta + \phi - \delta) =$$

$$\text{“ } \cos \frac{1}{2}(\zeta - \phi - \delta) = 9.988058$$

$$\text{“ } \sin \frac{1}{2}(\zeta - \phi + \delta) = 9.329724$$

$$9.317782$$

$$\log \tan^2 \frac{1}{2}A =$$

$$\text{“ } \tan \frac{1}{2}A =$$

$$\frac{1}{2}A = 57^\circ 03' 44''$$

$$A = \text{True bearing of sun} = \text{N. } 114^\circ 07' 28'' \text{ W.}$$

$$\text{Angle from sun to flag} = (+) 64 \quad 52 \quad 30$$

$$\text{True bearing of flag} = \text{N. } 178^\circ 59' 58'' \text{ W.}$$

$$= \text{S. } 1^\circ 00' 02'' \text{ W.}$$

$$\zeta = 64^\circ 36' 22''$$

$$\phi = 38 \quad 53 \quad 40$$

$$\zeta - \phi = 25^\circ 42' 42''$$

$$\delta = 1 \quad 02 \quad 16 \quad (-)$$

$$\zeta - \phi + \delta = 24^\circ 40' 26''$$

$$\frac{1}{2}(\zeta - \phi + \delta) = 12^\circ 20' 13''$$

$$\zeta - \phi = 25^\circ 42' 42''$$

$$\delta = 1 \quad 02 \quad 16 \quad (-)$$

$$\zeta - \phi - \delta = 26^\circ 44' 58''$$

$$\frac{1}{2}(\zeta - \phi - \delta) = 13^\circ 22' 29''$$

$$9.796697$$

$$9.898118$$

$$9.694815$$

$$9.317782$$

$$0.377033$$

$$0.188516$$

114. Let it also be required to reduce the first observation of the above series for time, making the reduction by the following equation:

$$\tan \frac{1}{2} t = \sqrt{\frac{\sin \frac{1}{2}(\zeta + \phi - \delta) \sin \frac{1}{2}(\zeta - \phi + \delta)}{\cos \frac{1}{2}(\zeta + \phi + \delta) \cos \frac{1}{2}(\zeta - \phi - \delta)}}$$

log sin $\frac{1}{2}(\zeta + \phi - \delta) =$	9.898118
“ sin $\frac{1}{2}(\zeta - \phi + \delta) =$	9.329724
	9.227842
“ cos $\frac{1}{2}(\zeta + \phi + \delta) =$	9.796697
“ cos $\frac{1}{2}(\zeta - \phi - \delta) =$	9.988058
	9.784755
	9.784755
log tan $2 \frac{1}{2} t =$	9.443087
“ tan $\frac{1}{2} t =$	9.721544
	9.721544
	$\frac{1}{2} t = 27^\circ 46' 29''$ $t = 55^\circ 32' 58'' = 3^h 42^m 12^s$
Apparent time of obsn.	= $3^h 42^m 12^s$ p. m.
Equation of time	= $+8 17$
Local mean time of obsn.	= $3^h 50^m 29^s$ p. m.
Watch time of obsn.	= $3 57 53$
Watch fast of l. m. t.	= $7^m 24^s$

75th meridian time of comparison with a Western

Union telegraph clock	= $4^h 30^m 00^s$ p. m.
Correction for longitude	= $-08 06$
L. M. T. of comparison	= $4 21 54$
Watch time of comparison	= $4 29 20$
Watch fast of l. m. t.	= $7^m 26^s$

115. The second observation of the above series is selected for an example of reduction by the equation:

$$\cos A = \frac{\sin \delta}{\cos \phi \cos h} - \tan \phi \tan h$$

log cos $\phi = 9.891149$	log sin $\delta = 8.257958$	(-) log tan $\phi = 9.906733$
“ cos $h = 9.958790$		“ tan $h = 9.660053$
9.849939	9.849939	log 9.566786
log	8.408019	nat (-) .36880
nat (-)	.02559	(-) .02559
		cos A = (-) .39439
A = True bearing of sun = S. $66^\circ 46' 20''$ W.		
Angle from sun to flag = (-) $65 46 00$		
True bearing of flag = S. $1^\circ 00' 20''$ W.		

116. The third observation of the above series is selected for an example of reduction by the equation:

$$\cos \frac{1}{2} A = \sqrt{\frac{\sin S \sin (S - \text{codecl.})}{\sin \text{colat.} \sin \text{coalt.}}}$$

$$90^\circ - \phi = 90^\circ - 38^\circ 53' 40'' = 51^\circ 06' 20'' = \text{colat.}$$

$$90^\circ - \delta = 90^\circ - 1^\circ 02' 16'' (-) = 91^\circ 02' 16'' = \text{codecl.}$$

$$90^\circ - h = 90^\circ - 23^\circ 48' 28'' = 66^\circ 11' 32'' = \text{coalt.}$$

$$2 S = 208^\circ 20' 08''$$

$$S = 104^\circ 10' 04''$$

$$\text{codecl.} = 90^\circ - \delta = 91^\circ 02' 16''$$

$$S - \text{codecl.} = 13^\circ 07' 48''$$

$$\log \sin S = 9.986585$$

$$\text{" } \sin (S - \text{codecl.}) = 9.356334$$

$$\hline 9.342919$$

$$\text{" } \sin \text{colat.} = 9.891149$$

$$\text{" } \sin \text{coalt.} = 9.961376$$

$$\hline 9.852525 \quad 9.852525$$

$$\log \cos^2 \frac{1}{2} A = 9.490394$$

$$\text{" } \cos \frac{1}{2} A = 9.745197$$

$$\frac{1}{2} A = 56^\circ 12' 35''$$

$$A = \text{True bearing of sun} = \text{N. } 112^\circ 25' 10'' \text{ W.}$$

$$\text{Angle from sun to flag} = (+) 66^\circ 35' 00''$$

$$\text{True bearing of flag} = \text{N. } 179^\circ 00' 10'' \text{ W.}$$

$$= \text{S. } 0^\circ 59' 50'' \text{ W.}$$

EQUAL ALTITUDE OBSERVATIONS OF THE SUN FOR MERIDIAN.

117. The true meridian may be established by the method of equal altitude observations of the sun. The observation is not well adapted to line work, but it possesses a certain usefulness in camp, in that the engineer may thus determine the true meridian by the sun with mere approximations as to time and latitude.

The fixation of the true meridian by this method depends upon the theory that the sun's center at equal altitudes occupies symmetrical positions in azimuth east and west of the meridian in the morning and in the afternoon except for the correction neces-

sary to be applied due to the change in the sun's declination in the interval between the a. m. and p. m. observations:

" dA_s ": Correction in azimuth in minutes of angular measure to be applied to the mean position in azimuth to obtain the true south point; the correction is to be applied to the east with a northerly hourly change in declination, or to the west with a southerly hourly change.

" $d\delta$ ": Change in declination of the sun from the a. m. to the p. m. observation, expressed in minutes of angular measure.

" (t_1+t_2) ": The sum of the hour angles from apparent noon, or the total watch time from the a. m. to the p. m. observation, expressed in angular measure.

$$dA_s = \frac{\frac{1}{2}d\delta}{\cos \phi \sin \frac{1}{2}(t_1+t_2)}$$

The symmetry of the equal altitude observation is maintained by observing opposite limbs in azimuth in the a. m. and p. m. observations, in connection with the same limb in vertical angle in both observations.

With " $\frac{1}{2}d\delta$ " and " $\frac{1}{2}(t_1+t_2)$ " calculated, the computation can be concluded by applying to " $\frac{1}{2}d\delta$ " the declination coefficient obtained by entering Table 22 of the Standard Field Tables, which gives coefficients for computing errors in azimuth due to small errors in declination, arguments: " ϕ " and " $\frac{1}{2}(t_1+t_2)$."

118. An equal altitude observation of the sun for azimuth consists in reading the horizontal deflection angles from a fixed reference point to opposite right or left limbs of the sun in a. m. and p. m. observations simultaneously with the same upper or lower limb at the epoch of equal vertical angle in both observations, from the record of which a calculation is made of the bearing of the reference point as referred to the true meridian. To guard against error the engineer is required to make a series of three equal altitude observations, taking the resulting mean. The most suitable a. m. and p. m. hours for this observation obtain when the sun is moving rapidly in altitude as compared with a relatively small change in azimuth.

EQUAL ALTITUDE OBSERVATIONS OF THE SUN, OBSERVING PROGRAM.

119. Select the observing station, or transit point, and a reference point preferably to the south, and not nearer than 5 or 10 chains distant.

Thoroughly level the transit for the a. m. observation.

Observe and record the horizontal deflection angle from the fixed reference point to the sun's right limb, and the vertical angle to the sun's lower limb; these observations must be simultaneous, at the epoch of which the sun will appear as indicated; note the watch time at the epoch of the observation: \perp

Thoroughly level the transit for the p. m. observation.

With the same vertical angle set off for the p. m. observation follow the sun's left limb until the sun's lower limb becomes tangent, as indicated, recording the watch time and horizontal deflection angle from the reference point: \perp

The above program constitutes one observation. A series of three observations are taken by three successive a. m. settings at intervals of about four or five minutes of time. In the p. m. the settings are of course made in the inverse order.

Consider each equal altitude observation separately and subtract the lesser horizontal angle from the greater and divide by two.

The mean of the three half-differences is then taken to determine the horizontal angle from the reference point to an *uncorrected* south point, this angle to be applied in a direction to equalize the south point between the two observed positions of the sun.

Compute the differential azimuth correction due to the change in the sun's declination from the mean period of the a. m. to the mean period of the p. m. observations, and apply this angle to the mean of the half-differences as stated above; the differential azimuth correction is to be applied to the east when the hourly change in the sun's declination is northerly or to the west when the hourly change in the sun's declination is southerly; the computed resultant angle indicates the bearing of the reference point referred to the true meridian.

The correct apparent times of the observations do not need to be known, as the function " $\frac{1}{2}(t_1+t_2)$ " equals one-half the time in hours and minutes, by the engineer's watch, from the a. m. to the p. m. observation.

The equal altitude observation may be modified by taking a p. m. observation one day followed by an a. m. observation the next, in which case the functions " $\frac{1}{2}d\delta$ " and " $\frac{1}{2}(t_1+t_2)$ " are to be computed for the period from the p. m. to the a. m. observation; and the differ-

ential azimuth correction, "*d A_s*", is then applied in the *opposite* direction.

120. Example of equal altitude observation of the sun for azimuth:

Final field notes.

May 3, 1913, at a transit point in Washington, D. C., in latitude $38^{\circ} 53' 40''$ N., and longitude $77^{\circ} 1'.6$ W., at $9^{\text{h}}27^{\text{m}}$ a. m. and $2^{\text{h}}33^{\text{m}}$ p. m., app. t., I make a series of three equal altitude observations upon the sun for azimuth, reading the horizontal deflection angle from a flag-pole about 20 chs. to the S., SE. in the a. m. to the sun's right limb, and SW. in the p. m. to the sun's left limb; equal vertical angles being taken to the sun's lower limb.

Observation.	Sun.	Watch time.	Vertical angle.	Horizontal angle flag to sun.
1st a. m.....	☉	9 ^h 29 ^m 25 ^s	48°28'00''	67°20'00'' to SE.
3d p. m.....	☉	2 41 40		65 28 30 to SW.
				1°51'30'' (Diff.)
2d a. m.....	☉	9 ^h 32 ^m 50 ^s	49°05'00''	66°29'30'' to SE.
2d p. m.....	☉	2 38 15		64 38 00 to SW.
Sum of hour angles.....		5 ^h 05 ^m 25 ^s		
Mean hour angle.....		2 ^h 32 ^m 42 ^s		1°51'30'' (Diff.)
3d a. m.....	☉	9 ^h 36 ^m 30 ^s	49°43'00''	65°34'30'' to SE.
1st p. m.....	☉	2 34 45		63 45 30 to SW.
				1°49'00'' (Diff.)

One-half differences, or bearing angles from uncorrected south point to flag:

By 1st obsn. = S. $0^{\circ} 55' 45''$ W.

" 2d " = S. $0 55 45$ W.

" 3d " = S. $0 54 30$ W.

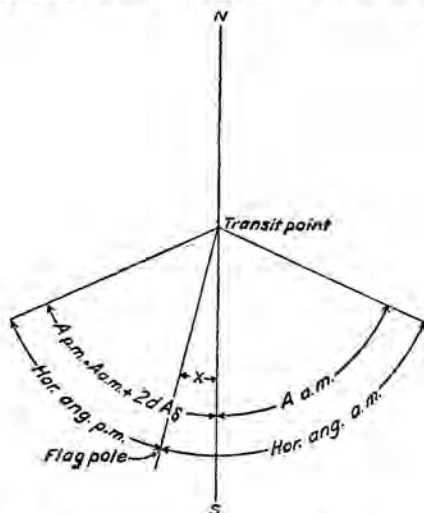
Mean = S. $0^{\circ} 55' 20''$ W.

Differential azimuth correction = (+) $3' 53''$

Mean true bearing of flag = S. $0^{\circ} 59' 13''$ W.

Field record.

The hourly change in the sun's declination = $44'' .3$ N.



$$\text{Hor. ang. a. m.} = A \text{ a. m.} + x = A + x$$

$$\text{Hor. ang. p. m.} = A \text{ p. m.} - x = A + 2dA\delta - x$$

$$\text{Hor. ang. a. m.} - \text{Hor. ang. p. m.} = 2x - 2dA\delta$$

$$x = \frac{\text{Hor. ang. a. m.} - \text{hor. ang. p. m.}}{2} + dA\delta$$

The following computation is made to obtain the differential azimuth correction for the above series:

$$\frac{1}{2} d\delta = \frac{1}{2} \times 5.08 \times 44.3 = 112''; \log \frac{1}{2} d\delta = 2.049218$$

$$\phi = 38^\circ 53' 40'' \text{ N.}; \log \cos \phi = 9.891149$$

$$\frac{1}{2} (t_1 + t_2) = 2^{\text{h}} 32^{\text{m}} 42^{\text{s}}$$

$$= 38^\circ 10' 30''$$

$$\log \sin \frac{1}{2} (t_1 + t_2) = 9.791034$$

$$\underline{\underline{9.682183}}$$

$$\underline{\underline{9.682183}}$$

$$\log dA\delta = 2.367035$$

$$dA\delta = \text{Differential azimuth correction} = 233''$$

$$= 3' 53''$$

121. The following reduction to obtain the value of the differential azimuth correction for the above series is made with the use of Table 22 of the Standard Field Tables:

Latitude.	$\frac{1}{2}(t_1+t_2)$, or hours from noon.		
	2 ^h	2 ^h 33 ^m	3 ^h
35° 00'	2.44	2.05	1.73
38 51		2.16	
40 00	2.61	2.19	1.85

Declination coefficient = 2.16

$d A_s = 2.16 \times \frac{1}{2} d\delta = 2.16 \times 112'' = 242''$

$d A_s =$ differential azimuth correction = 4' 02''

The small difference (09'') in the computation of " $d A_s$ " in the two processes of reduction is due to the error in adopting a coefficient obtained by linear interpolation in Table 22 of the Standard Field Tables, the tabular interval of which is large. Ordinarily the equal altitude method would be used when the latitude of the station is uncertain, and the slight error in using the declination coefficient taken by linear interpolation from Table 22 is small enough to be negligible.

122. The second a. m. and p. m. observations of the above series are selected for an example of reduction to the sun's center and direct computation of the sun's azimuth, and true bearing of the flag, by the equation:

$$\cos A = \frac{\sin \delta}{\cos \phi \cos h} - \tan \phi \tan h$$

Vertical angle to sun's lower limb = 49° 05' 00''

Reduction to sun's center = + 15' 54''

Refraction = - 49''

Parallax = + 06''

Sun's center, h = 49° 20' 11''

Declination of the sun at Greenwich apparent noon = $15^{\circ} 34' 37''$ N.

Diff. in time to a. m. obsn.:

For longitude = $5^{\text{h}} 08^{\text{m}}$

For time, a. m. = $-2 33$

$2.58^{\text{h}} = 2^{\text{h}} 35^{\text{m}}$

Diff. in declination to app. t. of a. m. obsn.:

$2.58 \times 44''.3 = 114'' = 1' 54''$ N.

Sun's decl. a. m. obsn. = $15^{\circ} 36' 31''$ N.

Diff. to p. m. obsn., already computed ($2 \times 112'' = 224''$) = $3' 44''$ N.

Sun's decl. p. m. obsn. = $15^{\circ} 40' 15''$ N.

a. m. obsn.

p. m. obsn.

$\log \cos \phi = 9.891149$ $\log \sin \delta = 9.429856(+)$ $\log \sin \delta = 9.431541(+)$

" $\cos h = 9.813992$

9.705141

9.705141

9.705141

" $\tan \phi = 9.906733$

$\log 9.724715$

$\log 9.726400$

" $\tan h = 0.065991$

nat (+) .53054

nat (+) .53260

$\log 9.972724$

nat (-) .93913

(-) .93913

(-) .93913

$\cos A =$

(-) .40859

(-) .40653

$A =$ true bearing of sun = S. $65^{\circ} 53' 02''$ E. S. $66^{\circ} 00' 47''$ W.

Horizontal angle from

flag to sun's right and

left limbs = $66^{\circ} 29' 30''$ to SE. $64^{\circ} 38' 00''$ to SW.

Reduction to sun's cen-

ter = $15.9'$

$\cos 49^{\circ} 20'$ = (+) $24' 24''$

(+) $24' 24''$

Hor. ang. to sun's center = $66^{\circ} 53' 54''$ to SE. $65^{\circ} 02' 24''$ to SW.

Sun's azimuth as com-

puted above = S. $65^{\circ} 53' 02''$ E. S. $66^{\circ} 00' 47''$ W.

True bearing of flag = S. $1^{\circ} 00' 52''$ W. S. $0^{\circ} 58' 23''$ W.

Mean true bearing of flag = S. $0^{\circ} 59' 37''$ W.

The discrepancy between the a. m. and p. m. results suggests a systematic instrumental error ordinarily eliminated by taking direct

and reversed observations, which in this instance is of opposite effect in a. m. and p. m. hours and apparently eliminated in the mean result.

123. One additional fact should be noted relative to the several reductions of the above equal altitude observations:

By above direct computation, A p. m. = $66^{\circ} 00' 47''$

A a. m. = $65^{\circ} 53' 02''$

Difference = $2dA\delta = 7' 45''$

$dA\delta = 3' 53''$

This value for $dA\delta$ ($3' 53''$) agrees with same function as first computed.

124. Upon concluding the subject of azimuth determinations it will be of interest to note that the weighted mean of a large number of observations gives a value of S. $0^{\circ} 59' 25''$ W. for the azimuth of the line from the Washington, D. C., transit point to the flag pole heretofore described. A comparison of the methods and results of the various observations as given on the preceding pages suggests that the engineer should seldom be without means by which accurately to determine time, latitude, and azimuth at any place in the field, however remote, and should doubt arise as to his results a "check" by independent method is nearly always available and a certain guide as to the accuracy of the determinations. It might be added that a careful engineer will not fail to surround his methods with adequate verification to insure the accuracy required in the execution of the public-land surveys.

THE TRUE PARALLEL OF LATITUDE.

125. The base lines and standard parallels of the rectangular system are established on the true parallel of latitude; the random latitudinal township boundary lines are also projected on the same curve; this curve is defined by a plane at right angles to the earth's polar axis cutting the earth's surface on a small circle. At every point on the true parallel the curve bears due east and west, the direction of the line being at right angles to the meridian at every point along the line. Two points at a distance of 20 chains apart on the same parallel of latitude may be said to define the direction of the curve at either point, without appreciable error, but the projection of a line so defined in either direction, easterly or westerly,

would describe a great circle of the earth gradually departing southerly from the true parallel. The great circle tangent to the parallel at any origin or reference point along the parallel is known as the "tangent to the parallel," and it is coincident with the true latitude curve only at the point of origin. The rate of the change of the azimuth of the tangent is a function of the latitude on the earth's surface. The azimuth of the tangent varies directly as the distance from the origin, and the offset distance from the tangent to the parallel varies as the square of the distance from the point of tangency. A great circle connecting two distant points on the same latitude curve has the same angle with the meridian at both points and the azimuth of such a line at the two points of intersection is a function of one-half the distance between the points.

There are three general methods of establishing a true parallel of latitude which may be employed independently to arrive at the same result: (1) The solar method; (2) the tangent method; and, (3) the secant method.

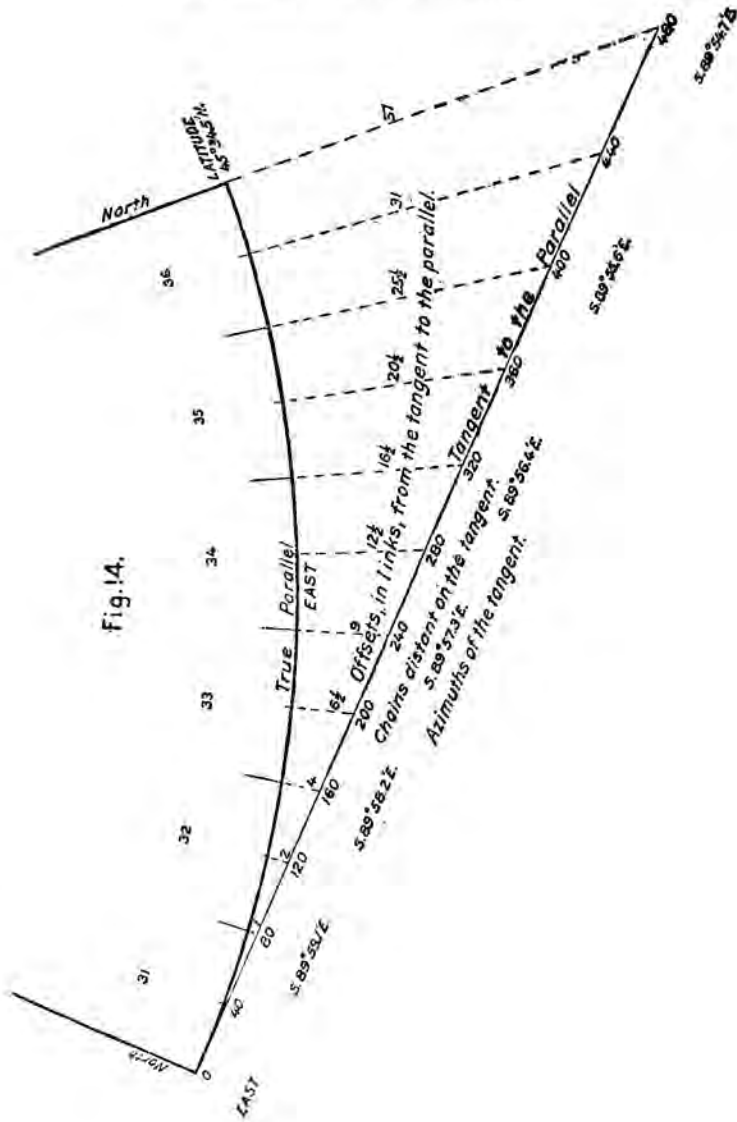
SOLAR METHOD.

126. The solar instruments are capable of following the true parallel of latitude without substantial offsets. If such an instrument, in good adjustment, is employed, the true meridian may be determined by observation with the solar at each transit point. A turn of 90° in either direction then defines the true parallel, and if sights are taken not longer than from 20 to 40 chains distant, the line so established does not appreciably differ from the theoretical parallel of latitude. The locus of the resulting line is a succession of points each one at right angles to the true meridian at the previous station. However, during a period each day the solar is not available, and during this time, also whenever the sun may be obscured by clouds, or on account of a disturbance of the adjustments of the solar attachment, and whenever an instrument without solar attachment is employed, reference must be made to a transit line from which to establish the true latitude curve by one of the following methods.

TANGENT METHOD.

127. The tangent method of determination of the true latitude curve consists in establishing the true meridian at the point of beginning, from which a horizontal deflection angle of 90° is turned to the east or west, as may be required, and the projection of the line thus determined is called the tangent. The tangent is projected 6

Fig. 14.



miles in a straight line, and as the measurements are completed for each corner point, proper offsets are measured north from the tangent to the parallel, upon which line the corners are established.

In Table 12, Standard Field Tables, are given the bearing angles or azimuths of the tangent to the parallel, referred to the true S. point, tabulated for any degree of latitude from 25° to 70° N., for the end of each mile from 1 to 6 miles. At the point of beginning the tangent bears east or west, but as the projection of the tangent is continued the deviation to the south increases in accordance with rules already stated.

In Table 13, Standard Field Tables, are shown the various offsets from the tangent north to the parallel, tabulated for any degree of latitude from 25° to 70° N., for each half mile from $\frac{1}{2}$ to 6 miles.

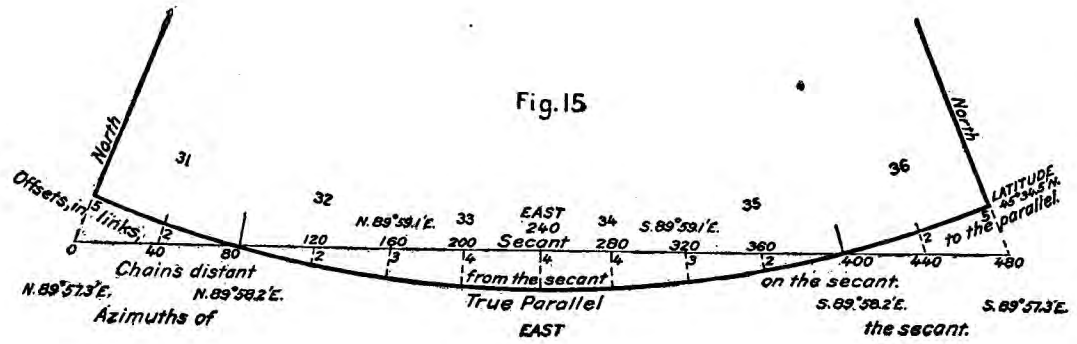
The accompanying diagram illustrates the establishment of a standard parallel in latitude $45^{\circ} 34'.5$ N., by the tangent method. (See Fig. 14.) The form of record is shown in the specimen field notes.

Objection to the use of the tangent method in a timbered country is found owing to the requirement that all blazing is to be made on the true surveyed lines. Also, all measurements to items of topography entered in the field notes are to be referred to the true established lines. These objections to the tangent method, on account of the increasing distance from the tangent to the parallel, are largely removed in the secant method.

SECANT METHOD.

128. The designated secant is a great circle which cuts any true parallel of latitude at the first and fifth mile corners, and is tangent to an imaginary latitude curve at the third mile point. From the point of beginning to the third mile corner the secant has a northeasterly or northwesterly bearing; at the third mile corner the secant bears east or west; and from the third to the sixth mile corners the secant has a southeasterly or southwesterly bearing, respectively, depending upon the direction of projection, east or west. From the point of beginning to the first mile corner and from the fifth to the sixth mile corners the secant lies south of the true parallel, and from the first to the fifth mile corners the secant lies north of the true parallel. It will thus be seen that the secant method is a mere modification of the tangent method, so arranged that the minimum offsets can be made from the projected transit line to the established true parallel of latitude.

Fig. 15



The secant method of determination of the true latitude curve consists in establishing the true meridian at a point south of the beginning corner a measured distance taken from the table, from which meridian the proper horizontal deflection angle, as taken from the table, is turned to the northeast or northwest to define the secant. The secant is projected 6 miles in a straight line, and as the measurements are completed for each corner point, proper offsets are measured, north or south, from the secant to the parallel, upon which parallel the corners are established.

In Table 14, Standard Field Tables, are given the bearing angles or azimuths of the secant, referred to the true N. point for the first 3 miles, and the same symmetrical bearing angles or azimuths referred to the true S. point for the last 3 miles, tabulated for any degree of latitude from 25° to 70° N., for the end of each mile from 0 to 6 miles.

In Table 15, Standard Field Tables, are shown the various offsets from the secant to the parallel, tabulated for any degree of latitude from 25° to 70° N., for each half mile from 0 to 6 miles.

The accompanying diagram illustrates the establishment of a standard parallel in latitude $45^{\circ} 34'.5$ N. by the secant method. (See Fig. 15.) The form of record is shown in the specimen field notes.

The secant method is recommended for its simplicity of execution and proximity to the true latitude curve, as all measurements and cutting by this method are substantially on the true parallel.

CONVERGENCY OF MERIDIANS.

129. The linear amount of the convergency of two meridians is a function of their distance apart, of the length of the meridian between two reference parallels, of the latitude, and of the spheroidal form of the earth's surface.

The following equation is convenient for the analytical computation of the linear amount of the convergency on the parallel, of two meridians any distance apart, and any length. The correction for convergency in any closed figure is proportional to the area, and may be computed from an equivalent rectangular area:

" m_{λ} ": Measurement along the parallel.

" m_{ϕ} ": Measurement along the meridian.

" a ": Equatorial radius of the earth = 3963.3 miles.

" e ": Factor of eccentricity, $\log e = 8.915\ 2515$.

" dm_λ ": Linear amount of the convergency on the parallel, of two meridians distance apart " m_λ ," and length " m_ϕ " along the meridian: " dm_λ ," " m_λ ," " m_ϕ " and " a " to be expressed in the same linear unit:

$$dm_\lambda = \frac{m_\lambda m_\phi}{a} \tan \phi \sqrt{1 - e^2 \sin^2 \phi}$$

Example of computation of the convergency of two meridians 24 miles long and 24 miles apart in a mean latitude of $43^\circ 20'$:

nat 1	=	1.0000000
log e	=	8.915 2515
" "	=	8.915 2515
" sin $43^\circ 20'$	=	9.836 477
" " " "	=	9.836 477
" $e^2 \sin^2 \phi$	=	7.503 457
nat " " "	=	0.0031875
" $(1 - e^2 \sin^2 \phi)$	=	0.9968125
log " " "	=	9.998 614
" $\sqrt{1 - e^2 \sin^2 \phi}$	=	9.999 307
" tan $43^\circ 20'$	=	9.974 720
" 24	=	1.380 211
" "	=	1.380 211
" 80*	=	1.903 090
" product	=	4.637 539
" 3963.3	=	3.598 057
" dm_λ	=	1.039 482
nat " "	=	10.9517 chs.

The convergency, measured on the parallel, of two meridians 24 miles apart and 24 miles long, in a mean latitude of $43^\circ 20'$, is therefore found to be 10.95 chains. The convergency of the east and west boundaries of a regular township in the same latitude would be equal to one-sixteenth of the convergency of the east and west boundaries of the quadrangle as computed above, or 68.44 links, which agrees with the value taken from Table 11 of the Standard Field Tables.

*This factor is introduced here for the purpose of conversion from the unit expressed in miles to the unit expressed in chains.

180. In Table 11, Standard Field Tables, are tabulated the linear amounts of the convergency of meridians, 6 miles long and 6 miles apart, for each degree of latitude from 25° to 70° N., together with the angle of convergency of the same meridians. These amounts of linear convergency are at once the proper corrections to apply to the north boundary of a regular township in the computation of the closing error around a township, or other computation by which a theoretical length of a north or south boundary of a township is compared with the length of the opposite boundary; the tabulated linear amounts of convergency are equal to double the amounts of the offsets from a tangent to the parallel at 6 miles for the same latitudes. Simple interpolation may be made for any intermediate latitude, and the amount of the convergency for a fractional township or other figure may be taken in proportion to the tabulated convergency as the fractional area is to 36 square miles.

The tabulated angle of convergency represents at once the deviation in azimuth of the tangent from the parallel at 6 miles; and $\frac{1}{6}$, $\frac{1}{8}$, $\frac{1}{2}$, $\frac{3}{8}$, and $\frac{5}{6}$ of the tabulated angles of convergency represent at once the amounts of the correction in the bearing of meridional section lines to compensate for convergency within a township.

In the same table are given the differences of longitude for 6 miles in both angular and time measure, also the differences of latitude, for 1 or 6 miles, in angular measure, in the various tabulated latitudes.

181. In the plan of subdivision of townships the meridional section lines are established parallel to the east boundary or other governing line; this necessitates a slight correction on account of the angular convergency of meridians. Meridional section lines west of the governing line are deflected to the left of the bearing of the governing line the amount shown in the second part of Table 2, Standard Field Tables, which is entered under two arguments: (1) Latitude, and (2) distance from the governing line. Meridional section lines east of a governing boundary are given the same amount of correction for bearing, but the deflection is made to the right.

LENGTHS OF ARCS OF THE EARTH'S SURFACE.

182. All computations involving a difference of latitude for a given measurement along a meridian or the converse calculation, or other computations involving a difference of longitude for a given measurement along a parallel or a similar converse calculation, are readily accomplished by the use of the values given in Table 16, Standard Field Tables; this table gives the lengths in miles and

decimal part of a mile of one degree of longitude measured on the parallel, and the lengths in miles of one degree of latitude measured on the meridian, for any latitude from 25° to 70° N.

The above tabulated values may be reduced to miles and chains, or to chains or feet, as convenient. In taking out lengths of degrees of longitude measured on the parallel an exact linear interpolation may be made, and in taking out lengths of degrees of latitude measured on the meridian the value should be taken out for the mean position in latitude of that portion of the meridian whose length it is desired to compute.

133. The first part of Table 2, Standard Field Tables, has been arranged for the reference of the latitude of any point within a township to the south boundary, the only argument being the miles and chains distant from the south boundary. Thus with the use of this table all observations for latitude within a township may be reduced to the south boundary; and conversely, given the latitude of the south boundary of a township, the latitude of any station within the township may readily be obtained by applying the difference given in the table for the known distance north.

HOOR ANGLE OBSERVATION OF POLARIS FOR LATITUDE.

133-A. Continuing subjects included in sections 73 to 76, inclusive, and sections 91 to 98, inclusive. The latitude may be determined by an altitude observation of Polaris at any hour angle. By this method the vertical angles are read in pairs, or double pairs, with reversals of the position of the telescope, and watch time noted at each setting. The watch correction is required, which will be applied to the mean (or average) of the watch readings to obtain the correct local mean time of observation for the pair or double pairs of settings. The mean time hour angle of Polaris at the epoch of observation is then taken out as in observations for azimuth, and the declination of Polaris for the date will be ascertained in the Ephemeris.

With the two values, mean time hour angle and declination, the latitude may be computed or there may be derived from the table in the Ephemeris the vertical angle equivalent for the position of Polaris above or below the earth's polar axis at the epoch of observation. The latter value is applied to the observed vertical angle, corrected for refraction, to secure the true elevation of the pole, or the *latitude* of the station. The method may be combined with the observation for azimuth, or it may be used independently.

The vertical angle reduction is tabulated in the Ephemeris in a simplified form in which the two principal arguments are employed to secure a primary adjustment to the elevation of the pole, subtractive when Polaris is above the pole and additive when below; a small supplemental correction is then secured from the table, with the arguments of mean time hour angle and observed altitude.

Example of hour angle observation of Polaris for latitude, making use of the table given in the Ephemeris:

Final field notes.

May 23, 1929, at station No. 1, in longitude $100^{\circ} 00' W.$, I make an hour angle observation of Polaris for latitude, reading two vertical angles, one each with the telescope in direct and reversed positions:

Mean observed vertical angle	35° 39' 30''
Mean watch time of observation, p. m.	7 ^h 41 ^m 12 ^s
Watch fast of l. m. t., determined by setting with a Western Union clock reading central standard time	40 ^m 00 ^s
Reduced latitude	36° 29' 48''

Field record.

Hour angle observation of Polaris for latitude:

Telescope.	Vertical angle.	Watch time.
Direct.....	35° 39' 00''	7 ^h 40 ^m 44 ^s p. m.
Reversed.....	35 40 00	7 41 40
Mean.....	35° 39' 30''	7 ^h 41 ^m 12 ^s p. m.
Watch fast of local mean time.....		40 00
L. M. T. of observation, May 23, 1929	=	7 ^h 01 ^m 12 ^s p. m.
	=	7 ^h 01.2 ^m p. m.
		+12
Gr. U. C. of Polaris, same date	= 9 ^h 33.2 ^m a. m.	
Red. to longitude $100^{\circ} 00'$	= -1.1	= 9 32.1 a. m.
Hour angle of Polaris west of the meridian	=	9 ^h 29.1 ^m
Declination of Polaris		+88° 55' 15''

Mean time hour angle.	Primary adjustment, additive, Polaris below the pole.			Mean obsd. δ .
	Declination.			ang., δ = 35° 39' 30''
				Corr. for refraction = -1 20
	+88° 55' 00''	+88° 55' 15''	+88° 55' 20''	$h = 35° 38' 10''$
9h 22.5m	0° 50' 46''	0° 50' 34''	0° 50' 30''	Primary adjustment to elev. of pole. + 0° 51' 42''
29.1		0 51 42		Supplemental corr. - 0 0 04
34.4	0 52 48	0 52 36	0 52 32	Latitude of station. = 36° 29' 48''

In order to proceed with the analytical reduction, it is convenient to begin with an angle α , computed from the equation:

$\tan \alpha = \frac{\tan \delta}{\cos t}$, in which equation the factor "cos t " becomes negative for hour angles exceeding 90°, whereupon α will exceed 90°.

The latitude may then be derived from the equation:

$$\cos (\phi - \alpha) = \frac{\sin \alpha \sin h}{\sin \delta}$$

The above example of a field observation is reduced as follows:

Mean time h. a.	9h 29.1m	log tan $\delta = 1.7249827$	log sin $\alpha = 9.9999513$
		" cos $t = 9.9004813$ (-)	" " $h = 9.7653968$
Red. to sidereal h. a.	+1.6	" tan $\alpha = 1.8245014$ (-)	9.7653481
Sidereal h. a.	<u>9h 30.7m</u>	" " $\delta = 9.9999230$	
		$\alpha = 90° 51' 30''$	
Same, red. to ang. meas.,	<u>$t = 142° 40' 30''$</u>		log cos ($\phi - \alpha$) = 9.7654251
		By inspection it will be seen that $\phi - \alpha$ is a negative angle.	$\phi - \alpha = -54° 21' 40''$ $\alpha = +90° 51' 30''$
		Latitude of station.....	$\phi = 36° 29' 50''$

CHAPTER III.

SYSTEM OF RECTANGULAR SURVEYS.

GENERAL SCHEME.

134. In the preceding chapters there has been outlined the system of nomenclature and procedure relating, in general terms, to the survey of the public domain. It is confidently assumed that the United States surveyor has become impressed with the purpose of his task and the stability and dignity which should be attached to a work so great and important, commensurate with its broad foundation in law and science.

For the purpose of disposal of the public domain the law provides, in general terms, for its description, subdivision and identification in conformity with the following general scheme:

1st. The township, 6 miles square, containing 36 sections, each 1 mile square.

2d. The numbering of the townships meridionally into a range and latitudinally into a tier, from which the necessity at once appears for the selection of independent initial points, each to serve as an origin for the extension of surveys synchronously needed in somewhat widely separated localities, to provide for which, principal or governing meridians and base lines have been established, to which might be related the surveys executed in each of such localities.

3d. The establishment of guide meridians and correction lines or standard parallels at intervals sufficiently near each other to maintain a practical workable adherence to the legal definition of the primary unit, the township 6 miles square, and at the same time to reduce to a minimum the number of corners required.

4th. The placing of fractional sections on the north and west boundaries of the township.

5th. The subdivision of the townships into 36 sections by running parallel lines through the township from south to north and from east to west at distances of 1 mile.

6th. The inflexible declaration of the integrity of the corners marked in the public surveys as the proper legal corners of the sections or of the subdivisions of the sections which they were intended to

designate, together with the equally important provisions (a) that the boundary lines actually run and marked shall be and remain the proper boundary lines of the sections or subdivisions for which they were intended; (b) that the length of such lines as returned by the surveyors shall be held as the true length thereof; and (c) that the sections shall be subdivided by running straight lines from the established quarter-section corners to the opposite established quarter-section corners.

135. The townships will be numbered to the north or south commencing with number 1 at the base line, and with range numbers to the east or west beginning with number 1 at the principal meridian.

The 36 sections into which a township is subdivided are numbered commencing with number 1 in the northeast section of the township, proceeding thence west to section 6, thence south to section 7; thence east to section 12, and so on, alternately, to number 36 in the southeast section. In the case of fractional townships, the sections will bear the same numbers they would have had if the townships were full, that is to say the section numbers should be employed which are the proper section numbers relating to the sides which are the governing boundaries, leaving any deficiency to fall on the opposite sides.

136. The specimen field notes will serve to illustrate the method of running lines to form quadrangles 24 miles square; the method of running the exterior lines of townships; and the method of subdividing regular townships. The methods here presented are designed to insure a full compliance with every practicable requirement, meaning and intent of the surveying laws.

137. By the terms of the original law and by general practice section lines are surveyed from south to north and from east to west, in order uniformly to place excess or deficiency of measurement on the north and west sides of the townships. For convenience the exterior lines on which subdivisions are based are called the governing boundaries. In unusual cases the north and west boundaries may be employed to govern the subdivision of a township, and in extreme cases an irregular township may be without even a single governing boundary.

INITIAL POINTS.

138. Initial points from which the lines of the public surveys are to be extended will be established whenever necessary, under such special instructions as may be prescribed in each case by the Com-

missioner of the General Land Office. The initial points are to be selected with a view to their control of extensive agricultural areas within reasonable geographical limitations. Upon the establishment of an initial point, the position of the point in latitude and longitude is to be determined by accurate field astronomical methods.

During the period since the organization of the system of rectangular surveys numbered and locally named principal meridians and base lines have been established as shown by the accompanying tabular exhibit. These bases and meridians may be found by examining the large wall map of the United States published by the General Land Office; they are also shown upon the various official State maps, and upon a special map entitled "United States, Showing Principal Meridians, Base Lines and Areas Governed Thereby."

139. The latitudes and longitudes given in the following table are based upon the best obtainable information, but in some cases the values shown are only approximately correct owing to the fact that many of the initial points were fixed in position and the surveys therefrom largely completed before the same importance was attached to the matter of accurate latitudes and longitudes as at the present time. It may also be noted, by way of explanation, that present-day facilities for accurate field astronomical determinations were not available to the early surveyors. It is not expected that the values of the latitudes given in the table will be used as the basis of the calculation of the latitude of an unknown station, in lieu of a field determination thereof, except as an approximate value may satisfy all requirements. The coördinates of the earliest surveys in Ohio can not be conveniently tabulated, but they are shown upon the maps as stated above.

PRINCIPAL MERIDIAN.

140. This line shall conform to the true meridian and will be extended from the initial monument, either north or south, or in both directions, as the conditions may require; regular quarter-section and section corners will be established alternately at intervals of 40 chains, and regular township corners at intervals of 480 chains; meander corners will be established at the intersection of the line with all meanderable bodies of water.

141. In the survey of the principal meridian and the other *standard lines* (base lines, standard parallels and guide meridians), hereinafter described, two independent sets of measurements will

MERIDIANS AND BASE LINES OF THE UNITED STATES RECTANGULAR SURVEYS.

Meridians.	Governing surveys (wholly or in part) in States of—	Longitude of principal meridians west from Greenwich.			Latitude of base lines north from Equator.		
		°	'	"	°	'	"
Black Hills.....	South Dakota.....	104	03	00	44	00	00
Boise.....	Idaho.....	118	24	15	43	22	31
Chickasaw.....	Mississippi.....	89	15	00	34	59	00
Choctaw.....	do.....	90	14	45	31	54	40
Cimarron.....	Oklahoma.....	103	00	00	36	30	00
Copper River.....	Alaska.....	145	18	42	61	49	11
Fairbanks.....	Alaska.....	147	38	33	64	51	49
Fifth Principal.....	Arkansas, Iowa, Minnesota, Missouri, North Dakota, and South Dakota.	91	03	42	34	44	00
First Principal.....	Ohio and Indiana.....	84	48	50	41	00	00
Fourth Principal.....	Illinois ¹	90	28	45	40	00	30
Do.....	Minnesota and Wisconsin.....	90	28	45	42	30	00
Gila and Salt River.....	Arizona.....	112	18	24	33	22	33
Humboldt.....	California.....	124	07	11	40	25	04
Huntsville.....	Alabama and Mississippi.....	80	34	45	35	00	00
Indian.....	Oklahoma.....	97	14	30	34	30	00
Louisiana.....	Louisiana ²	92	24	15	31	00	00
Michigan.....	Michigan and Ohio.....	84	22	24	42	26	30
Mount Diablo.....	California and Nevada.....	121	54	48	37	51	30
Navajo.....	Arizona and New Mexico.....	108	32	45	35	45	00
New Mexico Principal.....	Colorado and New Mexico.....	106	53	40	34	15	25
Principal.....	Montana.....	111	38	50	45	46	48
Salt Lake.....	Utah.....	111	54	00	40	46	04
San Bernardino.....	California.....	116	56	15	34	07	10
Second Principal.....	Illinois and Indiana.....	86	28	00	38	28	20
Seward.....	Alaska.....	149	21	53	60	07	25
Sixth Principal.....	Colorado, Kansas, Nebraska, South Dakota, and Wyoming.	97	23	00	40	00	00
St. Helens.....	Louisiana.....	91	09	15	31	00	00
St. Stephens.....	Alabama and Mississippi.....	88	02	00	31	00	00
Tallahassee.....	Florida.....	84	16	42	30	28	00
Third Principal.....	Illinois.....	89	10	15	38	28	20
Uintah.....	Utah.....	109	57	30	40	25	20
Ute.....	Colorado.....	108	33	20	39	08	40
Washington.....	Mississippi.....	91	09	15	31	00	00
Willamette.....	Oregon and Washington.....	122	44	20	45	31	00
Wind River.....	Wyoming.....	108	48	40	43	01	20

¹ The numbers are carried to fractional township 29 north in Illinois, and are repeated in Wisconsin, beginning with the south boundary of the State; the range numbers are in regular order.

² Latitude doubtful; is to be verified.

MEMO.: The east boundary of the State of Ohio, known as "Ellicott's Line," in longitude 80° 32' 20", was employed as the first reference meridian, with township numbers counting from the Ohio River and range numbers in regular order. The township and range numbers within the United States military land in Ohio are counted from the south and east boundaries of the tract.

be employed, unless subdivisational closings thereon are provided in the same assignment with the standard line, in which case the closings will furnish a satisfactory verification of the length of the lines thus surveyed. Where such closings are not to be made during the progress of the same survey, the proper supervising officer will provide suitable instructions for the employment of a second set of chainmen, or for the duplication of the measurement by the one set of chainmen. In either case, where two independent sets of measurements are employed, the distance to the mean point, and the difference between the measurements to each corner established, will be shown in the field notes; a form of record is given in the specimen field notes.

142. Should the difference between the two sets of measurements of any standard line, as above provided, exceed 20 links per 80 chains, it is required that the line be remeasured to reduce the difference, the final measurement of the line only to be shown in the field notes. Should the successive independent tests of the alinement of any standard line, or the average tests of the solar attachment employed in the projection thereof, indicate that the line has deflected from the true cardinal course to exceed $3' 00''$, the necessary corrections will be made to reduce the deviation in azimuth, the field notes of the true line only being shown. Every reasonable effort will be exercised to insure the accuracy of both the alinement and the measurement of the standard lines, and the stated discrepancies are the maximum that will be allowed in new surveys; corrective steps will be required where the differences are beyond the maximum.

BASE LINE.

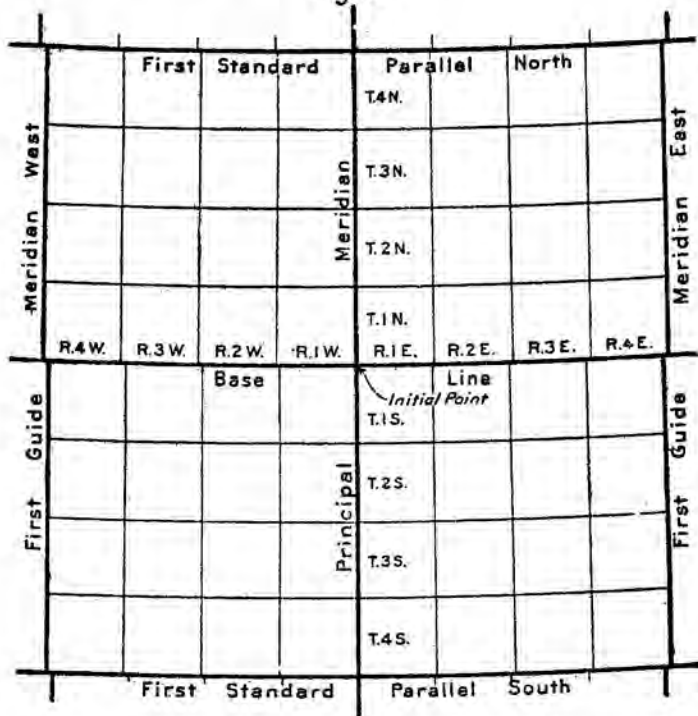
143. From the initial monument the base line will be extended east and west on a true parallel of latitude; upon the true line standard quarter-section and section corners will be established alternately at intervals of 40 chains, and standard township corners at intervals of 480 chains; meander corners will be established at the intersection of the line with all meanderable bodies of water.

The manner of making the measurement of the base line and the accuracy of both the alinement and measurement will be the same as required in the survey of the principal meridian. Any one of the methods heretofore set forth for the determination of the alinement of the true latitude curve may be used as existing conditions may require and the detailed process will be fully stated in the field notes.

STANDARD PARALLELS.

144. Standard parallels, which are also called correction lines, are extended east and west from the principal meridian, at intervals of 24 miles north and south of the base line, in the manner prescribed for the survey of the base line.

Fig. 16.



Illustrating the survey of quadrangles each embracing 16 townships bounded by standard lines, and showing the coordinate system of numbering the townships.

145. Where standard parallels have been placed at intervals of 30 or 36 miles, under practice then permissible, and present conditions require additional standard lines from which to initiate new, or upon which to close the extension of old surveys, an intermediate

correction line should be established to which a local name may be given, e. g., "Fifth Auxiliary Standard Parallel North," or "Cedar Creek Correction Line," etc., and the same will be run, in all respects, like a regular standard parallel.

GUIDE MERIDIANS.

146. Guide meridians are extended north from the base line, or standard parallels, at intervals of 24 miles east and west from the principal meridian, in the manner prescribed for running the principal meridian. Under all conditions the guide meridians will be terminated at the points of their intersections with the standard parallels; the guide meridian is to be projected on the true meridian and the fractional measurement is to be placed in the last half mile. At the true point of intersection of the guide meridian with the standard parallel a closing township corner is to be established; the parallel will be retraced between the first standard corners east and west of the point for the closing corner, in order to determine the exact alinement of the line closed upon, and the distance will be measured and recorded to the nearest corner on said standard parallel.

147. When existing conditions require that such guide meridians shall be run south from the base or correction lines, they will be initiated at the theoretical point for the closing corner of the guide meridian, which will be calculated on the basis of the survey of the line from south to north initiated at the proper standard township corner. At the theoretical point of intersection a closing township corner will be established.

148. Where guide meridians have been placed at intervals exceeding the distance of 24 miles, and new governing lines are required in order to limit the errors of the old or to control new surveys, a new guide meridian will be established, and a local name may be assigned to the same, e. g., "Twelfth Auxiliary Guide Meridian West," or "Grass Valley Guide Meridian," etc. These auxiliary guide meridians will be surveyed in all respects like regular guide meridians.

149. The above scheme covers the controlling lines contemplated under the rectangular system, and results regularly in the survey of quadrangles bounded on the north and south by true parallels of latitude, and on the east and west by true meridians, 24 miles apart. One exception may now be noted which will be found to depart

from former practice, that is, where a guide meridian is carried forward at a time when uncertainty exists as to how the exterior and subdivisional surveys to the east may close upon it, the corners upon the same will be marked only for the surveys to the west.

TOWNSHIP EXTERIORS.

REGULAR ORDER.

150. The controlling factors to be recognized in the establishment of new township boundary lines are found in the relation of these lines to the new subdivisional surveys which are to be executed. The south and east boundaries are normally the governing lines of the subdivisional surveys. Defective conditions which may be found in previously established exteriors can not be eliminated where subdivisional lines have been initiated from or closed upon an old boundary, but the errors of the former surveys are not to be incorporated into the new, and where the previously established south and east boundaries can not on that account be used to govern the subdivision of the adjoining township, other controlling lines known as the sectional correction line and the sectional guide meridian, hereinafter described, will be employed as expedient. A new meridional township exterior is normally the governing boundary of the township to the west, and a new latitudinal township exterior is normally the governing boundary of the township to the north; any new boundary should therefore be established with full consideration for its control upon the subdivisional surveys thereafter to be executed.

151. Whenever practicable the township exteriors will be surveyed successively through a quadrangle in ranges of townships, beginning with the townships on the south. The meridional boundaries of the townships will have precedence in the order of survey and will be run from south to north on true meridians; quarter-section and section corners will be established alternately at intervals of 40 chains, and meander corners at the intersection of the line with all meanderable bodies of water; a temporary township corner will be set at a distance of 480 chains, pending a determination of the controlling factor upon which its final position will be governed, whereupon the temporary point will be replaced by a permanent corner in proper latitudinal position. The latitudinal township boundary will be run first as a random line, setting temporary corners, on a cardinal course, from the old toward the new meridional boundary, and corrected back on a true line if ideal conditions are

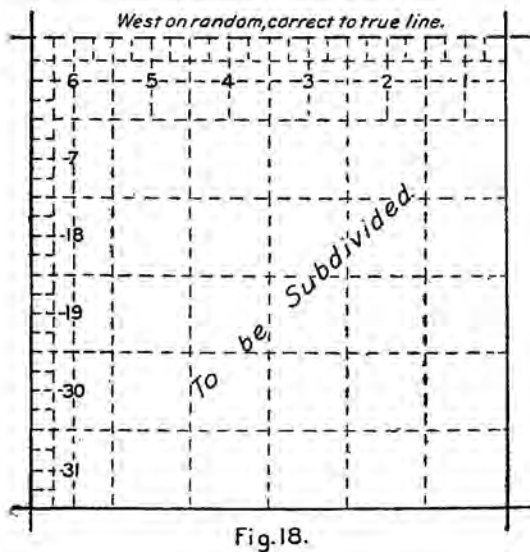
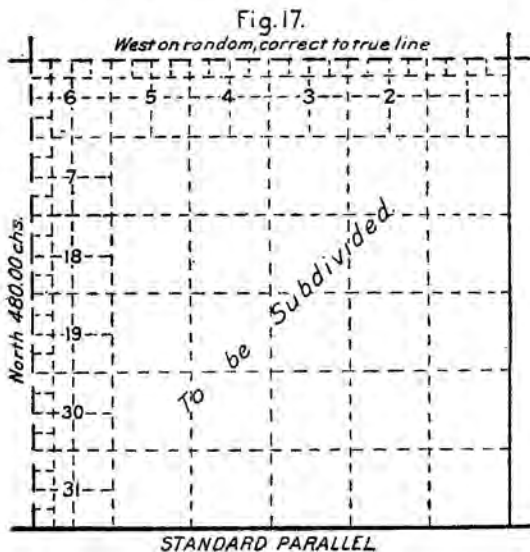


Fig. 19.

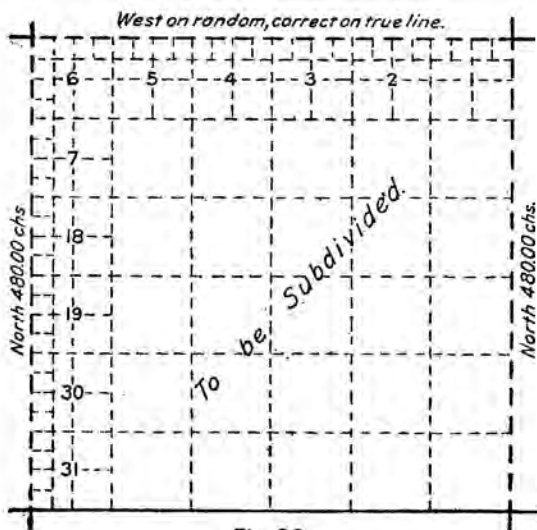
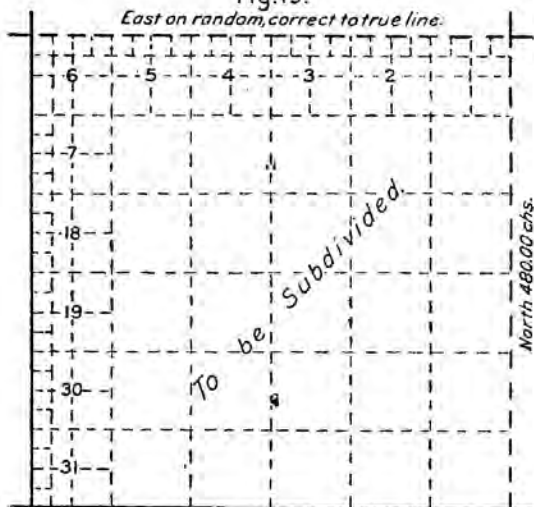
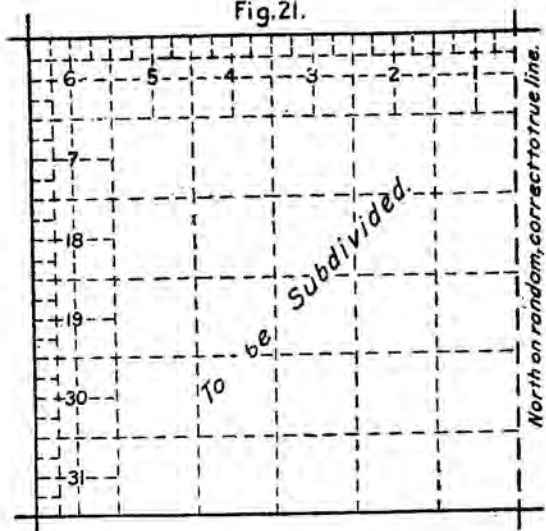


Fig. 20.

Fig. 21.



STANDARD PARALLEL

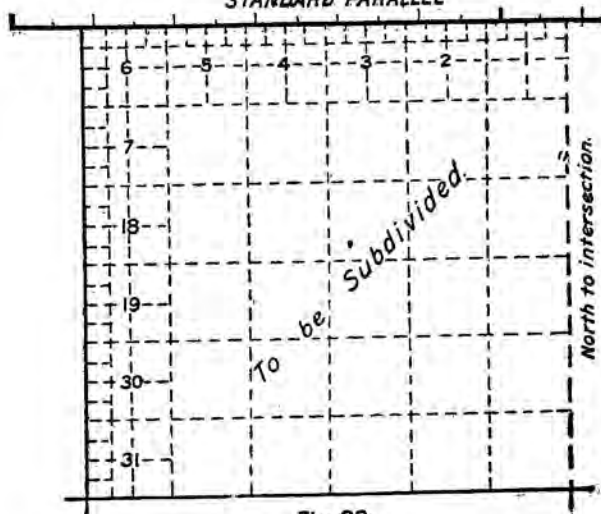


Fig. 22.

found to obtain. Where both meridional boundaries are new lines or where both have been previously established, the random latitudinal boundary will be run from east to west. In either case, if defective conditions are not encountered, the random line will be corrected back on a true line, upon which will be established regular quarter-section and section corners at intervals of 40 chains, alternately, counting from the east, and meander corners at the intersection of the true line with all meanderable bodies of water. The bearing of the true line will be calculated on the basis of the falling of the random, and the fractional measurement will be placed in the west half mile. A meridional township exterior will be terminated at the point of its intersection with a standard parallel, placing the excess or deficiency in measurement in the northernmost half mile. At the point of intersection of the meridional boundary with a standard parallel a closing township corner will be established; the parallel will be retraced between the first standard corners east and west of the point for the closing corner, in order to determine the exact alinement of the line closed upon, and the distance will be measured and recorded to the nearest corner on said standard parallel.

152. In order to complete the exteriors of a township it will often remain to establish a meridional boundary between previously established township corners; such boundaries will be run from south to north on random lines, with temporary corners set at intervals of 40 chains, and, if defective conditions are not encountered, the random will be corrected to a true line; by this plan the excess or deficiency of measurement will be placed in the north half mile, as required by law, and double sets of corners will be avoided where unnecessary.

153. The temporary points on any random exterior will be replaced by permanent corners, in proper position, when the final true line adjustments for the latter have been fully determined; the true line will be properly blazed through timber, and distances to important items of topography will be adjusted to correct true line measurements.

154. The field notes will embrace a full and complete record of the manner in which the township exteriors are run and established. The notes will show how the alinement of the random latitudinal curve was determined, the direction of the projection, the amount of the falling north or south of the objective township corner, and the calculated return course or true line.

IRREGULAR ORDER AND PARTIAL SURVEYS.

155. As the remaining unsurveyed public lands are found to contain less and less extensive areas surveyable under the law, it becomes necessary to depart from the ideal procedure in order more directly to reach the areas authorized for survey. The many possible combinations are entirely too numerous to state in detail, but where an irregular order appears to be necessary such departure from the ideal order of survey will be specifically outlined in the written special instructions. Such departure should always be based on the principle of accomplishing, by whatever plan, the same relation of one township boundary to another as would have resulted from regular establishment under ideal conditions.

In authorizing surveys to be executed it will not usually be provided that exteriors are to be carried forward until the township is to be subdivided; thus where causes operate to prevent the establishment of the boundaries in full it is not imperative that the survey of the exterior lines be completed; under such conditions it may be found necessary to run section lines as offsets to township exteriors and such section lines will be run either on cardinal courses or parallel to the governing boundaries of such townships, or even established when subdividing, as existing conditions may require.

GENERAL EXCEPTIONS.

156. The above rules accord with former practice, except that in certain instances the random latitudinal boundaries will be run from west to east, instead of invariably from east to west, as heretofore required. It is also deemed advisable to incorporate other exceptions which will lessen the difficulties of subdivisional surveys frequently experienced in the past.

It is especially desirable that the alinement of a new latitudinal boundary (which becomes the governing south boundary of the township to the north) shall not depart more than 14' from the true cardinal course; therefore the random line, run upon the cardinal course, may be made the true line where the falling would require a correction exceeding 14' of arc. Where the random latitudinal boundary thus closes on a *new* meridional exterior the temporary township corner may be adjusted to the latitude of the opposite township corner; but where both meridional boundaries have been previously surveyed a closing township corner will be established at the point of intersection of the random latitudinal line with the

Fig. 23.

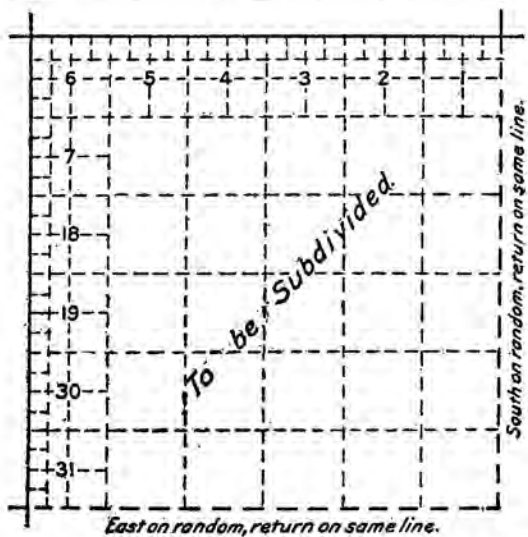
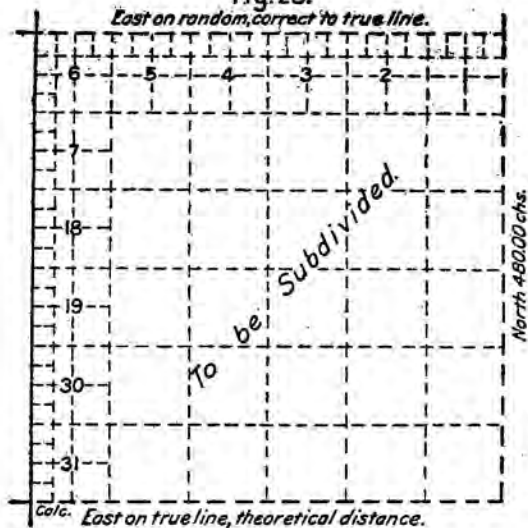
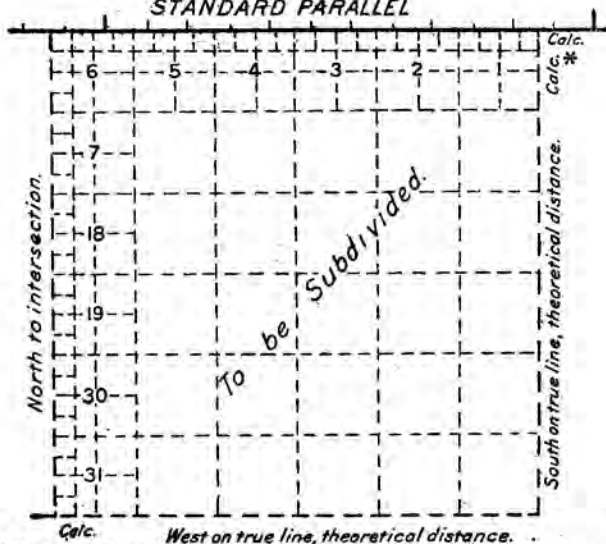


Fig. 24.

Fig. 25.
STANDARD PARALLEL



* Extensors initiated at a theoretical point for a closing corner.

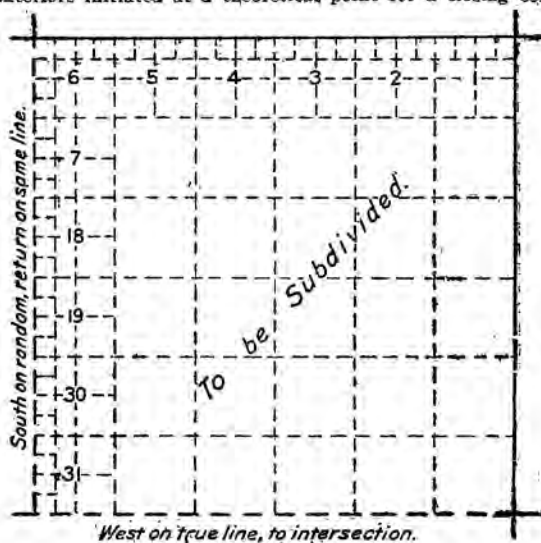


Fig. 26:

Fig. 27.

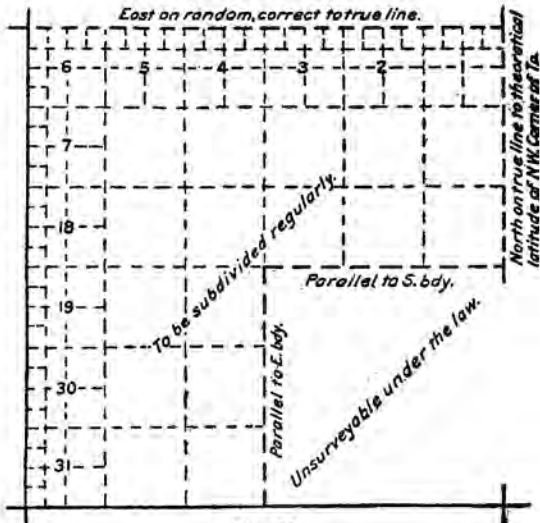
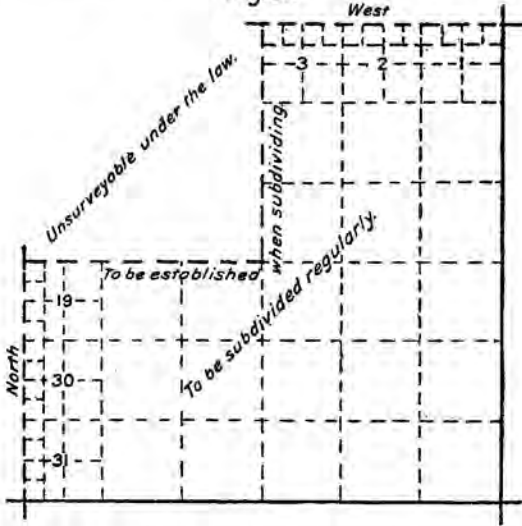


Fig. 28.

meridional boundary, or its projection to the north or south as the case may be. Likewise, where a meridional boundary is run as a random, the random will be made the true line if the adjustment for falling plus the usual correction to secure parallelism of the meridi-

Fig. 29.

6	R&T	5	R&T	4	R&T	3	R&T	2	R&T	1
7										12
18										13
19										24
30	N ^{0°12'E}	N ^{0°12'E}	N ^{0°12'E}	N ^{0°12'E}	N ^{0°12'E}	N ^{0°12'E}	N ^{0°12'E}	N ^{0°12'E}	N ^{0°12'E}	25
31	N ^{0°12'E}	N ^{0°12'E}	N ^{0°12'E}	N ^{0°12'E}	N ^{0°12'E}	N ^{0°12'E}	N ^{0°12'E}	N ^{0°12'E}	N ^{0°12'E}	36

6	R&T	5	R&T	4	R&T	3	R&T	2	R&T	1
7										12
18										13
19										24
30	N ^{0°14'W}	N ^{0°14'W}	N ^{0°13'W}	N ^{0°13'W}	N ^{0°13'W}	N ^{0°12'W}	N ^{0°12'W}	N ^{0°12'W}	N ^{0°12'W}	25
31	N ^{0°14'W}	N ^{0°14'W}	N ^{0°13'W}	N ^{0°13'W}	N ^{0°13'W}	N ^{0°12'W}	N ^{0°12'W}	N ^{0°12'W}	N ^{0°12'W}	36

Latitude 25° N.

6	R&T	5	R&T	4	R&T	3	R&T	2	R&T	1
7										12
18										13
19										24
30	N ^{0°08'E}	N ^{0°08'E}	N ^{0°10'E}	N ^{0°12'E}	N ^{0°14'E}	N ^{0°14'E}	N ^{0°14'E}	N ^{0°14'E}	N ^{0°14'E}	25
31	N ^{0°08'E}	N ^{0°08'E}	N ^{0°10'E}	N ^{0°12'E}	N ^{0°14'E}	N ^{0°14'E}	N ^{0°14'E}	N ^{0°14'E}	N ^{0°14'E}	36

6	R&T	5	R&T	4	R&T	3	R&T	2	R&T	1
7										12
18										13
19										24
30	N ^{0°14'W}	N ^{0°12'W}	N ^{0°10'W}	N ^{0°08'W}	N ^{0°08'W}	N ^{0°06'W}	N ^{0°06'W}	N ^{0°06'W}	N ^{0°06'W}	25
31	N ^{0°14'W}	N ^{0°12'W}	N ^{0°10'W}	N ^{0°08'W}	N ^{0°08'W}	N ^{0°06'W}	N ^{0°06'W}	N ^{0°06'W}	N ^{0°06'W}	36

Latitude 70° N.

Illustrating the adjustment in the direction of the meridional lines of a subdivisional survey on account of convergency of meridians, also the 14' limit of the rectangular "safety zone."

onal subdivisional lines (on account of convergency of meridians) would result in calculated bearings (in the northernmost miles of the latter lines) in excess of 14' from cardinal. This margin for the alinement of the random and true meridional lines of the subdivisional survey calls for a governing east boundary whose bearing will

fall within certain extremes suited to the latitude of the township, as for example (see second part of Table 2, Standard Field Tables):

Latitude 25° N.

1st Mi. Mer. Subdv. N. 0° 14' E.	5th Mi. Mer. Subdv. N. 0° 14' W.
Corr. for Conv. +00	Corr. for Conv. -02
E. bdy. may be <u>N. 0° 14' E.</u>	E. bdy. may be <u>N. 0° 12' W.</u>

Latitude 70° N.

1st Mi. Mer. Subdv. N. 0° 14' E.	5th Mi. Mer. Subdv. N. 0° 14' W.
Corr. for Conv. +02	Corr. for Conv. -10
E. bdy. may be <u>N. 0° 16' E.</u>	E. bdy. may be <u>N. 0° 04' W.</u>

It will be noted that the above text in reference to the 14' limit for exteriors applies only to the establishment of new boundaries. A previously established boundary every part of which is within 21' of cardinal will not be considered defective in alinement. Even in the case of new exteriors, where the engineer who establishes such line is also to subdivide the township of which such exterior is a governing boundary, the margin of 14' may be exceeded to a limited extent if the engineer is satisfied that existing conditions favor keeping within the 21' limit in the subdivisional survey. Thus it will be seen that the purpose of the 14' limit is merely to facilitate the establishment of all subdivisional lines within the prescribed definite limit of 21' from cardinal.

157. Another general exception may be noted where uncertainty exists as to how unsurveyed exteriors and subdivisional lines will close upon the newly established boundaries, in which case the corners thereon may be marked only for the townships of which the new exteriors control the subdivisions.

COMPLETION OF PARTIALLY SURVEYED EXTERIORS.

158. Where the end portions of a township exterior have been previously surveyed and closed upon, the fractional unsurveyed middle part will be completed by random and true line, without offset regardless of the deviation from cardinal; the fractional measurements will be placed as a general rule in the north and west half miles, thereby permitting the subdivisional lines to be extended as usual from the south to the north and from the east to the west. In the case of a fractional part of an exterior remaining unsurveyed

at either end of the line, the boundary will be completed by random line, initiated at the previously established terminal monument, which will be projected on a cardinal course in the direction of the objective township corner. The random will be corrected to a true line where the calculated bearing of any subdivisional line, governed by such exterior, comes within 14' from cardinal, and the

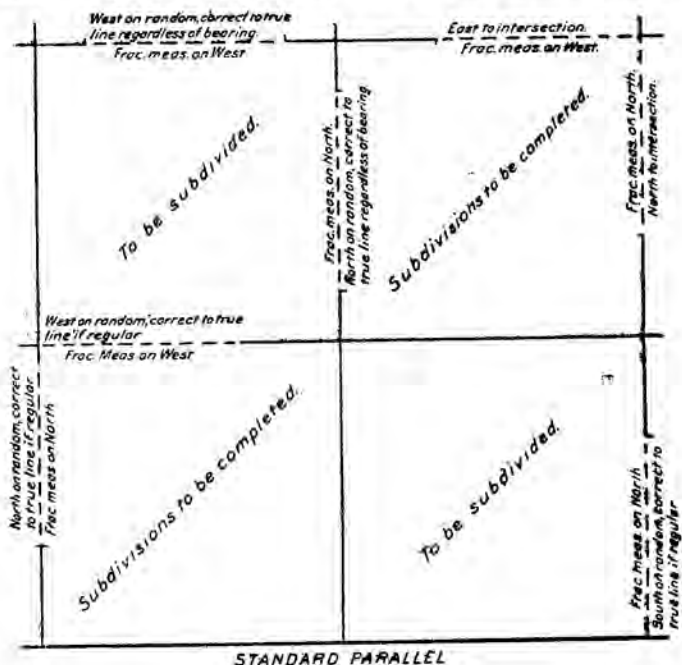


Fig. 30.

fractional measurement will be placed generally in the north or west half miles. However, should irregularity be developed, or in the absence of a previously established objective township corner, the partially surveyed exteriors will be completed on cardinal courses beginning as above; and in either case the fractional measurements will generally be placed in the north and west half miles.

RETRACEMENTS BEFORE SUBDIVIDING.

159. If any part or all of the boundaries of a township which is to be subdivided have been previously surveyed, and the proper supervising officer has reason to question the accuracy of any portion of such exteriors, or the condition of the corner monuments thereon, the fact will be stated in the written special instructions, and the engineer will be authorized and required, as a condition precedent to beginning the subdivisive survey of such township, to retrace such boundaries in order to determine the true alinement and lengths of the lines, to rebuild any corners found to be in a poor condition, and otherwise to accomplish the following purposes:

(a) To locate all material errors, (b) to test every line as to what alterations may be required, and (c) to determine all data necessary for the computation of the areas of all fractional lots.

160. All data obtained in the retracements will be embodied in the field notes and shown upon the plat of the survey, unless the retracement results are in substantial agreement with the record of the original survey, in which case a general statement to that effect may be made in the field notes, and the original record may be permitted to govern the data to be placed upon the plat.

RECTANGULAR LIMITS.

161. Before approaching the subject of "subdivision of townships" it is necessary to consider the requirement of law relative to rectangular surveys, wherein the square mile, or section, is the unit of subdivision. The normal township will include 36 sections in all, 25 of which are returned as containing 640 acres each; 10 sections (on the north and west boundaries) each contain regular aliquot parts totaling 480 acres with 4 additional fractional lots in each section, each lot containing 40 acres plus or minus definite differences to be determined in the survey; and, section 6 containing regular aliquot parts totaling 360 acres with 7 additional fractional lots each containing 40 acres plus or minus certain definite differences to be determined in the survey, all as contemplated by law. The aforementioned aliquot parts of 640 acres may be termed "regular or legal subdivisions of a section," as a quarter section, a half-quarter section, or a quarter-quarter section, the legal minimum of which, for purposes of disposal under the general land laws, is 40 acres.

162. In the administration of the surveying laws it has been necessary to establish a definite relation between rectangularity

Fig. 31.

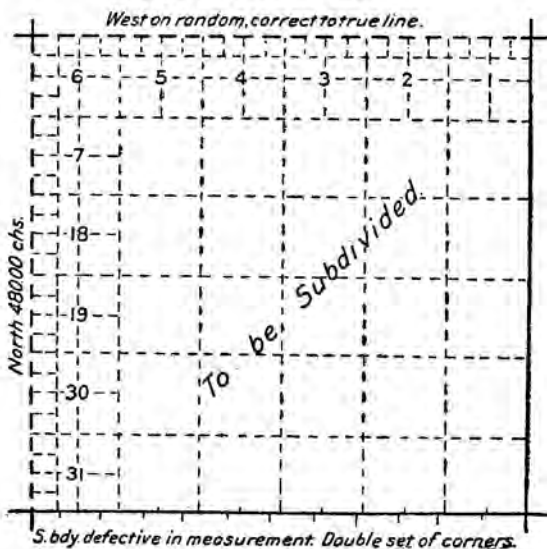
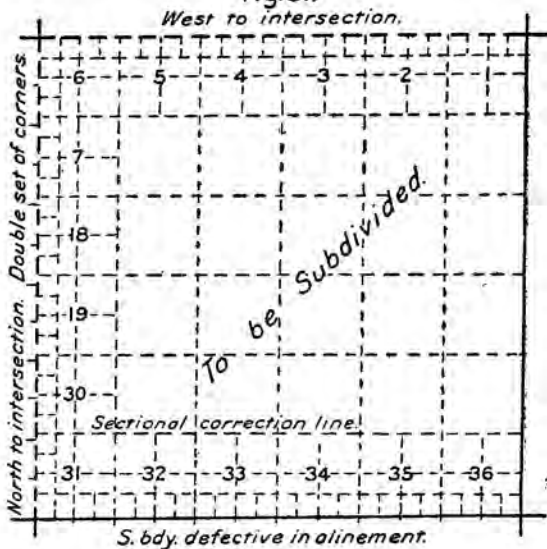


Fig. 32.

(square miles of 640 acres, or aliquot parts thereof), as contemplated by law, and the resulting unit of subdivision consequent upon the practical application of surveying theory to the marking out of the lines on the earth's surface, wherein the ideal section is allowed to give way to one which may be termed "regular." Such relation, as applied to the boundaries of a section, has been placed at the following limits:

(a) For alinement, not to exceed 21' from cardinal in any part; (b) for measurement, the distance between regular corners to be normal according to the plan of survey, with certain allowable adjustments not to exceed 25 links in 40 chains; and (c) for closure, not to exceed 50 links in either latitude or departure.

Township exteriors, or portions thereof, will be considered defective when they do not qualify within the above limits. It is also necessary, in order to subdivide a township regularly, to consider a fourth limit, as follows:

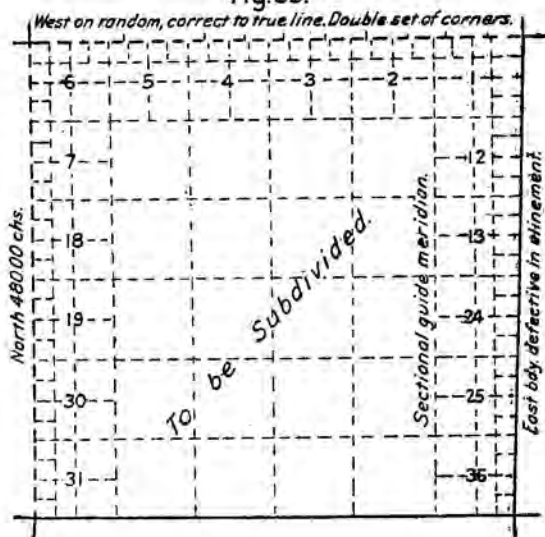
(d) For position, the corresponding section corners upon the opposite boundaries of the township to be so located that they may be connected by true lines which will not deviate more than 21' from cardinal.

A previously established exterior will not be considered defective if the above limits are satisfied, and a *subdivisional survey* may proceed in safety if the rectangular limits (in such subdivisional survey) are not exceeded. On the other hand, if the conditions relating to the previously established *governing boundaries* are such that the rectangular limits have already been exceeded or that the danger point is likely to be reached at an early stage in the subdivisional survey, the necessary corrective steps will be taken before subdividing, as hereinafter described.

RECTIFICATION OF DEFECTIVE EXTERIORS BEFORE SUBDIVIDING AND METHOD OF ESTABLISHING NEW GOVERNING BOUNDARIES WHERE THE PREVIOUSLY SURVEYED EXTERIORS ARE FOUND TO BE DEFECTIVE.

163. Where subdivisional lines have been initiated from or closed upon an exterior prior to the subdivision of one of the adjoining townships, its alinement can not legally be changed. A defective boundary not so closed upon may be obliterated, after connecting the old with the new monuments, whereupon a new boundary will be projected in accordance with regular methods. If a legal claim of any character such as mineral, forest-homestead, small-holding,

Fig. 33.



West to intersection.

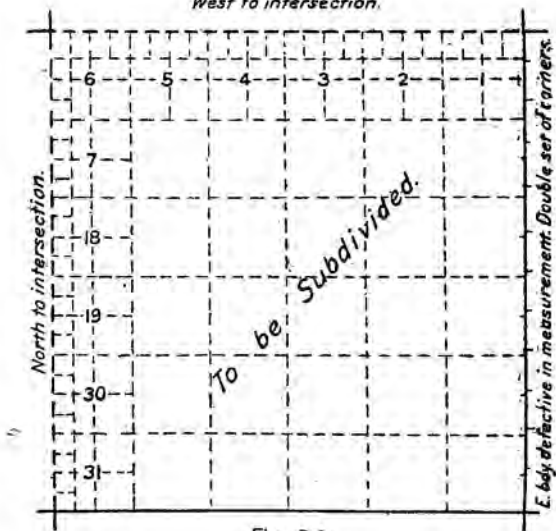


Fig. 34.

railroad or canal right-of-way, reservoir site, etc., has been connected with any corner on an exterior which may be subject to rectification, the fact will be specifically stated in the written special instructions, and in case such exterior is found to be defective the engineer will accurately connect the old corner by course and distance with the new monument. Such old corners will not be destroyed, but the letters "W P" (signifying "witness point") will be distinctly added to the original markings. A complete record of the connection from the new to the old monument, a description of the latter and its accessories, and the new markings, will be included in the field notes, and the position of the old monument will be shown on the plat of the survey.

164. If a boundary is defective in measurement or position and is not subject to rectification, the location of the original corners will not be changed, but the marks thereon, and the marks upon or position of the accessories, may be appropriately altered to stand only for the sections of the previously established surveys. New corners to control the surveys of the adjoining township may then be established on the old line, but at regular distances of 40 and 80 chains. Where new corners are placed on an oblique exterior (one whose bearing departs more than 1° from cardinal) the same will be so located for measurement that the oblique distance multiplied by the cosine or sine of the bearing angle, as the case may be, will result in cardinal equivalents of 40 and 80 chains.

165. Where subdivisional lines have been initiated from or closed upon one side of a portion of a township boundary prior to the subdivision of the township on the opposite side, while upon the remaining portion of the same such conditions do not interfere, said remaining portion may be obliterated, if found defective, whereupon a new line will be projected in accordance with regular methods.

166.. The position of the new exteriors, or of new corners on defective township boundaries must be established by an actual rerunning of such lines; the data acquired in surveying subdivisional lines closing upon defective exteriors can not be accepted in lieu of such retracement or resurvey.

167. Instances will occur both in closing subdivisional surveys upon regular exteriors and in the retracement of defective boundaries not subject to rectification where it will be developed that the original monuments have become lost or obliterated, or where such

Fig. 35.

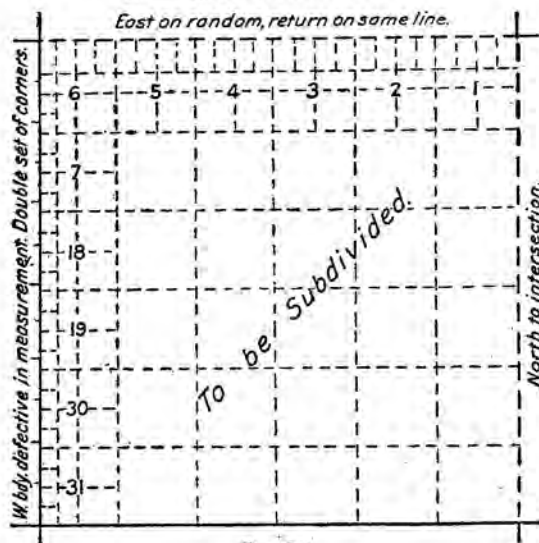
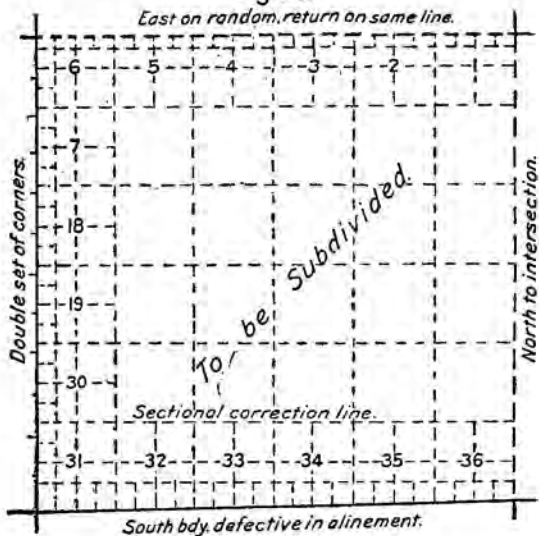


Fig. 36.

corners may be identified in an advanced state of deterioration. All such exterior corners will be reestablished and remonumented in their correct original positions in strict accordance with the provisions of Chapters IV and V, and a complete record thereof will be embodied in the field notes.

168. The south boundary of a township is regularly the governing latitudinal boundary and will be used as such unless defective in alinement; if defective in measurement, and not subject to rectification, the position of the original corners will not be changed, but the marks thereon and the accessories will be appropriately altered to stand only for the sections of the township to the south; new corners of two sections and quarter-section corners common to the sections of the township to the north will be established at regular intervals of 40 chains, counting from the east, and the excess or deficiency in measurement placed in the west half mile. If the south boundary is defective in alinement, a sectional correction line will be required.

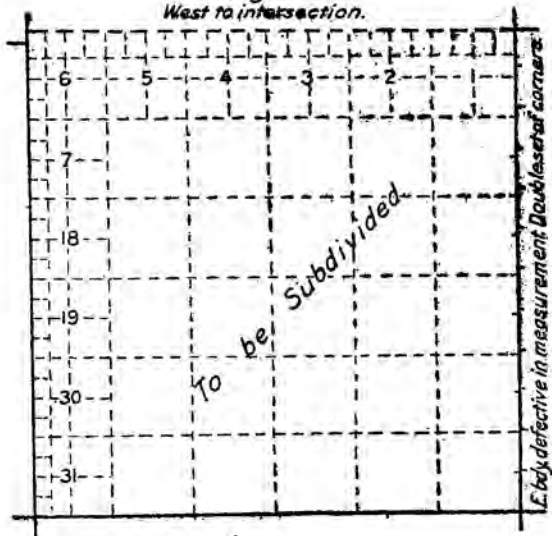
169. The east boundary of a township is regularly the governing meridional boundary and will be used as such unless defective in alinement; if defective in measurement, and not subject to rectification, the position of the original corners will not be changed, but the marks thereon and the accessories will be appropriately altered to stand only for the sections of the township to the east; new corners of two sections and quarter-section corners common to the sections of the township to the west will be established at regular intervals of 40 chains, counting from the south. If the east boundary is defective in alinement a sectional guide meridian will be required.

170. New west and north boundaries of a township become the governing meridional and latitudinal boundaries of the townships to the west and north, respectively, and are required to be properly established as such.

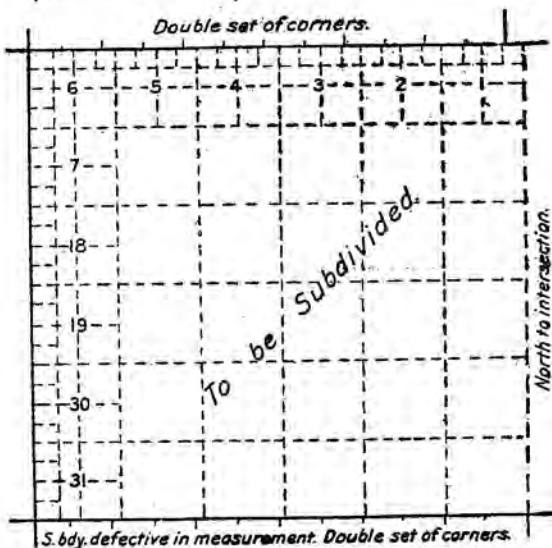
171. New east and south boundaries of a township become the closing meridional and latitudinal boundaries of the townships to the east and south, respectively, and where by peculiar necessity the ideal plan must be modified and doubt exists as to how unsurveyed lines may close upon same, the corners thereon may be established common only to the sections of the township of which the new lines are the governing boundaries. The corners appropriate to the sections upon the opposite side will be duly established as closing corners at the time of the survey of the subdivisional lines

Fig. 37.

West to intersection.



Double set of corners.



North to intersection.

S. bdy. defective in measurement. Double set of corners.

Fig. 38.

of the adjoining townships if the original corners are then found to be defective in position, and where regular connections can be made the marks upon the original corners will be appropriately altered to corners of maximum control.

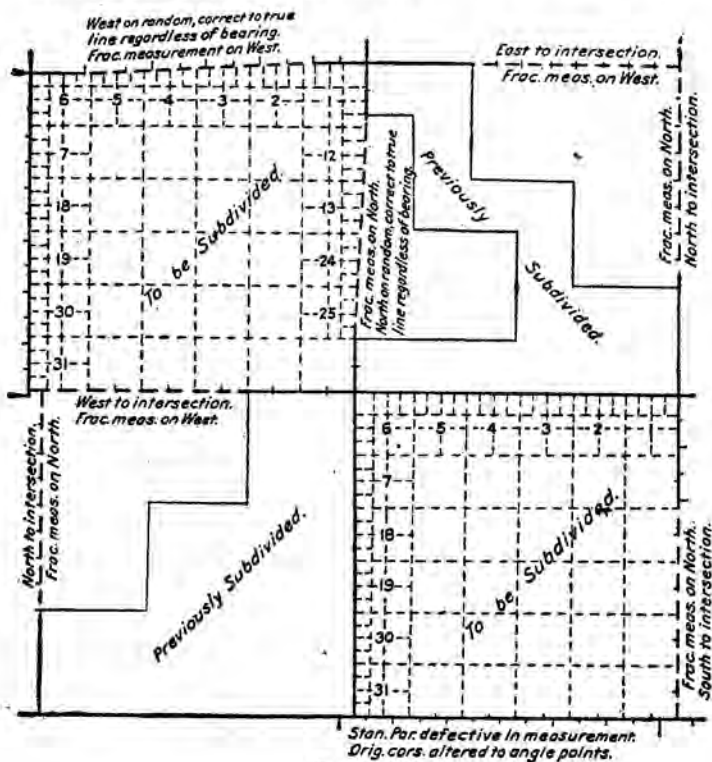


Fig. 39.

172. Where the previously established north or west boundaries are found to be defective in measurement or position and subdivisational surveys in the adjoining townships have been initiated upon the same, thereby preventing rectification, the marks upon the original corners will be appropriately altered to corners of two sections and quarter-section corners common only to the sections of

the townships to the north or west, respectively. Closing section corners will be established when subdividing and the distance measured to an original corner; new quarter-section corners, common to the sections of the township which is being subdivided, will be placed on the old line at the mean distances between the closing section corners, or at 40 chains from one direction, depending upon the plan of the subdivision of the section. Where such previously established north and west boundaries are defective in alinement, but not in measurement or position, no changes are required, and the section lines of the township which is being subdivided will be connected regularly to the original corners; the resulting fractional measurements will be placed uniformly in the north and west half miles.

173. The diagrams which accompany the text illustrate the guiding principles involved in the method of establishing new governing boundaries where the previously surveyed exteriors are found to be defective. Each diagram illustrates a simple condition affecting one boundary only, and the examples are taken only from the regular order of procedure. Combinations of two or more of the simple defective conditions are best solved by an analysis of the complex problem into its several parts of simple defective conditions. The same statement is applicable to the solution of complex defective conditions encountered in the establishment of township exteriors under an irregular order of procedure. The engineer will be expected to exercise skill and judgment in dealing with similar field problems, but where extraordinary conditions are encountered which will not admit of analysis and solution in harmony with the principles herein set forth he will report the facts to the proper supervising officer for his counsel.

TABLES OF LATITUDES AND DEPARTURES AND CLOSING ERRORS.

174. Upon the completion of the survey of one or more township exteriors closing the figure of either a full or fractional township, a table of latitudes and departures and closing errors will be prepared, wherein due allowance for convergency of meridians will be introduced. The closing errors will furnish an immediate guide to the accuracy of the lines included in the table and, in case the limit of closure ($\frac{1}{8125}$ of the perimeter, in either latitude or departure) is exceeded, will serve to show what additional retracements or other corrective steps may be necessary in order to perfect the survey

before leaving the field. The table of latitudes and departures and closing errors, including every part of any closed figure embracing township exteriors, based upon final field determination after all necessary retracements and final true lines have been completed, will be filed with the field tablets and computation sheets. The general subject of "limits of closure" will be amplified hereinafter.

SUBDIVISION OF TOWNSHIPS.

REGULAR BOUNDARIES.

175. The boundaries of a township will be considered within satisfactory governing limits from which to control the subdivisional survey when the calculated position of the latter lines may be theoretically projected from said boundaries without invading the danger zone in respect to rectangular limits as previously described. The danger zone has already been placed at theoretical bearings exceeding $14'$ from cardinal, and the corresponding zone in respect to lengths of lines may be placed at theoretical adjustments exceeding 33 links per mile:

176. The direction of the east boundary may qualify anywhere within the governing limits set forth under the subject of "township exteriors," and where this boundary is broken in alinement, but otherwise within the governing limits, its mean course will be adopted when considering the control upon the direction of the meridional subdivisional lines.

177. The subdivision of a township may proceed in the normal order, where the above conditions are satisfied, as follows:

The meridional section lines will be initiated at the regularly established section corners on the south boundary of the township and will be run from south to north parallel to the governing east boundary, or, in case the east boundary is within limits, but has been found by retracement to be imperfect in alinement, the meridional section lines will be run parallel to the mean course of such east boundary. Regular quarter-section and section corners will be established alternately at intervals of 40 chains, as far as the northernmost interior section corner. The last miles of the meridional section lines will be continued as random lines, each successive line being run parallel to the true east boundary of the section to which it belongs; a temporary quarter-section corner will be set at 40 chains, the distances will be measured to the points of intersection of the random lines with the north boundary of the township, and the

fallings of the random lines east or west of the objective section corners will be noted. The randoms will then be corrected to true lines by returning to accomplish the required markings between the section corners, including the permanent establishment of the quarter-section corners on the true lines at distances of 40 chains from the south, thus placing the fractional measurements in the north half miles. The bearings of the true lines will be calculated on the basis of the fallings of the randoms (see Table 3, Standard Field Tables). Where the north boundary of the township is a base line or standard parallel, the last miles of the meridional section lines will be continued as true lines parallel to the east boundary of the township, setting permanent quarter-section corners at 40 chains from the south and closing section corners at the points of intersection of the several lines with the base or standard or correction line, where the distances will be measured to the nearest corners on said line. The adjustment of the bearing of all meridional section lines on account of convergency of meridians has already been explained in Chapter II.

178. The latitudinal section lines, except in the west range of sections, will normally be run from west to east on random lines parallel to the south boundaries of the respective sections, setting temporary quarter-section corners at 40 chains; the distances will be measured to the points of intersection of the random lines with the north and south lines passing through the objective section corners, and the fallings of the random lines north or south of said corners will be noted. Each random will be corrected to a true line by returning to accomplish the required markings between the section corners, including the permanent establishment of quarter-section corners at the *mid-points* on the true lines. The bearings of the true lines will be calculated on the basis of the fallings of the randoms (see Table 3, Standard Field Tables). In the west range of sections the random latitudinal section lines will be run from east to west, parallel to the south boundaries of the respective sections, and on the true lines the permanent quarter-section corners will be established at 40 chains from the east, thus placing the fractional measurements in the west half miles.

179. Meander corners will be established at the points of intersection of the several true lines with all meanderable bodies of water.

180. The meridional section lines will have precedence in the order of execution, and these will be surveyed successively, begin-

ning with the first meridional section line counting from the east. A meridional section line will not be continued beyond a section corner until after the connecting latitudinal section line has been surveyed, and in the case of the fifth meridional section line, both latitudinal section lines connecting east and west will be surveyed before continuing with the meridional line beyond a section corner. The successive meridional lines may be taken up at the convenience of the engineer at any time in order as previously stated, but none will be carried beyond uncompleted sections to the east. The field notes will be compiled in ranges of sections beginning with the easternmost, and the west two ranges will be compiled by alternating with the adjoining east and west sections. The specimen field notes exemplify the usual order of survey and the prescribed method of arranging the field notes.

181. Thus, to recapitulate, the subdivisational survey will be commenced at the corner of sections 35 and 36, on the south boundary of the township, and the line between sections 35 and 36 will be run parallel to the east boundary of the township, or to the mean course thereof, if it is imperfect in alinement, but within limits, establishing the quarter-section corner at 40 chains, and at 80 chains, the corner of sections 25, 26, 35 and 36. From the last-named corner, a random line will be run eastward, without blazing, parallel to the south boundary of section 36, to its intersection with the east boundary of the township, placing at 40 chains from the point of beginning, a post for temporary quarter-section corner. If the random line intersects said township boundary exactly at the corner of sections 25 and 36, it will be blazed back and established as the true line, the permanent quarter-section corner being established thereon, midway between the initial and terminal section corners. If the random intersects said township boundary to the north or south of said corner, the falling will be carefully measured, and from the data thus obtained, the true return course will be calculated, and the true line blazed and established, and the position of the quarter-section corner determined, as directed above. The meridional section line will be continued on the same plan, likewise the successive latitudinal section lines except that each random will be run parallel to the true south boundary of the section to which it belongs. After having established the west and north boundaries of section 12, the line between sections 1 and 2 will be projected northward, on a random line, parallel to the east boundary of the township, or to its mean

course, as the case may be, setting a post for temporary quarter-section corner at 40 chains, to its intersection with the north boundary of the township. If the random intersects said north boundary exactly at the corner of sections 1 and 2, it will be blazed back and established as the true line, the quarter-section corner being established permanently in its original temporary position, and the fractional measurement thrown into that portion of the line between the

6	60	5	44	4	33	3	22	2	11	1
59		58		43		32		21		10
7	57	8	42	9	31	10	20	11	9	12
56		55		41		30		19		8
18	54	17	40	16	29	15	18	14	7	13
53		52		39		28		17		6
19	51	20	38	21	27	22	16	23	5	24
50		49		37		26		15		4
30	48	29	36	28	25	27	14	26	3	25
47		46		35		24		13		2
31	45	32	34	33	23	34	12	35	1	36

FIG. 40.—The numbers on the section lines indicate the normal order of subdivision and arrangement of the field notes.

permanent quarter-section corner and the north boundary of the township. If, however, said random intersects the north boundary of the township, to the east or west of the corner of sections 1 and 2, the falling will be carefully measured, and from the data thus obtained the true return course will be calculated and the true line established, the permanent quarter-section corner being placed upon the same at 40 chains from the initial corner of the random line.

thereby throwing the fractional measurement in that portion lying between the quarter-section corner and the north boundary of the township. When the north boundary of a township is a base line or standard parallel, the line between sections 1 and 2 will be run as a true line parallel to the east boundary of the township, or to its mean course, as the case may be; the quarter-section corner will be placed at 40 chains, and a closing corner will be established at the point of intersection with such base or standard line; and in such case, the distance from said closing corner, to the nearest standard corner on such base or standard line, will be carefully measured and noted. The successive ranges of sections proceeding from east to west will be surveyed in the same manner; then after having established the west and north boundaries of section 32, a random line will be initiated at the corner of sections 29, 30, 31 and 32, which will be projected westward parallel to the south boundary of the township, setting a temporary quarter-section corner at 40 chains, to an intersection with the west boundary of the township, where the falling will be measured and the bearing of the true line calculated, whereupon the line between sections 30 and 31 will be permanently marked between the section corners, and the quarter-section corner thereon will be established at 40 chains from the east, thereby placing the fractional measurement in the west half mile as required by law. The survey of the west two ranges of sections will be continued on the same plan, and the random line between sections 6 and 7 will be run westward parallel to the true line between sections 7 and 18; the random will be corrected to a true line and the fractional measurement placed in the west half mile; finally the random line between sections 5 and 6 will be run northward parallel to the true line between sections 4 and 5; the random will be corrected to a true line and the fractional measurement placed in the north half mile.

It may well be noted again that the meridional section lines are surveyed as true lines for 5 miles, i. e., the lines are surveyed and permanently monumented in the first instance without later adjustment. Every means is placed at the disposal of the engineer by which he is expected to accomplish accurate results, and the system of survey provides amply for the adjustment of all reasonable closing errors. Thus, a slight error in the alinement of the meridional section lines is taken up in the measurement of the latitudinal lines which, in order to come within the rectangular limit, must be within 50 links of 80 chains in length, except in the west range of

sections where the convergency of the meridional lines is regularly provided for; the accumulated error in alinement for the 5 miles of true meridional line is taken up in the sixth mile, which is run random and true; here the true line must be within 23' of cardinal in order to come within the rectangular limit. The slight, ordinary errors in the measurement of the meridional section lines are taken up by the adjustment of the bearings of the latitudinal section lines which, in order to come within the rectangular limit, must be within 21' of cardinal; the accumulated error in measurement in running north is placed in the last fractional half mile; here the meridional distance will be checked by a calculated closing around the last section, and the latitudinal error must not exceed 50 links (or $\frac{1}{8}v$) in order to come within the usual limits of closure. The accuracy of the subdivisional survey will everywhere be tested by the usual rules for limits of closure, hereinafter described. The engineer should discriminate carefully between the limits for subdivision and limits of closure and note with due respect that whereas the latter may admit of differences as great as 50 links in any one section, the former are controlled by the limit of rectangularity and will be exceeded if the accumulative error is greater than $3\frac{1}{2}'$ in alinement, or $8\frac{1}{2}$ links per mile in measurement. The accumulative error must ever be guarded against and avoided, and the order of survey is arranged with a view to furnishing continuous checks upon the accuracy of all lines.

182. Any random subdivisional line may be run for distance only where the objective section corner is in sight, but the bearing will be recorded, and the usual rules for running random and true lines will be duly observed in every other respect. The random latitudinal section lines, except in the west range of sections, will normally be run from west to east, thus always closing upon a previously established section corner; but when under the exigencies of the field work, in order to economize the time of his party, the engineer may elect to project the random from east to west (always parallel to the south boundary of the section), a temporary section corner (if the permanent corner has not already been established) will be set at 80 chains, and the true point for the section corner will be determined as usual at the 80-chain point on the meridional section line, whereupon the connection of the random latitudinal line and the permanent marking of the true line will be completed as regularly provided. Examples of the authorized rules for running subdivisional lines will be found in the specimen field notes.

IRREGULAR BOUNDARIES.

183. Where either of the governing boundaries of a township is disqualified as a controlling line upon which to initiate a subdivisional survey, the necessary retracements and resurveys or alterations will be accomplished before subdividing as previously explained under the subject of township exteriors; thus may be assured every possible provision for a correct subdivisional survey except as either the south or the east boundary may be defective in alinement and not subject to rectification.

SECTIONAL GUIDE MERIDIAN.

184. If the east boundary of the township is defective in alinement, and can not be rectified, and the north boundary is thus made defective in position, the first meridional section line will be projected on a true meridian to an intersection with the north boundary of the township where a closing section corner will be established and the distance measured to the nearest regular corner. The intermediate quarter-section and section corners will be established alternately at regular intervals of 40 chains, counting from the south, unless the south boundary of the township is itself defective in alinement. Where the north boundary is not defective in position (nor within the danger zone) with reference to the section corners on the south boundary (by reason of the errors in the alinement of the east boundary being compensating), the first meridional section line will be projected 5 miles as a true line on a bearing calculated to intersect the objective section corner on the north boundary, and the last mile will be run as a random line on the same course and corrected to a true line after the falling has been measured. The remaining meridional section lines will be run parallel to the one first established, in the usual manner, to closing section corners on the last mile or random and true as the case may be.

The fractional measurements of the latitudinal section lines in the first range of sections will be placed in the east half mile; elsewhere, unless the south boundary is defective in alinement, the latitudinal section lines will be run in the usual manner.

SECTIONAL CORRECTION LINE.

185. If the south boundary of the township is defective in alinement, and can not be rectified, and the west boundary is thus made defective in position, a sectional correction line will be surveyed

Fig. 41.

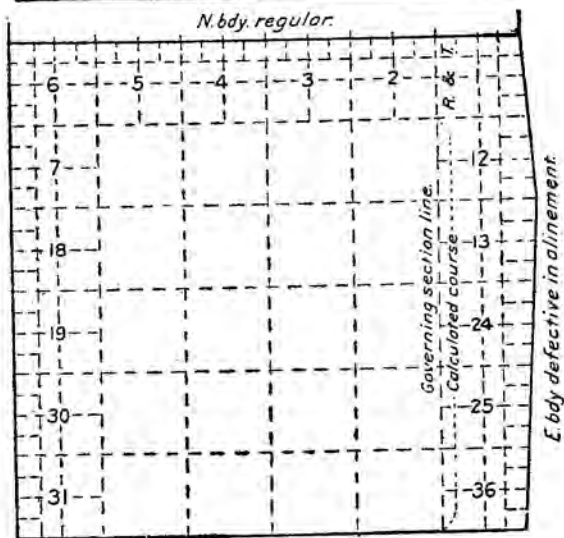
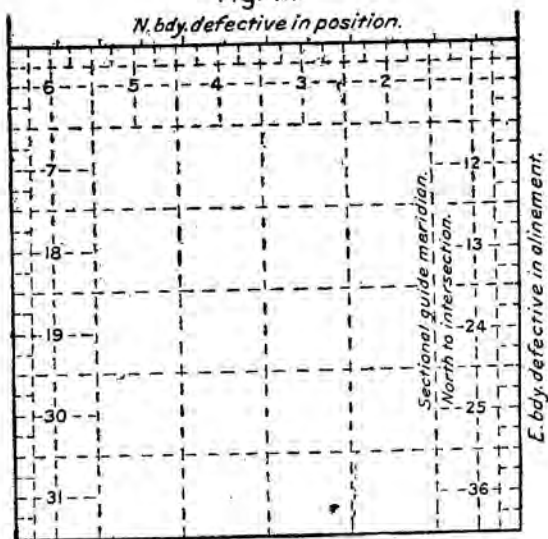


Fig. 42.

as a permanent line on a true latitudinal curve initiated at the first regular section corner on the east boundary and projected to an intersection with the west boundary of the township where a closing section corner will be established and the distance measured to the nearest regular corner. The intermediate quarter-section and section corners will be marked as temporary points at regular intervals of 40 chains, alternately, counting from the east. Where the west boundary is not defective in position (nor within the danger zone) with reference to the section corners on the east boundary (by reason of the errors in alinement of the south boundary being compensating), the first latitudinal section line will be projected 5 miles as a permanent line on a bearing calculated to intersect the objective section corner on the west boundary; temporary quarter-section and section corners will be marked at regular intervals of 40 chains, alternately, counting from the east.

The section corners on the sectional correction line will be established at the several points of intersection of the meridional section lines alined in the normal manner. Thereafter the quarter-section corners on the sectional correction line will be established at the usual mid-point positions except in the east and west ranges of sections. The quarter-section corner between sections 25 and 36 will be established at 40 chains from the west if the east boundary is defective in alinement; otherwise it will be fixed at the usual mid-point position. The quarter-section corner between sections 30 and 31 will be placed at 40 chains from the east, and if the sectional correction line has not been terminated at a closing section corner on the west boundary of the township (as previously provided), the line between sections 30 and 31 will be run random and true in the normal manner. The quarter-section corners on the meridional section lines in the south tier of sections will be permanently established at 40 chains south from the corners on the sectional correction line. The balance of the subdivisional lines will be continued from the sectional correction line in the usual manner.

186. Where the south part of the east boundary, or the east part of the south boundary, is regular, and the balance of the exterior is found to be defective in alinement and not subject to rectification, the subdivisional survey will be made regular as far as possible. The initial point for the sectional guide meridian, or for the sectional correction line, will be determined by existing conditions, and the subdivisional survey continued in harmony with the principles

Fig. 43.

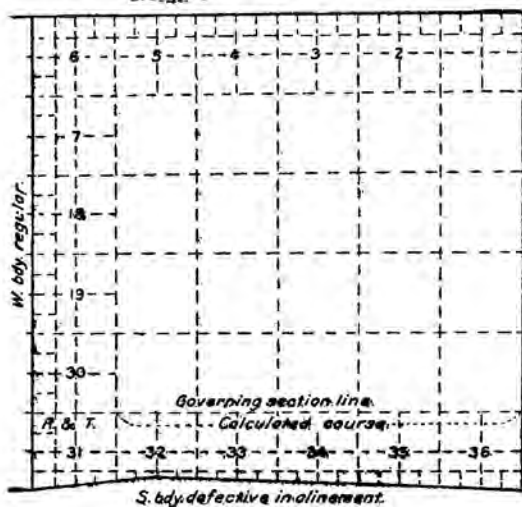
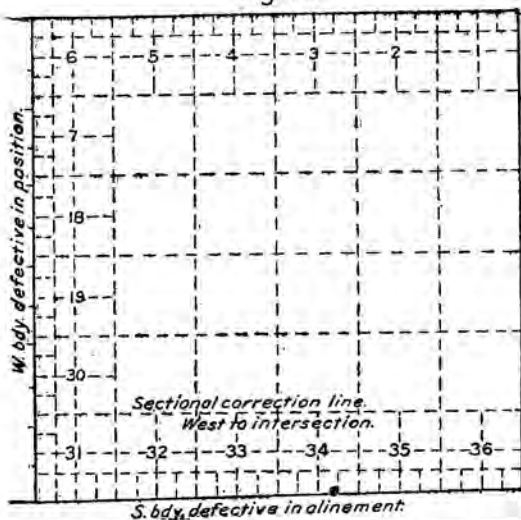


Fig. 44.

already outlined. Thus the first meridional section line would be continued as a sectional guide meridian if the north part of the east boundary is defective in alinement and the north boundary is thereby made defective in position, but if the north boundary is not defective in position (nor within the danger zone) the first meridional section line should be continued on a course calculated to intersect the objective section corner on the north boundary. The same principle would be observed if the west part of the south boundary is defective in alinement and the west boundary is not defective in position (nor within the danger zone), but if the west boundary is thus made defective in position the sectional correction line should be established on the true latitudinal curve.

Under the provisions of the above paragraph it will be seen that the maximum number of normal sections are to be secured where the condition of the governing boundaries warrants a combination of the several general plans of subdivisational surveys. The sections adjoining the east boundary may be considered regular to the full extent of their conformity with the usual rectangular limits, and where such agreement obtains the quarter-section corners on the latitudinal section lines will be placed at the normal mid-point position. The sections adjoining the south boundary of the township can not be considered regular unless the meridional lines are established at 80 chains in length, and the sections are otherwise in conformity with the usual rectangular limits; certain exceptions to this rigid requirement will be noted under the subject of "fragmentary subdivision."

187. The field notes of subdivisational surveys embracing either a sectional guide meridian, a sectional correction line, or other governing section line, will be compiled in the same regular order heretofore described, but appropriate explanatory remarks will be added indicative of the method and order of procedure.

CLOSING SECTION LINES.

188. In the event of defective north or west boundaries, not subject to rectification, where the subdivisational lines can not be connected with the previously established exterior section corners, regularly by random and true lines not exceeding 21' from cardinal and at the same time not deviating more than 21' from a line parallel to the opposite (regular) boundary of the section, the normal positions of the randoms will be made the true lines; a closing section corner will then be established at the point of intersection of the

Fig. 45.

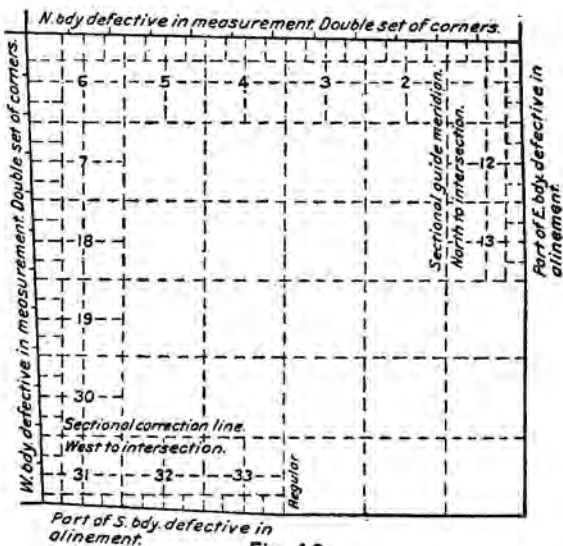
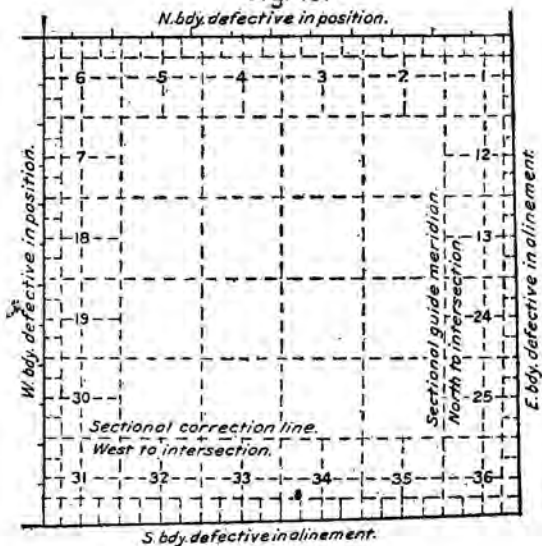


Fig. 46.

section line with the original boundary, and the distance will be measured to the nearest original corner. The quarter-section corners on the closing section lines will be placed uniformly at 40 chains from the south or east as the case may be. If not already accomplished, the defective boundaries of the township will be retraced as may be necessary, and the marks upon the original corners appropriately altered as previously provided under the subject of rectification of defective exteriors, whereupon new quarter-section corners, common to the sections of the township which is being subdivided, will be established on the original defective boundaries at the mean distance between the closing section corners, or at 40 chains from one direction, depending upon the plan of the subdivision of the section to which a particular quarter-section corner belongs.

189. Corners of two sections on the governing south or east boundaries of a township will not be established as closing section corners, but at regular distances by measurement on said boundaries as already provided under the subject of rectification of defective exteriors before subdividing; thereafter the position of said corners will control the subdivisional survey.

190. Where a section is invaded by a State or reservation or grant boundary, or by a private claim of any description, such as mineral claims, forest-homestead claims, small-holding claims, etc., whose boundaries are at variance with the lines of legal subdivision, the distance on the township boundary or section line to the point of intersection with the irregular boundary will be carefully measured, likewise the exact bearing of the irregular boundary will be determined and the distance will be measured to the nearest corner on such irregular boundary. Where a private claim is located entirely within the limits of a section, a connection will be made from a regular corner on one of the boundaries of the section to a corner of the claim, and the bearing and length of the connecting line will be carefully determined. In the latter case a connecting traverse line will be recorded, if one is run, but it will also be reduced to the equivalent direct course and distance, all of which will be stated in the field notes, and the course and length of the direct connecting line will be shown upon the plat of the survey.

191. If a survey is to be concluded upon an irregular boundary at variance with the lines of legal subdivision, or if the survey is to be continued on a blank line to acquire a definite location upon the

opposite irregular boundary, but without monumenting the rectangular survey between such irregular boundaries, a closing township or section corner, as the case may be, will be required at the point of intersection of the regular with the irregular line. On the other hand, if the survey is not to be so concluded, but is to be continued for the purpose of establishing a full complement of section and quarter-section corners for the control of the subdivision of a section so invaded by a private claim, no closing corner will be required.

102. In every case where a closing township or section corner is to be established upon a standard parallel, State, reservation, grant, or claim boundary, or upon an irregular section line or exterior, the line closed upon (if the latter was not established by the engineer who runs the closing line, or if not already retraced by him), will be retraced between the first corners to the right and left of the point for the closing corner, in order to determine the exact alinement of the line closed upon, to the end that the closing corner may be established at the precise point of intersection of the two lines. The distance from the closing corner to the nearest corner on the line closed upon will always be measured and recorded.

SUBDIVISION OF SECTIONS.

103. The acts of Congress approved February 11, 1805, and April 5, 1832, contain the fundamental provisions for the subdivision of sections into quarter sections and quarter-quarter sections; the principles recognized by law have already been stated in Chapter I. The sections are not subdivided in the field by the United States surveyors unless provision therefor is specifically mentioned in the written special instructions, but certain subdivision-of-section lines are always protracted upon the official plats, and the local surveyor who may be employed by entrymen to run said lines in the field is compelled to correlate the conditions as found upon the ground with those shown upon the approved plat. The United States surveyor is required to so establish the official monuments that a proper foundation is laid for the subdivision of the section, whereby the officially surveyed lines may be identified and the subdivision of the section controlled as contemplated by law.

104. The rectangular system provides for the unit of disposal under the general land laws, broadly, the quarter-quarter section of 40 acres, upon a plan in which the square mile, or section of 640

acres, is the unit of subdivision, while the unit of survey is the township of 36 sections. All agricultural entries are based upon descriptions in accordance with legal subdivisions shown upon the official plat. The plats are constructed in harmony with the official field notes returned by the engineer. The land included in an entry is identified on the ground by fixed monuments established by the engineer. A United States land patent grants to the entryman a title of ownership to a tract defined by certain fixed monuments on the ground and related by description and outline to the official plat. The function of the United States surveyor has been fulfilled when he has properly executed and monumented his survey and returned an official record thereof in the shape of complete detailed field notes and a plat. The function of the local surveyor begins when he is employed as an expert to identify the lands which have passed into private ownership; this may be a simple or a most complex problem, depending largely upon the condition of the original monuments as affected principally by the lapse of time since the execution of the official survey. The work of the local surveyor usually includes the subdivision of the section, already mentioned as the official unit of subdivision, into the fractional parts shown upon the approved plat. In this capacity the local surveyor is performing a function contemplated by law, and he can not properly serve his client or the public unless he is familiar with the legal requirements concerning the subdivision of sections. In the event that the original monuments have become lost the surveyor can not hope effectively to recover said corners without a full understanding of the record concerning their original establishment, nor can the surveyor hope legally to restore the same until he has mastered not only the principles observed in the execution of the original survey, but the principles upon which the courts having jurisdiction over such matters have based their rulings.

195. The General Land Office assumes no control or direction over the acts of local and county surveyors in the matters of subdivision of sections and reestablishment of lost corners of original surveys where the lands have passed into private ownership, nor will it issue instructions in such cases. It follows the general rule that disputes, arising from uncertain or erroneous location of corners, originally established by the United States, are to be settled by the proper local authorities or by amicable adjustment, and the office desires that the rules controlling the acts of its own surveying service be considered by all other surveyors as merely

advisory and explanatory of the principles which should prevail in performing such duties.

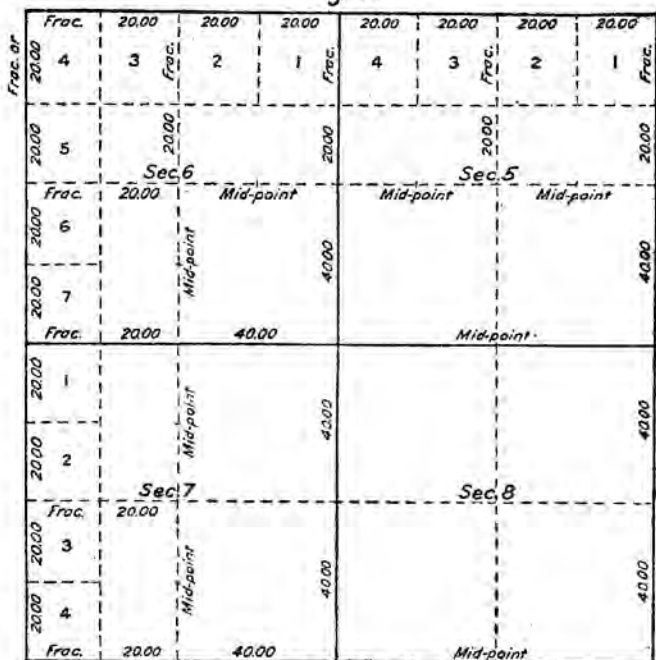
The subject of restoration of lost corners will be treated in a later chapter, as the purpose here is to outline the principles concerning the subdivision of sections, which will be recognized alike by the General Land Office surveying service and by all local surveyors.

SUBDIVISION BY PROTRACTION.

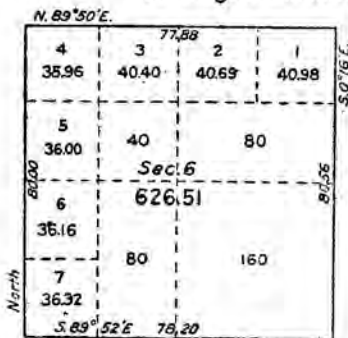
196. Upon the plat of all regular sections the boundaries of the quarter sections are shown by broken straight lines connecting the opposite quarter-section corners. The sections bordering the north and west boundaries of a normal township, excepting section 6, are further subdivided by protraction into parts containing two regular half-quarter sections and four lots, the latter containing the fractional areas resulting from the plan of subdivision of normal townships; the lines of the half-quarter sections are protracted from three points 20 chains distant from the line connecting the opposite quarter section corners, two of said distances counting on the opposite section lines and one counting on the line between the fractional quarter sections; the lines subdividing the fractional half-quarter sections into the fractional lots are protracted from mid-points on the opposite boundaries of the fractional quarter section. The two interior sixteenth-section corners on the boundaries of the fractional northwest quarter of section 6 are similarly fixed at points 20 chains distant north and west from the center of the section, from which points lines are protracted to corresponding points on the west and north boundaries of the section, resulting in subdivisions containing one regular quarter-quarter section and three fractional lots. The fractional lots herein described will be numbered in a regular series progressively from east to west or from north to south, in each section. As section 6 borders on both the north and west boundaries of the township, the fractional lots in the same will be numbered commencing with No. 1 in the northeast, thence progressively west to No. 4 in the northwest, and south to No. 7 in the southwest fractional quarter-quarter section.

Entrymen are allowed, under the law, to acquire title to any regular quarter-quarter section, but as such subdivisions are aliquot parts of quarter sections based upon mid-point protraction, it is not deemed necessary to indicate these lines upon the official plat.

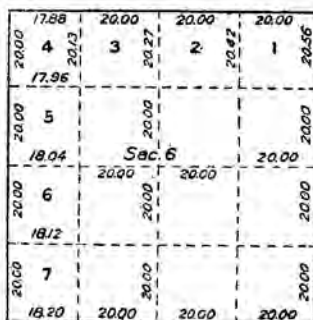
Fig. 47.



Showing normal subdivision of sections.



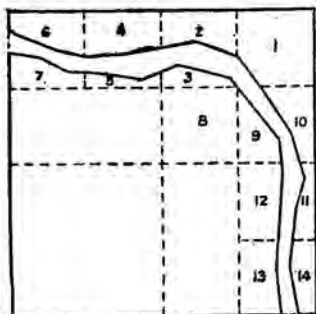
Showing areas.



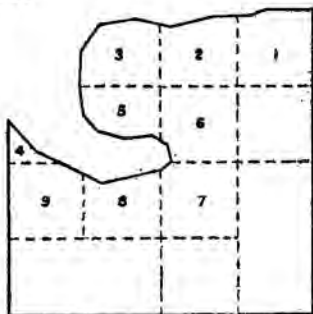
Showing calculated distances.

Examples of subdivision by protraction.

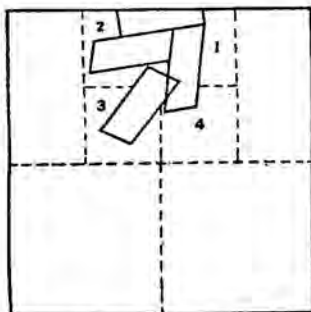
Fig. 48.



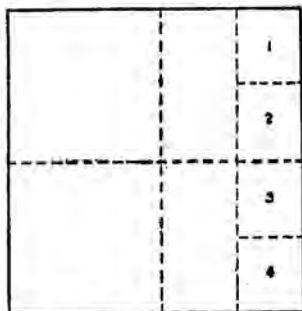
Meanderable River.



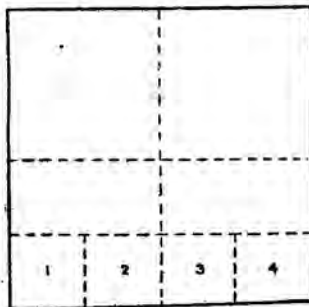
Meanderable Lake.



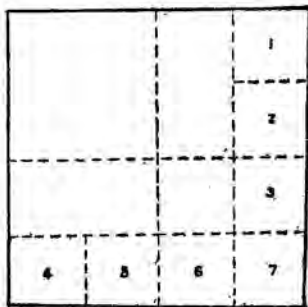
Mineral Claims.



E. bdy. defective in alignment.



S. bdy. defective in alignment.



E & S. bdrs. defective in alignment.

Examples of subdivision of fractional sections.

197. Sections which are invaded by meanderable bodies of water, or by approved claims at variance with the regular legal subdivisions, are subdivided by protraction into regular and fractional parts as may be necessary to form a suitable basis for the entry of the public lands remaining undisposed of, and to describe the latter separately and apart from the segregated areas.

The meander line of a body of water and the boundary lines of private claims are platted in accordance with lines run or connections made in the field; thereupon the sections so invaded are subdivided as nearly as possible in conformity with the uniform plan already outlined. The subdivision-of-section lines are terminated at the meander line or claim boundary, as the case may be, but the position of the subdivision-of-section lines is controlled precisely as though the section had been completed regularly. In the case of a section whose boundary lines are in part within the limits of a meanderable body of water, or within the boundaries of a private claim, the said fractional section lines are, for the purpose of uniformity, completed in theory, and the protracted position of the subdivision-of-section lines is controlled by the theoretical points so determined.

198. In the subdivision of fractional sections as many regular parts should be secured as possible, except to avoid thus creating poorly shaped fractional lots. Skill and judgment must be exercised to accomplish a subdivision which embraces simplicity of platting as well as a form to each and every lot that will prove to be equitable to the entryman. In the case of fractional lots along the north and west boundaries of a township, and in other similar cases where a lot has a full normal width of 20 chains in one direction, it is generally advisable to avoid areas of less than 10 or more than 50 acres, but in the instance of fractional lots along a meander line or other irregular broken boundary, where the width of the lot in both directions may be considerably less than 20 chains, resulting in tracts of more compact form, it is generally better to avoid an area of less than 5 or more than 45 acres. The purpose of the aforesaid limits is to create fractional lots of dimensions that will facilitate all entries being made in a form that is optional with the entryman; an adherence to this practice will greatly reduce the necessity for the construction of supplemental plats now frequently demanded for no other purpose. Extreme lengths or narrow widths should be avoided; the longer direction should extend back from a meander line or

claim boundary rather than along the same. It is inconsistent that a fractional lot lie partly in two sections, and it is generally better, when consistent with other rules, to avoid fractional lots extending from one into another fractional quarter section.

199. To secure a uniform system for numbering lots of fractional sections, including those above specified, imagine the section divided by parallel latitudinal lines into tiers, numbered from north to south; then, beginning with the eastern lot of the north tier, call it No. 1, and continue the numbering west through the tier, then east in the second, west in the third, east in the fourth tier, etc., until all fractional lots have been numbered. A lot extending north and south through two, or part of two tiers, will be numbered in the tier containing its greater area. In case any tier is without numbered lots, the numbering will be continued in the next tier to the south. This method of numbering will apply to any part of a section. A section that has been partly surveyed at different times should have no duplication of lot numbers.

200. When, by reason of irregular surveys or from other causes, the length of a township from south to north exceeds the regular length of 480 chains, or the width from east to west exceeds 480 chains, to such an extent as to require two or more tiers of lots along the north boundary, or two or more ranges of lots along the west boundary, as the case may be, the entire north or west portions of said sections beyond the regular legal subdivisions usually provided in these sections, will be suitably lotted, and to each lot will be assigned a proper number. Certain exceptions to this rule will be found in Chapter VII, in the instance of townships which possess abnormal dimensions in one or both directions.

201. If the first meridional section line of a township has been established as a sectional guide meridian, or the first latitudinal section line has been established as a sectional correction line, fractional lots will result along the east or south boundary of the township, as existing conditions may necessitate. Thus, where either the east or south boundaries of a township are defective in alinement (and not subject to rectification before subdividing) the sections bordering such defective boundaries will be subdivided by protraction in accordance with rules similar to those which operate in regard to sections bordering the north and west boundaries of a normal township. Other examples of subdivision of sections will be found under the general subject of "fragmentary subdivision."

SUBDIVISION BY SURVEY.

202. The rules for subdivision of sections by actual survey in the field are based upon the laws governing the survey of the public lands. When cases arise which are not covered by these rules, and the advice of the General Land Office in the matter is desired, the letter of inquiry should, in every instance, contain a description of the particular tract or corner, with reference to township, range and section of the public surveys, to enable the office to consult the record; also a diagram showing conditions found, giving distances in chains and links and not in feet.

203. Preliminary to subdivision it is essential to know the actual boundaries of the section, as it can not be subdivided legally until the section corners and quarter-section corners have either been found or restored by proper methods, and the resulting courses and distances determined by survey. The practice of entering a section to survey a tract from only one or two corners, and those perhaps unreliable, is unlawful.

204. The order of procedure is: First, identify or reestablish the boundary corners; next, fix the lines of quarter sections; then, form smaller tracts by equitable and proportionate division, according to the following rules:

205. *Subdivision of sections into quarter sections.*—Under the provisions of the act of Congress approved February 11, 1805, the course to be pursued in the subdivision of sections into quarter sections is to run straight lines from the established official quarter-section corners to the opposite corresponding corners. The point of intersection of the lines thus run will be the corner common to the several quarter sections, or, in other words, the legal center of the section.

Upon the lines closing on the north and west boundaries of a regular township the quarter-section corners are established by the United States surveyors at 40 chains to the north or west of the last interior section corners, and the excess or deficiency in the measurement is thrown into the half mile next to the township or range line, as the case may be.

Where there are double sets of section corners on township and range lines the quarter-section corners for the sections south of the township lines and east of the range lines have not always been established in the field by the United States surveyors, but in subdividing such sections said quarter-section corners should be so

placed as to suit the calculations of the areas of the quarter sections adjoining the township boundaries as expressed upon the official plat, adopting proportionate measurements where the new measurements of the north or west boundaries of the section differ from the original measurements.

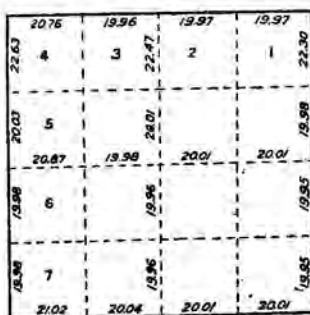
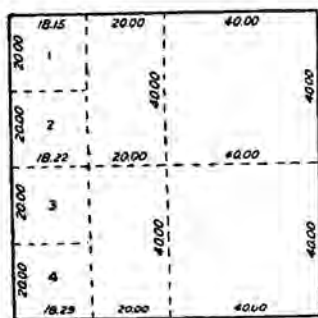
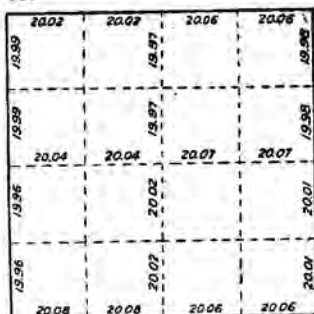
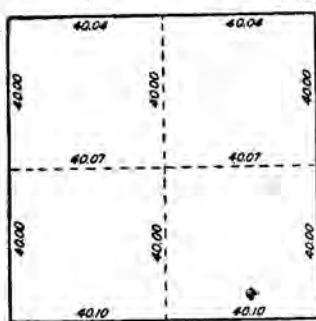
206. Subdivision of fractional sections.—The law provides that where opposite corresponding quarter-section corners have not been or can not be fixed, the subdivision-of-section lines should be ascertained by running from the established corners north, south, east or west lines, as the case may be, to the water course, reservation line, or other boundary of such fractional section, as represented upon the official plat. In this the law presumes the section lines surveyed and marked in the field by the United States surveyors to be due north and south or east and west lines, but this is not usually the case. Hence, in order to carry out the spirit of the law, it will be necessary in running the subdivisional lines through fractional sections to adopt mean courses, where the section lines are not due lines, or to run the subdivision-of-section lines parallel to the east, south, west or north boundary of the section, as conditions may require, where there is no opposite section line. (See sec. 197.)

207. Subdivision of quarter sections into quarter-quarter sections.—Preliminary to the subdivision of quarter sections, the quarter-quarter- or sixteenth-section corners will be established at points midway between the section and quarter-section corners, and between the quarter-section corners and the center of the section, except on the last half mile of the lines closing on irregular boundaries, where they should be placed at 20 chains, proportionate measurement, counting from the regular quarter-section corner.

The quarter-quarter- or sixteenth-section corners having been established as directed above, the center lines of the quarter section will be run straight between opposite corresponding quarter-quarter- or sixteenth-section corners on the quarter-section boundaries. The intersection of the lines thus run will determine the legal center of a quarter section.

208. Subdivision of fractional quarter sections.—The subdivisional lines of fractional quarter sections will be run from properly established quarter-quarter- or sixteenth-section corners, with courses governed by the conditions represented upon the official plat, to the lake, water-course or reservation which renders such tracts fractional. (See sec. 197.)

Fig. 49.



Official measurements.

Remeasurements.

The above examples of subdivision by survey show the relation of the official measurements and calculated distances to the remeasurements, and indicate the proportional distribution of the differences.

209. By "proportionate measurement" is meant a measurement having the same ratio to that recorded in the original field notes as the length of the line by re-measurement bears to its length as given in the record. Reasonable discrepancies between former and new measurements may generally be expected. Errors may occur through many causes and should be as carefully avoided in re-measurements as in original surveys. Instead of the old practice of "adjusting the chain" to suit the former measure, the distance obtained by a precise method is compared with that of the record, and the shortage or surplus is computed by proportion, producing the same result in a more reliable manner. For example: The length of the line from the quarter-section corner on the west boundary of section 2 to the north line of the township, by the United States surveyor's measurement was reported as 43.40 chains, and by the county surveyor's measurement was found to be 42.90 chains; then the distance which the quarter-quarter- or sixteenth-section corner should be located north of the quarter-section corner would be determined by proportion as follows: As 43.40 chains, the official measurement of the whole distance, is to 42.90 chains, the county surveyor's measurement of the same distance, so is 20 chains, original measurement, to 19.77 chains by the county surveyor's measurement, showing that by proportionate measurement in this case the quarter-quarter- or sixteenth-section corner should be set at 19.77 chains north of the quarter-section corner, instead of 20 chains north of said corner, as represented on the official plat. In this manner the discrepancies between original and new measurements are equitably distributed.

210. By way of recapitulation it should be emphasized that when entrymen have acquired title to certain legal subdivisions they have become the owners of the identical ground area represented by the same subdivisions upon the official plat. It is a matter of expert or technical procedure to mark out the legal subdivisions called for in a patent, and entrymen are advised that a competent surveyor should be employed. The surveyor must necessarily identify the section boundaries and locate the legal center of the section in order to determine the boundaries of a quarter section. Then, if the boundaries of quarter-quarter sections, or fractional lots, are to be determined on the ground, the boundaries of the quarter section must be measured, and the sixteenth-section corners thereon should be fixed in accordance with the proportional distances represented upon the approved plat, thereupon the legal center of the quarter section

may be duly located. Thus will be produced in the field the figure represented upon the plat, every part of the former in true proportion to the latter, where the elements of absolute distance and area have given away to corresponding proportional units as defined by fixed monuments established in the original survey.

FRAGMENTARY SUBDIVISION OF TOWNSHIPS.

211. In the preceding articles covering the subject of subdivision of townships every assumption was based upon initiating the subdivisional survey upon regularly established exteriors, or, when necessary, a sectional guide meridian or a sectional correction line, or both, were to be established, upon which rested the control of the subdivision of the township. The subdivision of every full township may always be governed by the aforesaid rules, but many other factors operate in determining the method and order of procedure to be adopted in the instance of fractional townships which have no linear south or east boundary, or in the case of continuing with the survey of partially subdivided townships, where one or more of the previously established section lines may be found to be defective in respect to the rectangular limit, or where partially surveyed sections, or sections containing outlying areas protracted as surveyed, are to be completed. The engineer can not hope to master the subject of fragmentary subdivision of townships until he has become thoroughly familiar with every question relating to the subdivision of sections, nor is it possible to give in the Manual an example of every intricate problem which may be encountered in the field; thus the following discussion deals primarily with the principles, which must be considered in the field, operating to control the engineer's method and order of procedure. It is possible, however, that cases may arise so complex in their character as to produce a feeling of doubt relative to the proper solution of the problem; in which case the engineer will at once communicate with the proper supervising officer, submitting information, by letter and diagram, of the exact condition as found by him, and the necessary instructions will be forwarded as soon as practicable.

FRACTIONAL TOWNSHIPS.

212. Where by reason of the presence of a large meanderable body of water, impassable objects, a State or reservation or grant boundary, or for other similar reasons a township is made fractional

Fig.50.

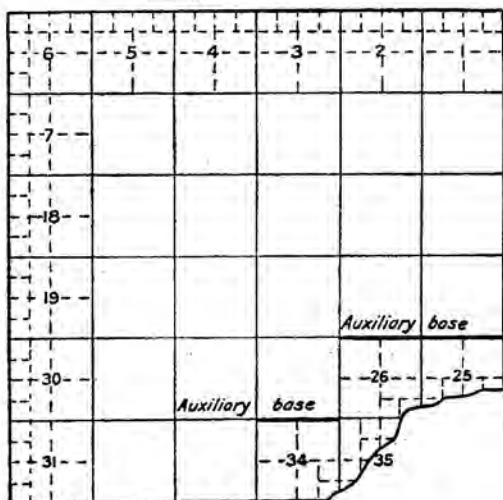
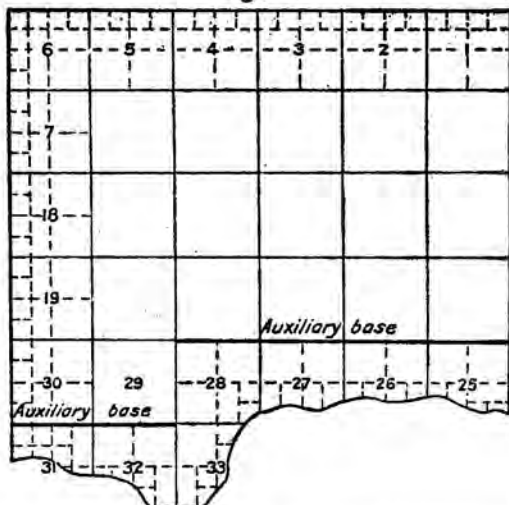


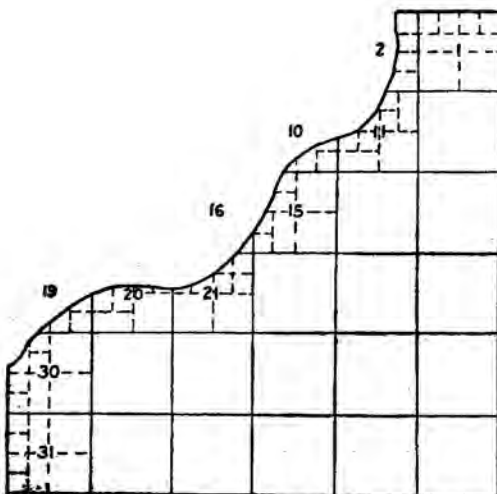
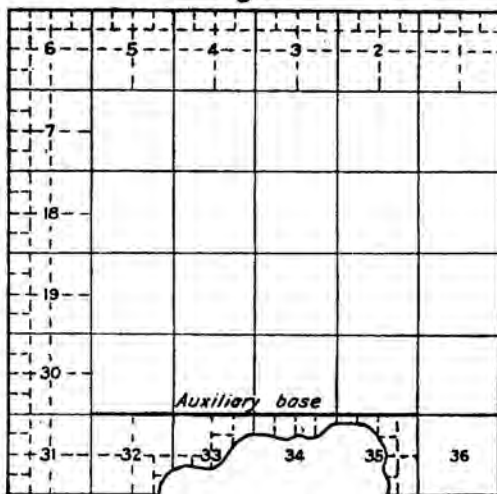
Fig.51.

and is without a full linear south or east boundary, and it has been found advisable to run section lines as offsets to the township exteriors, the fractional section lines south and east of said controlling lines will be projected opposite to the usual direction; the fractional measurements on said lines and the resulting fractional lots will be placed against the irregular boundary. If similar conditions obtain throughout the north or west part of a fractional township no departure from the regular order of subdivision becomes necessary; in all such cases the fractional measurements on the exterior and subdivisional lines, and the resulting fractional lots, will be placed to the north and west against the irregular boundary.

213. Where on account of impassable objects or for other reasons no part of the south boundary of a township can be regularly established, the subdivision thereof may proceed from north to south and from east to west, thereby throwing all fractional measurements and areas against the west boundary and the meanderable stream or other boundary limiting the township on the south; if the east boundary is without regular section corners and the north boundary has been run eastwardly as a true line, with section corners at regular intervals of 80 chains, the subdivision of the township may be made from west to east, in which case the fractional measurements and areas will be thrown against the irregular east boundary; on the other hand, if the north boundary of section 6 is fractional, a sectional guide meridian will be initiated at the easternmost regular section corner on the north boundary of the township, which will be projected to the south to take the place of a governing east boundary, thus the subdivisional survey would be projected from north to south and from east to west, with fractional measurements, and resulting fractional lots, on the east, south and west boundaries of the township. The accompanying diagrams are illustrative of the principles which operate to control the subdivision of partial townships.

214. A very considerable class of surveys now coming before the General Land Office embraces the continuation of the subdivisional survey of townships previously subdivided in part only, frequently including the completion of partially surveyed sections or of sections containing outlying areas protracted as surveyed. If defective conditions are encountered in the previously established surveys, the problems concerning the procedure to be adopted multiply rapidly and require the greatest skill on the part of the engineer.

Fig. 52.

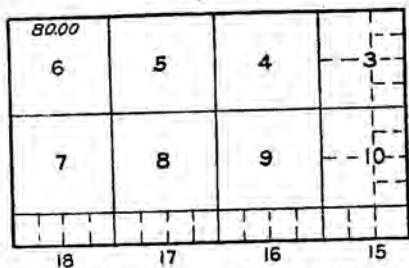
Subdivide Regularly.
Fig. 53.

In the construction of new township plats the former practice of showing certain outlying areas of sections protracted as surveyed has been abandoned as unsatisfactory and inconsistent with the surveying laws.

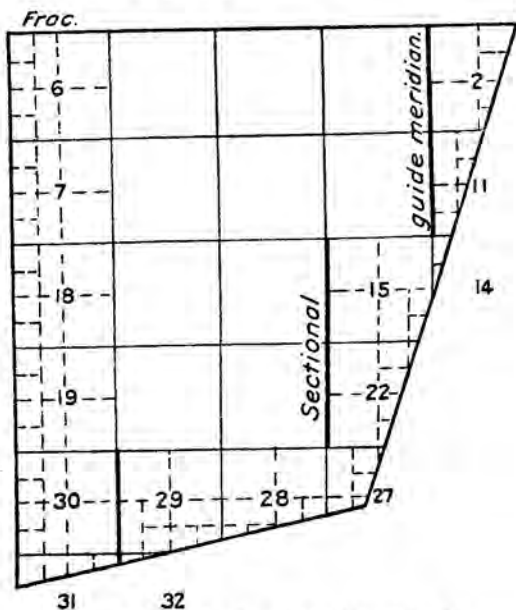
RETRACEMENTS.

215. Practically all fragmentary surveys require more or less retracement of the original surveys in order to identify the initial and closing lines; such retracements will always be accompanied by the restoration of all lost corners adjacent to the sections embracing, in whole or in part, the areas to be included in the extension survey, in-so-far as the section or subdivision-of-section lines controlling the new areas may depend upon the position of the previously established corners. The engineer will often be required, in order to determine properly the position of a lost corner, to retrace additional lines which are not the boundaries of sections containing the new areas to be surveyed, but no reestablishments on such lines are required. The theoretical position of a lost corner may be at variance with an unofficial corner established by local survey, accepted and recognized by the owners of the private lands affected; thus much trouble between landowners is avoided if the reestablishments are confined strictly to those corners which control the position of the section boundaries or the subdivision-of-section lines affecting the public lands to be surveyed. A general exception to the foregoing rule will be made in the case of identified original corners which are adopted as a basis from which to control the reestablishments bordering the public land sections; such original corners, if not in a good state of preservation, will be reconstructed in first-class order, a complete record of which will be embodied in the field notes. All restorations of lost corners will be made in strict accordance with the provisions of Chapter V of the Manual. In the instance of defective conditions contained in the previously established lines, exceeding the rectangular limit, even though all original corners may be fully identified and in a good state of preservation, the necessary retracements of the section boundaries will be made in order to determine the factors entering into the closing error and to furnish suitable data for the calculation of the areas of the resulting fractional lots embraced in the extension survey.

Fig. 54.



Subdivide from north to south, and
from west to east.



Subdivide from north to south,
and from east to west.

Fig. 55.

COMPLETION OF PARTIALLY SURVEYED SECTIONS.

216. Many assignments for fragmentary surveys require the completion of the survey of portions of boundaries of sections heretofore unsurveyed, in which sections are contained areas fixed in position by less than the regular complement of corners usually established for the identification of the legal subdivisions of the section. In the completion of such partially surveyed sections, the engineer will be expected to give full consideration to the manner of protecting acquired rights based upon the former approved plats.

The following ten principles are distinctly applicable to the subject:

1st. The legal procedure governing the subdivision of any normal section into quarter sections is based broadly on the principle that the partition lines may be definitely fixed by four opposite quarter-section corners established on its boundaries; the intersection of the true center lines thus controlled is the legal point for the interior quarter-section corner of a section.

2d. The legal procedure governing the subdivision of regular quarter sections into quarter-quarter sections is based broadly on the same principle of controlling lines projected between opposite sixteenth-section corners of the quarter section, the latter corners established at mid-points on the true lines bounding the quarter section; the intersection of the true center lines of the quarter section is the legal point for the interior sixteenth-section corner of such regular quarter section.

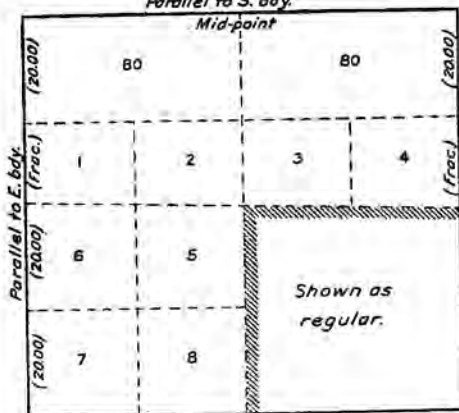
3d. The legal procedure governing the subdivision of sections containing fractional lots into their component regular quarter-quarter sections and fractional lots is based on the same principle with the simple modification that the sixteenth-section corners on the boundaries of such quarter sections are themselves established at distances conformable to the proportions shown on the official plat.

4th. The fact that the full complement of four section corners of the section and all of the four opposite quarter-section corners has not been established in an accepted survey does not impair the validity of any areas shown upon the approved plat, and the legal procedure to be adopted in the extension of the boundaries of such sections must be such as to fix, within reasonable limits, the remaining quarter-section corners in a position which will protect the integrity of the original areas by controlling center lines connecting the old and new quarter-section corners.

5th. In the rectangular system the section is recognized as the unit of subdivision, and in proceeding with the extension of fragmentary surveys first consideration must necessarily be

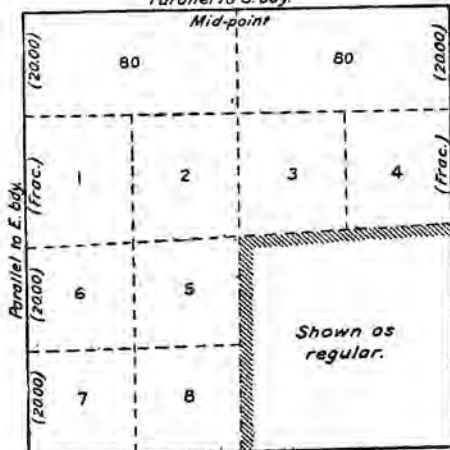
Fig. 56.

Parallel to S. bdy.



Parallel to S. bdy.

Mid-point



East boundary of section out of limits in measurement; southeast quarter protracted as surveyed; and section to be completed.

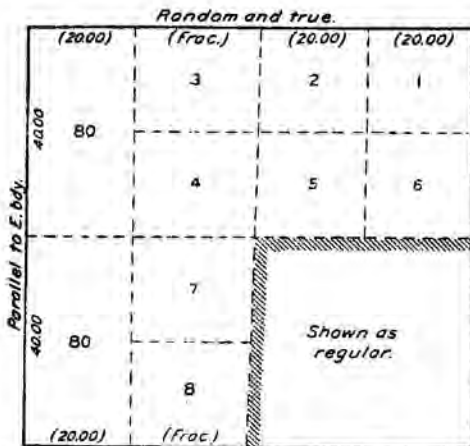
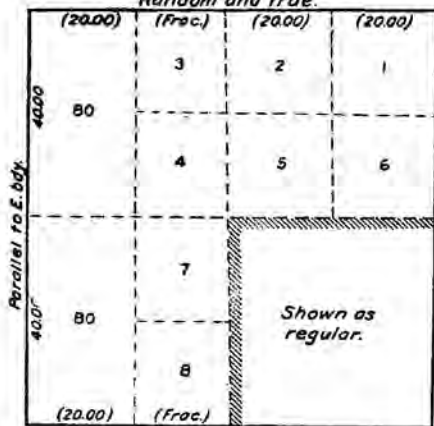
given to the completion of the survey of fractional sections. No invasion of the original unit is tolerable if any portion of such unit has been surveyed, or if outlying areas have been shown protracted as surveyed.

6th. "Reasonable limits" for the fixation of the remaining quarter-section corners of a section in a position which will protect the integrity of the original areas of such section may be considered such as for alinement when not to exceed 21' from a cardinal course, and for measurement when not to exceed 25 links from 40 chains where the opposite portion of the section boundary is shown as 40 chains, or in proportion as a limiting difference when the opposite portion of the section is more or less than 40 chains. This concession as to limits is made in the interest of simplicity, where by such concession rectangularity of both the old and new surveys may be maintained if so harmonized.

7th. The position of the new quarter-section corner which is to be established on the new opposite boundary of a fractional section will be controlled from one direction only if the old opposite distance has been made to count from one direction only, and the controlling measurement will be made to harmonize with the length of the opposite portion of the section, but if the old opposite distance has been made to count from two directions the position of the new quarter-section corner will be controlled from the two directions and the proportional lengths of the two portions of the new line will be made to harmonize with the proportional lengths of the two parts of the old opposite boundary, all as indicated by the distances and areas shown on the original approved plat.

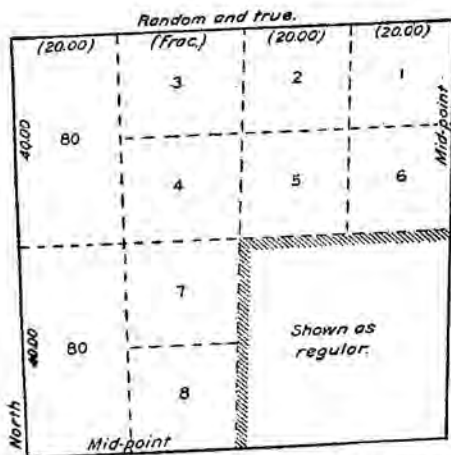
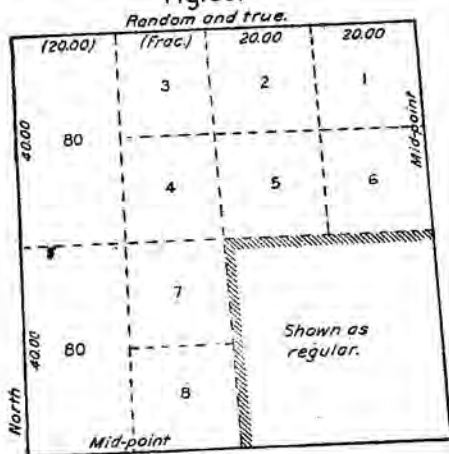
8th. The underlying principles governing the rectangular surveying system are equally applicable to the completion of the survey of fractional sections, and given a condition in an original survey which in all its various elements is "within limits" within the meaning of the rectangular surveys, the simple plan of continuing in the same manner and order as would have been adopted in the original survey, if the same had not been discontinued, will accomplish usually in its simplest form the completion of the survey of fractional sections; this becomes the first duty of the engineer before proceeding with the survey of additional sections, so that should irregularity be developed, no invasion of partially surveyed sections can result from the irregularities of other sections. It follows in principle, when irregularity is developed, that the engineer will be best prepared to determine the proper method of survey adapted to procure simplicity of correction of existing irregularities and an early resumption of regularity, when he is in possession of full data concerning the conditions of all the old lines limiting the fragmentary surveys and upon which the new lines are to be initiated or closed, his knowledge being based upon the results of actual retracement of such irregular

Fig. 57.
Random and true.



South boundary of section out of limits in measurement; southeast quarter protracted as surveyed; and section to be completed.

Fig. 58.



East boundary of section out of limits in alinement; southeast quarter protracted as surveyed; and section to be completed.

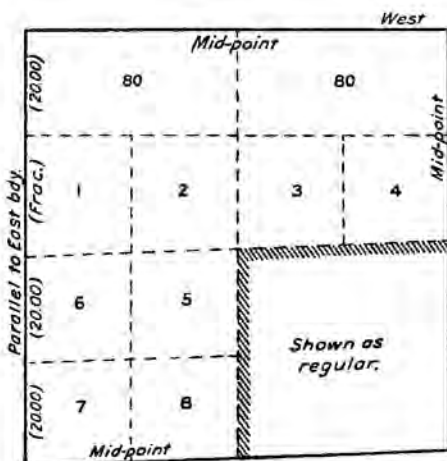
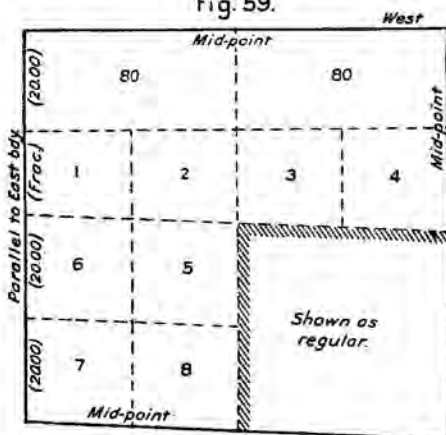
old lines. It must be granted that a skillful exercise of judgment by the engineer based upon his knowledge of the facts is far more desirable than to restrict him to the application of empirical rules devised to cover possible, but innumerable combinations of irregularity.

9th. The completion of the survey of the partially surveyed sections will be made as nearly as possible in accordance with the regular rules for subdividing when the original lines are found to be within limits, otherwise, such sections will be completed by surveying all lines in such a manner that each and every section (excepting in cases of unavoidable hiatus or overlap) shall have four regular boundaries without offsets, with four governing section corners and four controlling quarter-section corners in such positions as to maintain the integrity of the fractional areas already shown upon the original plat. The subdivision thereof may then be made by connecting the opposite quarter-section corners in the regular manner with resulting locations agreeable to the legal subdivisions shown upon the original plat. If an hiatus or overlap is unavoidable, the position of the new quarter-section corner or corners will be carefully determined for latitude on a meridional line or for departure on a latitudinal line on the same plan as would have resulted in the regular survey of a new boundary extending in full from the one or two directions which control the position of the new quarter-section corner or corners.

10th. Adjoining sections must be considered separately when placing the new quarter-section corners, and the new corner need not be common to the four quarters of the two adjoining sections unless the theoretical position for each section falls within 25 links of a common point in which case the difference may be adjusted in such a manner as to secure maximum regularity.

217. Let it be assumed that adjacent to two established section lines, the *meridional* line of which is out of limits in measurement, an outlying regular quarter section has been protracted as surveyed; then to complete the section the new section lines will be extended from the previously established section corners, parallel to the opposite established boundaries, or mean course thereof, to a mutual intersection. The quarter-section corner on the new latitudinal section line would be established regularly at the mean point, and would ordinarily be marked to control the subdivision of two sections. On the new meridional boundary one or two quarter-section corners may be required; one marked to control the subdivision of the section under consideration will be established at 40 chains from the original section corner; the same quarter-section corner would be marked to control the subdivision of the adjoining section if the fractional

Fig. 59.

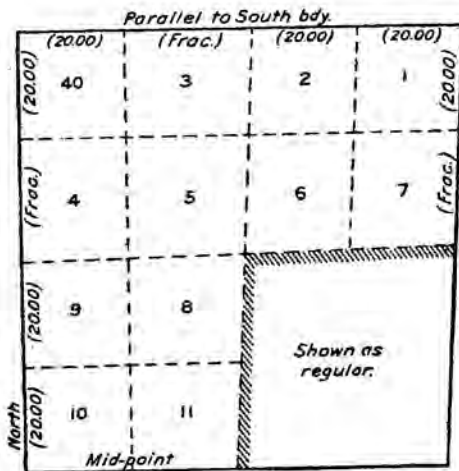
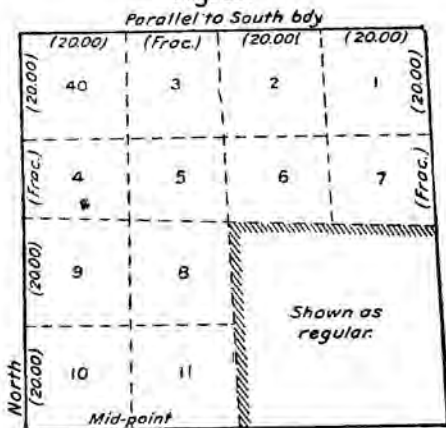


South boundary of section out of limits in alinement; southeast quarter protracted as surveyed; and section to be completed.

measurement is to be thrown in the same direction in the two sections, otherwise an additional quarter-section corner marked to control the subdivision of the adjoining section would ordinarily be placed at 40 chains from the new section corner. Again, let the same condition be assumed with the exception that the *latitudinal* section line instead of the meridional line is found to be defective in measurement. Then, to complete the section, the new meridional line would be surveyed as in regular subdivision, parallel to the opposite meridional line, or mean course thereof, ordinarily with quarter-section and section corners of maximum control at 40 and 80 chains, respectively. The new latitudinal section line would then be established on a true line between the section corners, and one or two quarter-section corners will be established as required; one marked to control the subdivision of the section under consideration will be established at 40 chains from the original section corner; the same quarter-section corner would be marked to control the subdivision of the adjoining section if the fractional measurement is to be thrown in the same direction in both sections, otherwise an additional quarter-section corner marked to control the subdivision of the adjoining section would ordinarily be placed at 40 chains from the new section corner.

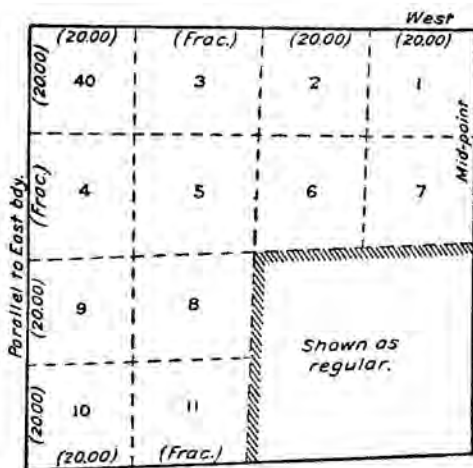
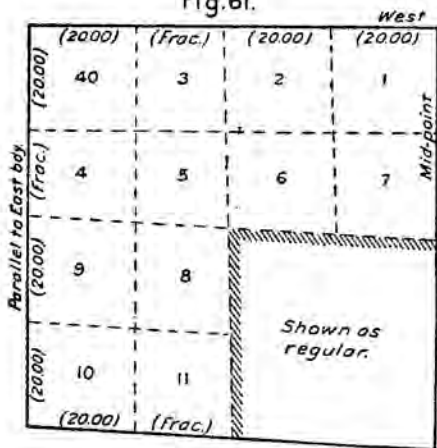
218. Let another assumption be made that adjacent to two established section lines, the *meridional* line of which is out of limits in alinement, an outlying regular quarter section has been protracted as surveyed; then to complete the section, the new meridional line will be projected as a sectional guide meridian, in accordance with the usual rules, ordinarily with quarter-section and section corners of maximum control at 40 and 80 chains, respectively. The new latitudinal section line would then be established on a true line between the section corners, with one or two quarter-section corners as required; one marked to control the subdivision of the section under consideration will be required at 40 chains from the original section corner; the same quarter-section corner would be marked to control the subdivision of the adjoining section if the fractional measurement is to be thrown in the same direction in both sections; otherwise an additional quarter-section corner marked to control the subdivision of the adjoining section will ordinarily be established at 40 chains from the new section corner. On the other hand, if the same conditions be assumed with the exception that the original *latitudinal* section line instead of the meridional line is found to be

Fig. 60.



East boundary of section out of limits in alinement and measurement; southeast quarter protracted as surveyed; and section to be completed.

Fig. 61.



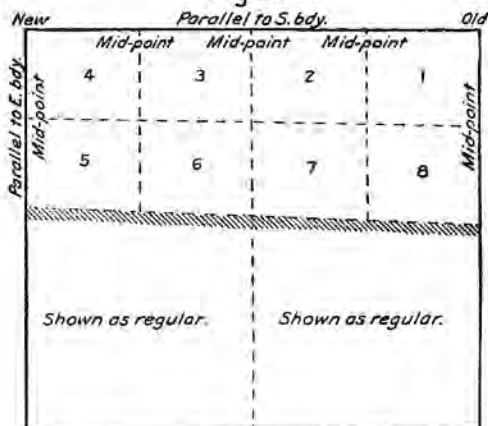
South boundary of section out of limits in alinement and measurement; southeast quarter protracted as surveyed; and section to be completed.

defective in alinement, then the new latitudinal section line will have to be established as a sectional correction line, exactly in accordance with the rules already given for running such lines, ordinarily with section corner of maximum control at its intersection with the new meridional section line, and quarter-section corner of maximum control at mid-point. On the new meridional section line one or two quarter-section corners may be required; one marked to control the subdivision of the section under consideration will be established at 40 chains from the original section corner; the same quarter-section corner may be marked to control the subdivision of the adjoining section if the fractional measurement is to be placed in the same direction in the two sections, but if the fractional measurement is to be thrown in the opposite direction in the adjoining section an additional quarter-section corner marked to control the subdivision of that section would ordinarily be required at 40 chains from the new section corner.

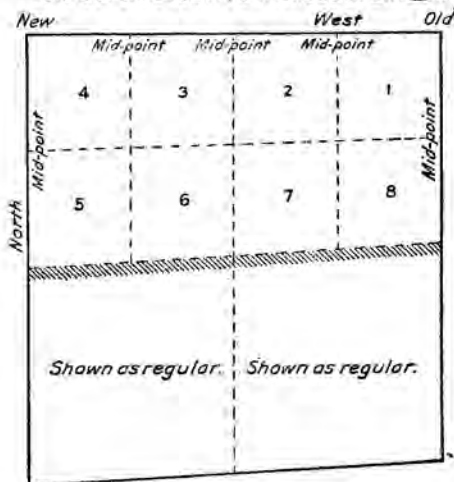
219. Many cases will arise in the field involving combinations of two or more of the above simple examples, in which instance the engineer is advised to prepare a diagram illustrating the conditions found in the original survey, whereupon the new section lines may be shown with alinement in accordance with the usual rules for subdividing townships, noting that the new section lines are to be initiated at the previously established original section corners, and that the *length* of the meridional boundary will depend both upon the regularity of the length of the opposite original meridional section line and upon the alinement of the previously established latitudinal section line; thereupon the engineer may at once show upon his diagram the position of the necessary quarter-section corners on the new section lines, all in conformity with the simple rules already stated.

220. Other instances will be found where half sections are shown upon the original approved plat protracted as surveyed, in some cases where only the opposite section line has not been established and in other cases where parts of the adjacent as well as the opposite section lines have not been established. In case only one section line remains to be established, it will be located upon the true line connecting the original section corners, regardless of bearing; the new opposite quarter-section corner marked to control the subdivision of the stated section will be placed at mid-point, regardless of the length of the new section line; the position of the quarter-

Fig. 62.



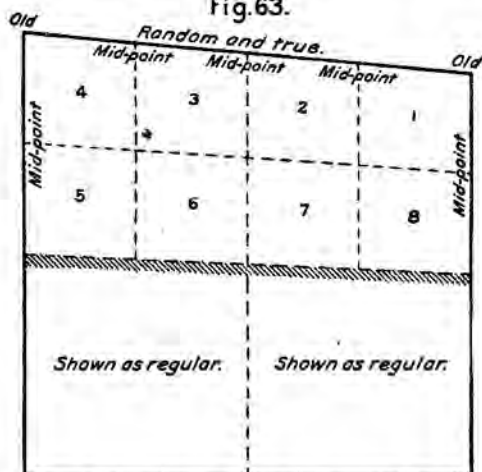
Old bdrs. defective in measurement.



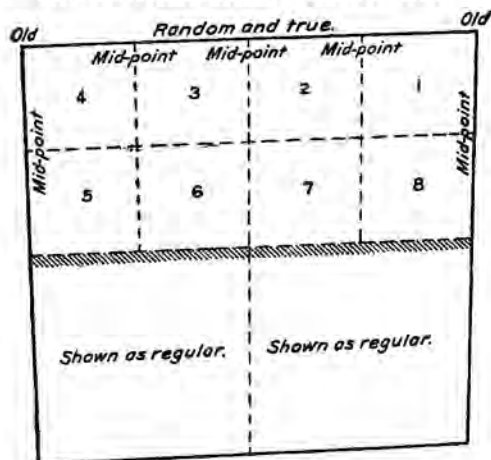
Old bdrs. defective in alignment.

South half protracted as surveyed, and section to be completed.

Fig. 63.



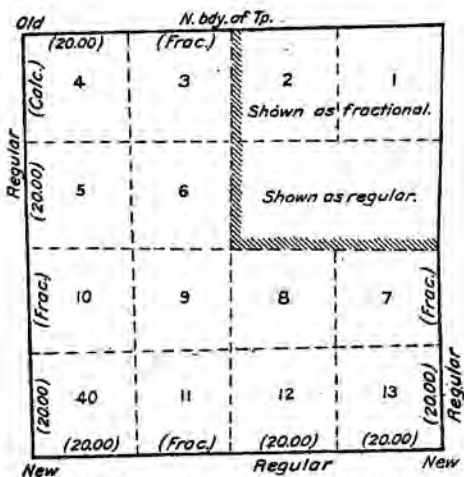
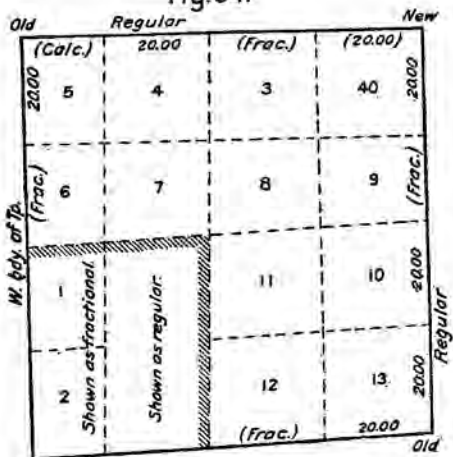
Old bdrs. defective in measurement.



Old bdrs. defective in alignment.

South half protracted as surveyed, and section to be completed.

Fig. 64.



Old surveys irregular; protracted areas shown as fractional; and section to be completed.

section corner marked to control the subdivision of the adjoining section will depend upon the plan of subdividing the remaining public land. Partially surveyed section lines will be completed by extension, the alinement of the same being governed by the usual rules for regular subdivision; the latitudinal or meridional position of the remaining section line (opposite to the half section protracted as surveyed) will usually be controlled by the position of the nearest original section corner, and the alinement of the same will depend upon the usual rules for regular subdivision; the new opposite quarter-section corner marked to control the subdivision of the section containing such half section protracted as surveyed will be placed at mid-point in every case; the position of the quarter-section corner marked to control the subdivision of the adjoining section will depend upon the manner of subdividing the remaining public land.

221. Various other examples will be found where fractional areas, as along the north or west boundary of a township, are shown upon the original approved plat protracted as surveyed. In all such instances the same rules, heretofore stated, may be applied, with the single exception that a calculation must be made, based upon the areas shown upon the original plat, of the theoretical lengths of all lines not established in the original survey. Such calculated distances will then control instead of the usual regular lengths of section lines as heretofore assumed; also, if such calculated distances count from two directions, and irregularities are developed, the calculations must again be resolved into proportional distances to agree with actual measurements between the controlling points.

222. On the accompanying diagrams are shown various exaggerated examples of the manner of completing the survey of irregular sections containing outlying areas protracted as surveyed, showing the application of the means necessary for the protection of the integrity of such areas. It is recognized that the general principles above set forth will not always permit the complete establishment and appropriate marking of all corners at the first determination of their locations, by reason of the fact that only the bringing up of the new surveys to be closed upon the completed units will develop the appropriate markings of the finished corner, but this need not impair the engineer's confidence in his knowledge of necessary procedure in the initiatory work, to be recognized and applied appropriately when the new surveys are brought up to their closings.

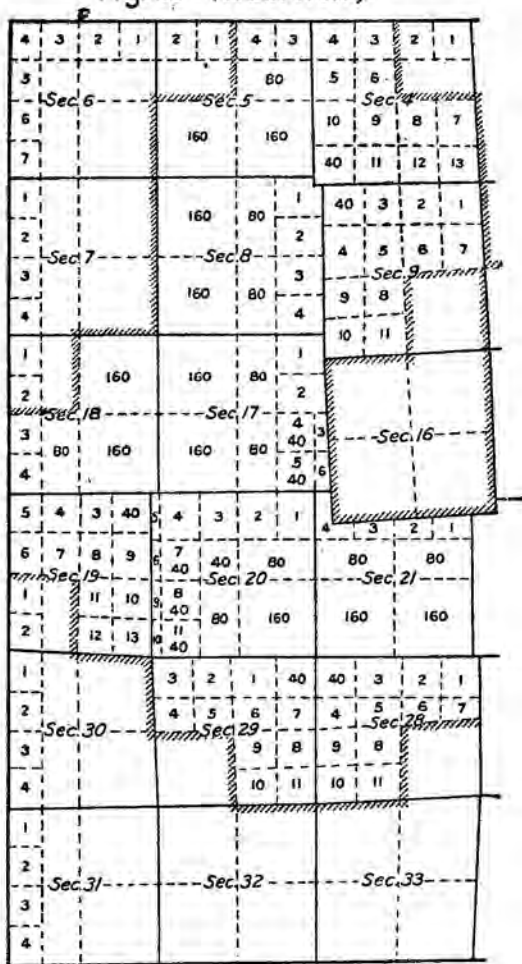
223. A distinctly different class of partially surveyed sections is found along erroneous meander lines shown upon approved plats of fractional townships. Such sections are never subject to completion except as definitely authorized in the written special instructions furnished to the engineer, as the approved plat must be held to represent correctly a true meanderable body of water until proven otherwise to the satisfaction of the Department of the Interior, as intimated in Chapter I. Numerous instances are on record, however, where the evidence submitted to the Department is conclusive that surveyors have erroneously classified overflowed lands as meanderable, or where the recorded meander line does not and never did conform to the mean high-water elevation of an actual meanderable body of water, thus erroneously omitting considerable areas of land. The questions of title to such areas are extremely intricate, and it is the practice of the General Land Office not to allow any extension of such original surveys until the procedure has been definitely authorized by the Secretary of the Interior. The surveying problems arise only when the extension of the original survey beyond the meander line shown upon the approved plat has been duly authorized.

The reestablishment of the original meander line with a suitable monument at each angle point is a usual accompaniment of the above class of surveys, the purpose being to segregate definitely the previously surveyed areas from the unsurveyed public lands; it is more appropriate to consider the surveying questions thus involved along with other problems relating to the reestablishment of broken boundaries, where the subject will be found in sec. 380, Chapter V. The next step in the field is to complete the partially surveyed sections and the procedure in practically every instance will be controlled by the rules already outlined in respect to the completion of the survey of sections containing outlying areas protracted as surveyed; it seems unnecessary to repeat the governing principles in such closely related cases.

SUBDIVISION OF FRACTIONAL SECTIONS RESULTING FROM FRAGMENTARY SURVEYS.

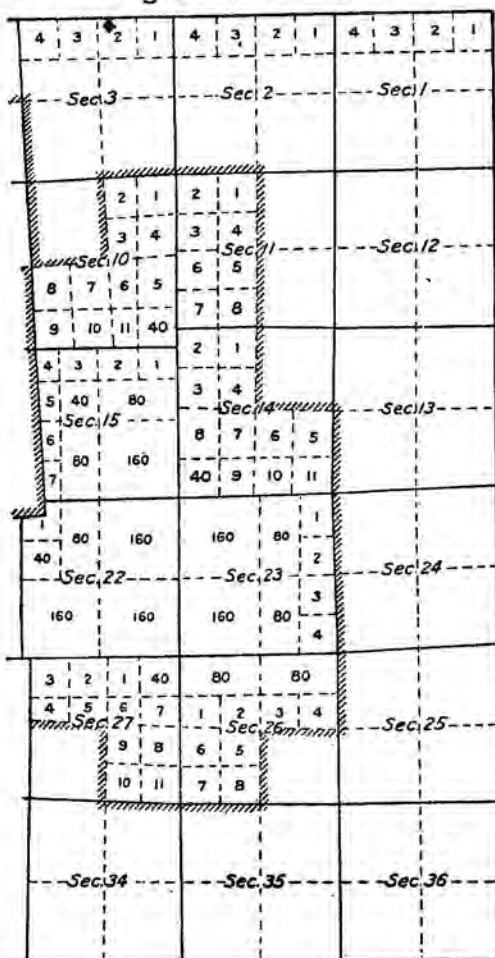
224. The one best test of the fitness of a proposed method incident to the completion of partially surveyed sections will be found in platting the section for subdivision by protraction; thereupon the regular rules for subdivision of sections should be applicable. Thus

Fig. 65 (West half)



Example showing the completion of partially surveyed sections, the subdivision of resulting from

Fig. 65 (East half)



fractional sections, and the completion of the subdivisinal lines of a partial township fragmentary surveys.

the position of the new quarter-section corners, established to control the subdivision of a particular section in question, must be such as to permit the center lines from said points to the opposite original quarter-section corners to be connected in strict harmony with the conditions represented upon the original approved plat, disregarding the effect upon the subdivision of the newly surveyed public land. Likewise the lines connecting the sixteenth-section corners on the opposite boundaries of a quarter section must conform to the conditions represented upon the original plat. When the subdivision-of-section lines are thus platted the section may be considered satisfactory if the integrity of the original areas is in no way violated. When the subdivision-of-section lines are platted as suggested, the permanent conditions affecting the new areas may be considered, and should be harmonized with the following additional rules:

1st. The new areas should be complementary to the original areas by the extension of the subdivision-of-section lines as already protracted upon the original plat, except as poorly shaped lots, or lots of too great or too little area, would result in violation of the regular rules for subdivision of sections.

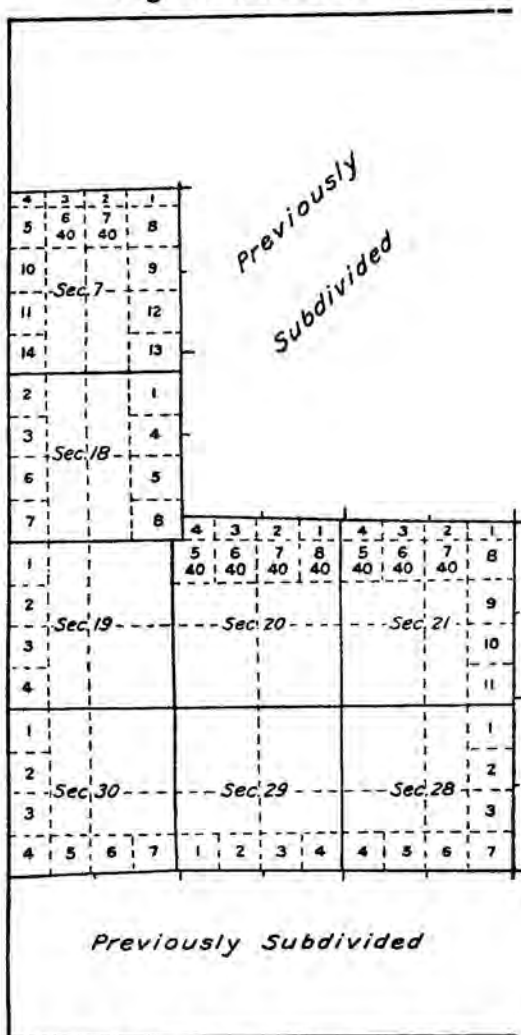
2d. The same meridional limit may be permitted, in the interest of regularity and simplicity of platting, as is ordinarily allowed in latitudinal section lines; i. e., a section may be considered regular whose boundary lines are all for alinement when not to exceed 21' from a cardinal course, and for measurement when not to exceed 25 links from 40 chains between the section and quarter-section corners. Such regular sections may be subdivided into regular quarter sections and quarter-quarter sections as far as possible. A section having three regular boundary lines may be subdivided in accordance with the usual rules for subdividing sections along the north and west boundaries of a normal township. A section having two adjacent regular boundary lines may be subdivided similarly to the manner in which section 6 of a normal township is treated. All other sections should be treated as irregular, with subdivision-of-section lines protracted to mid-points on the boundaries of the quarter sections, except as a calculated proportional position for a sixteenth-section corner is made necessary by reason of conditions relating to the complementary area shown upon the original plat.

3d. All new fractional lots will be numbered beginning with the next higher number in the series of the same section already begun upon the previously approved plat, and proceeding in the usual

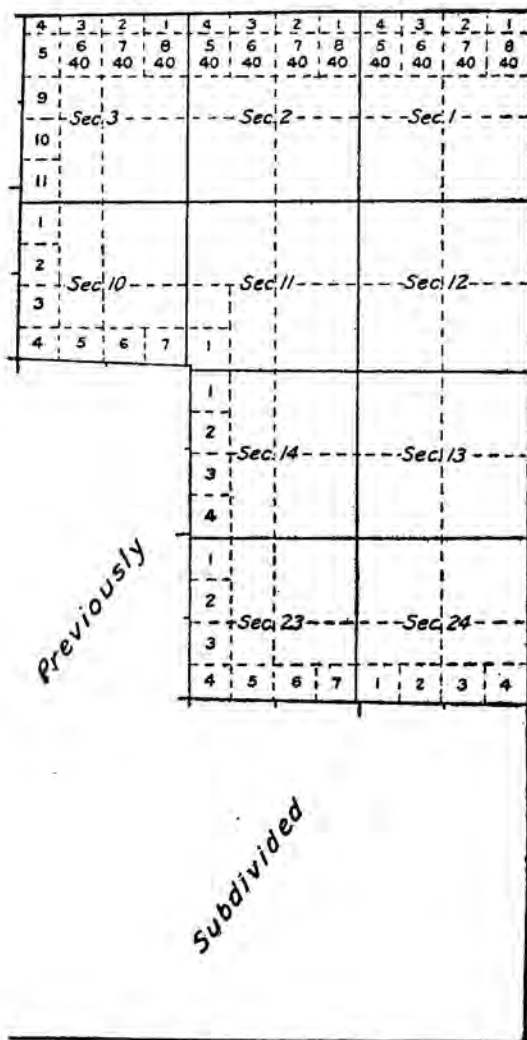
order in which fractional lots are normally numbered. The new series may begin with No. 1 in case the fractional parts of the original area are not designated by lot number.

COMPLETING THE SUBDIVISION OF A PARTIAL TOWNSHIP RESULTING FROM FRAGMENTARY SURVEYS.

225. After the partially surveyed sections have been fully completed the engineer may proceed with the subdivision of the remaining portions of the township. Every condition represents a separate problem, and few specific rules would serve any purpose in guiding the engineer to a definite procedure. If no irregularities are to be found in the previously established lines the new survey may proceed normally, but if defective conditions are encountered the irregularities are not to be extended into unsurveyed sections any farther than necessary to incorporate the resulting fractional measurements into suitable fractional lots adjoining the former surveys. Preference should be given to extending all surveys from south to north and from east to west, but if a better control is available by reversing the procedure in one or both directions, thus resulting in a simpler and better survey in respect to minimizing the number of extra corners as well as fractional lots, such reversal of procedure is fully warranted. The principle relating to controlling coördinate measurements in two directions at right angles, as along the south and east boundaries of a township, may be applied to the subdivisional lines best suited to control the new surveys to be executed; and, if the selected bases are defective in alinement, in whole or in part, the new section lines may serve the function of a sectional guide meridian or a sectional correction line as required. The corners from which the new surveys are to be initiated and controlled in latitude and departure will be termed corners of four sections, or of two sections as appropriate, and where the terminal lines can not be connected regularly with the previously established section corners by random and true line not exceeding 21' from cardinal, a closing section corner will be established in full accord with the principle relating to the establishment of closing section corners on the north or west boundaries of a township where the latter lines are found to be defective in measurement. The fractional measurements of the closing section lines will be placed adjacent to the old surveys, and the distance from the closing section corner to the nearest original corner will

Fig. 66^v (West half)

Example showing the completion of the subdivisional lines

Fig. 66 (*East half*)

of a partial township resulting from fragmentary surveys.

be measured; the original lines forming the boundary of the lands to be surveyed will be retraced, as already provided, and the marks upon the original corners will be appropriately modified as necessary; new quarter-section corners marked to control the subdivision of the new sections will be established on the original lines at mid-points between the closing section corners, or at 40 chains from one direction, according to the manner in which a new section is to be subdivided.

There are generally two or more ways in which a fragmentary subdivision may be executed, but a careful study of a sketch plat representing existing conditions will generally reveal the superiority of one method over another, and objectionable results should be avoided as far as existing conditions relating to the original surveys will permit.

MEANDERING.

226. All navigable bodies of water and other important rivers and lakes (as hereinafter described) are to be segregated from the public lands at mean high-water elevation. The traverse of the margin of a permanent natural body of water is termed a meander line.

The running of meander lines has always been authorized in the survey of public lands fronting on large streams and other bodies of water, but the mere fact that an irregular or sinuous line must be run, as in case of a reservation boundary, does not entitle it to be called a meander line except where it closely follows the bank of a stream or lake. The legal riparian rights connected with meander lines do not apply in case of other irregular lines, as the latter are strict boundaries.

Mean high-water mark has been defined in a State decision (47 Iowa, 370) in substance as follows: High-water mark in the Mississippi River is to be determined from the river bed; and that only is river bed which the river occupies long enough to wrest it from vegetation. In another case (14 Penn. St., 59) a bank is defined as the continuous margin where vegetation ceases, and the shore is the sandy space between it and low-water mark.

Numerous decisions in the United States Supreme Court and many of the State courts assert the principle that meander lines are not boundaries defining the area of ownership of tracts adjacent to waters. The general rule is well set forth (10 Iowa, 549) by saying that in a navigable stream, as the Des Moines River in Iowa,

high-water mark is the boundary line. When by action of the water the river bed changes, high-water mark changes and ownership of adjoining land progresses with it.

Meander lines will not be established at the segregation line between upland and swamp or overflowed land, but at the ordinary high-water mark of the actual margin of the river or lake on which such swamp or overflowed lands border.

227. Practically all inland bodies of water pass through an annual cycle of changes from mean low water to flood stages, between the extremes of which will be found mean high water. In regions of broken topography, especially where bodies of water are bounded by sharply sloping lands, the horizontal distance between the margins of the various water elevations is comparatively slight, and the engineer will not experience much difficulty in determining the horizontal position of mean high-water level with approximate accuracy; but in level regions, or in any locality where the meanderable bodies of water are bordered by relatively flat lands, the horizontal distance between the successive levels is relatively great. The engineer will find the most reliable indication of mean high-water elevation in the evidence made by the water's action at its various stages, which will generally be found well marked in the soil, and in timbered localities a very certain indication of the locus of the various important water levels will be found in the belting of the native forest species.

Mean high-water elevation will be found at the margin of the area occupied by the water for the greater portion of each average year; at this level a definite escarpment in the soil will generally be traceable, at the top of which is the true position for the engineer to run the meander line. A pronounced escarpment, the result of the action of storm and flood waters, will often be found above the principal water level, and separated from the latter by the storm or flood beach; another less evident escarpment will often be found at the average low-water level, especially of lakes, the lower escarpment being separated from the principal escarpment by the normal beach or shore. While these questions properly belong to the realm of geology, they should not be overlooked in the survey of a meander line.

Where native forest trees are found in abundance bordering bodies of water, those trees showing evidence of having grown under favorable site conditions will be found accurately belted along

contour lines; thus a certain class of mixed varieties common to a particular region will be found only on the lands seldom if ever overflowed; another group of forest species will be found on the lands which are inundated only a small portion of the growing season each year, and indicate the area which should be included in the classification of the uplands; other varieties of native forest trees will be found only within the zone of swamp and overflowed lands. All timber growth normally ceases at the margin of permanent water.

228. At every point where either standard, township or section lines intersect the bank of a navigable stream, or any meanderable body of water, corners at such intersections will be established at the time of running these lines. Such monuments are called meander corners. In the survey of lands bordering on tide waters, meander corners may be temporarily set at the intersection of the surveyed lines with the margin of mean high tide, but no monument should be placed in a position exposed to the beating of waves and the action of ice in severe weather. In all such cases a witness corner on the line surveyed, at a secure point near the true point for the meander corner, will be established. The crossing distance between meander corners on the same line will be ascertained by triangulation or direct measurement, and the full particulars will be given in the field notes.

229. Inasmuch as it is not practicable in public-land surveys to meander in such a way as to follow and reproduce all the minute windings of the high-water line, the United States Supreme Court has given the principles governing the use and purpose of meandering shores in its decision in a noted case (*R. R. Co. v. Schurmeir*, 7 Wallace, 286-287) as follows:

“Meander lines are run in surveying fractional portions of the public lands bordering on navigable rivers, not as boundaries of the tract, but for the purpose of defining the sinuocities of the banks of the stream, and as the means of ascertaining the quantity of land in the fraction subject to sale, which is to be paid for by the purchaser. In preparing the official plat from the field notes, the meander line is represented as the border line of the stream, and shows to a demonstration that the water-course, and not the meander line as actually run on the land, is the boundary.”

230. The engineer will commence the meander line at one of the meander corners, follow the bank or shore line, and determine the true bearing and measure the exact length of each course, from

the beginning to the next meander corner. All meander courses are to be taken or counted from the true meridian and will be determined with precision; "transit angles" showing only the amount of the deviation from the preceding course are not acceptable in field notes of meanders. For convenience the courses of meander lines should be adjusted to the exact quarter degree; meander lines are not strict boundaries and this method will give approximate agreement with the minute sinuosities of mean high-water elevation. Again, for convenience of platting and computation, the engineer is required to adopt turning points at distances of whole chains, or multiples of 10 links, with odd links only in the final course.

In cases where the engineer finds it impossible to carry his meander line along mean high-water mark, his notes should state the distance therefrom and the obstacles which justify the deviation. A table of latitudes and departures of the meander courses should be computed before leaving the vicinity, and if misclosure is found, indicating error in measurement or in reading courses, the lines should be rerun.

All streams flowing into a river, lake or meanderable bayou will be noted, and the width at their mouths stated; also, the position, size and depth of springs, whether the water be pure or mineral; also, the heads and mouths of all bayous, all rapids and bars, will be noted, with intersections to the upper and lower ends of the latter, to establish their exact situation. The elevation of the banks of lakes and streams, the height of falls and cascades, and the length and fall of rapids, will be recorded in the field notes.

The field notes of meanders will show the corners from which the meanders commenced and upon which they closed, and will exhibit the meanders of each fractional section separately; following, and composing a part of such notes, will be given a description of the adjoining land, soil and timber, and the depth of inundation to which the bottom land is subject. The utmost care will be taken to pass no object of topography, or change therein, without giving a particular description thereof in its proper place in the notes of the meanders.

RIVERS.

231. Proceeding downstream, the bank on the left hand is termed the left bank and that on the right hand the right bank. These terms will be universally used to distinguish the two banks of a

river or stream. Navigable rivers and bayous, as well as all rivers not embraced in the class denominated "navigable," the right-angle width of which is 3 chains and upwards, will be meandered on both banks, at the ordinary mean high-water mark, by taking the general courses and distances of their sinuosities. Rivers not classed as navigable will not be meandered above the point where the average right-angle width is less than 3 chains, except that streams which are less than 3 chains wide and which are so deep, swift and dangerous as to be impassable may be meandered, where good agricultural lands along the banks require their separation into fractional lots for the benefit of settlers.

Shallow fresh-water streams, without any well-defined channel or permanent banks, will not be meandered. Tidewater streams, whether more or less than 3 chains wide, should be meandered at ordinary high-water mark, as far as tidewater extends.

LAKES.

232. The meanders of all lakes of the area of 25 acres and upwards, will be commenced at a meander corner and continued, as above directed for navigable streams; from said corner, the courses and distances of the entire margin of the same, and the intersections with all meander corners established thereon, will be noted.

In the case of lakes which are found to be located entirely within the boundaries of a section, a quarter-section line, if one crosses the lake, will be run from one of the quarter-section corners, on a theoretical course to connect with the opposite quarter-section corner, to the margin of the lake, and the distance will be measured; then at the point thus determined a "special meander corner" will be established. If a meanderable lake is found to be located entirely within a quarter section, an "auxiliary meander corner" will be established at some suitable point on its margin, and a connecting line will be run from said monument to a regular corner on the section boundary. A connecting traverse line will be recorded, if one is run, but it will also be reduced to the equivalent direct connecting course and distance, all of which will be stated in the field notes, and the course and length of the direct connecting line will be shown on the plat of the survey.

The meander line of a lake lying within the interior of a section will be initiated at the established special or auxiliary meander corner, as the case may be, and continued around the margin of the

normal lake at its mean high-water level, to a closing at the point of beginning. All proceedings are to be fully entered in the field notes.

Artificial lakes and reservoirs are not to be segregated from the public lands, unless specially provided in the instructions, but the true position and extent of such bodies of water will be determined in the field and shown on the plat.

ISLANDS.

233. In the progress of the regular surveys every island above the mean high-water elevation of any meanderable body of water, excepting only those islands which may have formed in navigable bodies of water after the date of the admission of a State into the Union, will be definitely located by triangulation or direct measurement or other suitable process, and will be meandered and shown upon the official plat.

In the survey of the mainland fronting on any non-navigable body of water, any island opposite thereto, above mean high-water elevation, is subject to survey. Also, even though the United States may have parted with its title to the adjoining mainland, an island in any meandered body of water, navigable or non-navigable, known or proven to have been in existence at the date of the admission of a State into the Union, and at the date of the survey of the mainland, if omitted from said original survey, remains public land of the United States, and as such the island is subject to survey.

The survey of islands not shown upon the original approved plats of subdivided townships is authorized by the Department only upon the receipt of formal application, and subject to the approval thereof. The proof of the time of the formation of such islands is often more or less difficult, and it is the practice of the Department to make a careful examination of the history of an island in relation to the question of its legal ownership before approving the application for its survey.

Any township boundary or section line which will intersect an island will be extended as nearly in accordance with the plan of regular surveys as conditions will permit, and the usual township, section, quarter-section and meander corners will be established on the island. If an island falls in two sections only, the line between those particular sections should be established in its proper theoretical position based upon suitable sights and calculations.

If an island falls entirely in one section, and is large enough to be subdivided (over 50 acres in area), a suitable sight or calculation will be made to locate on the margin of the island an intersection with the theoretical position of any suitable subdivision-of-section line, and at the point thus determined a "special meander corner" will be established. In the case of an island falling entirely in one section and found to be too small to be subdivided, an "auxiliary meander corner" will be established at any suitable point on its margin, which will be accurately connected with any regular corner on the mainland. The direct course and length of the connecting line will be given in the field notes, together with all sights, measurements, triangulations and traverse lines upon which the calculation may be based. The course and length of the direct connecting line will be shown on the plat.

The meander line of an island will be surveyed in harmony with principles and rules heretofore stated; all township and section lines crossing the island will be shown on the plat; and, if the island is large enough to be subdivided, the subdivision will be accomplished by the protraction of suitable subdivision-of-section lines in their correct theoretical position.

Agricultural upland within the limits of swamp and overflowed lands should be so classified and shown upon the plat accordingly, but such land will not be meandered as an island.

LIMITS OF CLOSURE.

284. Under the general subjects of "township exteriors" and "subdivision of townships" certain definite limits were prescribed beyond which previously established surveys are classed as "defective," or in the case of new surveys corrective steps are required. Such limits constitute the standard of accuracy of the United States rectangular surveys, and, for convenience, have been variously referred to as the "rectangular limit," "limit for the control of new surveys," "limit relating to defective exteriors and section lines," "limits for subdivision," etc., each expression having been formed to suit the descriptive exigency of the text. A more general requirement known as the "limit of closure" will be applied as a test of the accuracy of the alinement and measurement of all classes of lines embraced in any closed figure incident to the public-land surveys, and corrective steps will be required wherever this test discloses an error beyond the allowable limit.

The "error of closure" of a survey may be defined, in general terms, as the ratio of the length of the line representing the equivalent of the errors in latitude and departure (as found by a table of latitudes and departures) to the length of the perimeter of the figure constituting the survey; but, with due regard for the controlling coördinate governing lines of a rectangular survey, pronounced accuracy in latitude will not be permitted to offset gross error in departure, or vice versa, and, in order to be consistent with this fundamental theory, a double test must be applied in place of the one expressed in general terms. The "limit of closure" fixed for the United States rectangular surveys may be expressed by the fraction $\frac{1}{432}$ provided that the limit of closure in neither latitude nor departure exceeds $\frac{1}{864}$, and where a survey qualifies under the latter limit the former is bound to be satisfied; thus an accumulative error of $12\frac{1}{2}$ links per mile of perimeter, in either latitude or departure, will not be exceeded in an acceptable survey. The limit of closure as thus expressed may be applied to various specific conditions as heretofore stated.

The latitudes and departures of a normal section shall each close within 50 links; of a normal range or tier of sections, within 175 links; and of a normal township, within 300 links. The boundaries of each fractional section including irregular claim lines or meanders, or the meanders of an island or lake in the interior of a section, should close within a limit to be determined by the fraction $\frac{1}{864}$ when the error in either latitude or departure is considered separately; the same rule will be applied to all broken or irregular boundaries.

Engineers are required to compute all doubtful closings while in the field in the immediate vicinity of a particular line, or series of lines, in question, and to accomplish all necessary corrective work before concluding a survey.

MARKING LINES BETWEEN CORNERS.

285. The marking of a survey upon the ground in such a manner as to fix forever the position of the legal lines in relation to the earth's surface is the final step in the field work, and is accomplished in three ways, which, if well executed, will individually or collectively furnish the means of the identification of the survey at even remote future dates. Careful attention to these details is one of the most important phases of the engineer's field work. (a) The regular corners of the public-land surveys are marked by fixed monuments

of specified character as described in Chapter IV; (b) the relation of the officially surveyed lines to natural topographical features is recorded in much detail as hereinafter outlined, and again exemplified in the specimen field notes; and, (c) the locus of the legal lines, wherever living timber is encountered, is plainly marked upon the forest trees, which is accomplished by the process of "blazing" and by "hack" marks.

A "blaze" is an ax mark which is made upon a tree trunk at about breast height, in which a flat scar is left upon the tree surface. The bark and a very small amount of the live wood tissue are removed, leaving a smooth surface which forever brands the tree. The size of the blaze depends somewhat upon the size of the tree, but is never made larger than the surface of an ax blade; a blaze 5 or 6 inches in height and from 2 to 4 inches in width is ample to mark any tree.

A "hack" is also an ax mark which is made upon a tree trunk at about breast height, in which a horizontal notch is cut into the surface of the tree. The notch is made "V-shaped," and is cut through the bark and well into the wood. Two hacks are cut in order to distinguish those made in the survey from accidental marks resulting from other causes; a vertical section of the completed official hack mark resembles a "double-V" (Σ) extending across a tree from 2 to 6 inches in length, depending upon the diameter of the tree. The "hack" and "blaze" marks are equally permanent, but so different in character that one mark should never be mistaken for the other.

The marking of trees along the surveyed lines was required by law as positively as the erection of monuments, by the act of 1796, which is still in force. All lines on which are to be established the legal corners will be marked after this method, viz: Those trees which may be intersected by the line will have two hacks or notches cut on each of the sides facing the line, without any other marks whatever. These are called sight trees or line trees. A sufficient number of other trees standing within 50 links of the line, on either side of it, will be blazed on two sides quartering toward the line, in order to render the line conspicuous, and readily to be traced in either direction, the blazes to be opposite each other coinciding in direction with the line where the trees stand very near it, and to approach nearer each other toward the line the farther the line passes from the blazed trees.

Due care will ever be taken to have the lines so well marked as to be readily followed, and to cut the blazes plainly enough to leave recognizable scars as long as the trees stand. This can be accomplished by blazing just through the bark into the live wood tissue. Where trees 2 inches or more in diameter occur along a line, the required blazes will not be omitted. Where trees have branches growing to the ground, the blazes will be omitted unless it is necessary to remove the branches to permit sighting.

Lines are also to be marked by cutting away enough of the undergrowth to facilitate correct sighting of instruments. Where lines cross deep wooded valleys, by sighting over the tops, the usual blazing of trees in the low ground when accessible will be performed, that settlers may find their proper limits of land and timber without special survey. The undergrowth will be especially well cut along all lines within distances of 5 chains of corner monuments and within 2 chains of arteries of travel, to enable other surveyors and settlers to locate the survey readily, but the cutting of the undergrowth may be omitted in deep untraveled ravines unless necessary for accurate sighting or measurement.

Line trees and blazing will be marked only with reference to the established true line, and where lines are run by the "random and true" line method, the marking of line trees and the blazing will be accomplished by returning over the line after all corrections or adjustments to the final line are definitely known. A sufficient number of temporary stakes should be set along a random line to render it generally unnecessary to rerun the true line instrumentally merely for the purpose of blazing the line through timber, as this can usually be accomplished by properly estimating the distance from the temporary stakes, but intersections with line trees will be made with precision, and distances thereto accurately measured.

SUMMARY OF OBJECTS TO BE NOTED, AND SKETCHES.

236. The field notes and plat of a survey are designed to furnish not only a technical record of the procedure, but also of equal importance a report upon the character of the land, soil and timber traversed by the survey, and a detailed schedule of the topographical features along every line, with accurate connections showing the relation of the rectangular surveys to other surveys, to natural objects and to improvements. A triple purpose is thus served: (a) the technical procedure is made a matter of official record; (b)

general information relating to a region is gathered; and, (c) the "calls" of the field notes and the representations of the plat in respect to objects along the surveyed lines furnish important evidence by which the locus of the survey becomes practically unchangeable as contemplated by law.

The specimen field notes and plats are intended to standardize the form of record, and many special matters relating to these subjects are brought together in Chapters VIII and IX, but before concluding the special questions concerning rectangular surveys it is deemed expedient to outline the technical and topographical features which are to be carefully observed and recorded in the field during the progress of the public-land surveys:—

1. The precise course and length of every line run, noting all necessary offsets therefrom, with the reason for making them, and method employed.

2. The kind and diameter of all bearing trees, with the course and distance of the same from their respective corners, and the markings; all bearing objects and marks thereon, if any; and the precise relative position of witness corners to the true corners.

3. The kind of material of which corners are constructed, their dimensions and markings, depth set in the ground, and their accessories.

4. Trees on line. The name, diameter and distance on line to all trees which it intersects, and their markings.

5. Intersections by line of land objects. The distance at which the line intersects the boundary lines of every reservation, town-site, or private claim, noting the exact bearing of such boundary lines, and the precise distance to the nearest boundary corner; the center line of every railroad, canal, ditch, electric transmission line, or other right-of-way across public lands, noting the width of the right-of-way and the precise bearing of the center line; the change from one character of land to another, with the approximate bearing of the line of demarcation, and the estimated height in feet of the ascents and descents over the principal slopes typifying the topography of the country traversed, with the direction of said slopes; the distance to and the direction of the principal ridges, spurs, divides, rim rock, precipitous cliffs, etc.; the distance to where the line enters or leaves heavy or scattering timber, with the approximate bearing of the margin of all heavy timber, and the distance to where the line enters or leaves dense undergrowth.

6. Intersections by line of water objects. All unmeandered rivers, creeks and smaller water-courses which the line crosses; the distance measured on the true line to the center of the same in the case of the smaller streams, and to both banks in the case of the larger streams, the course downstream at points of intersection, and their widths on line, if only the center is noted. All intermittent water-courses, such as ravines, gulches, arroyos, draws, dry-drains, etc.

7. The land's surface; whether level, rolling, broken, hilly or mountainous.

8. The soil; whether rocky, stony, gravelly, sandy, loam, clay, etc., and also whether first, second, third or fourth rate.

9. Timber; the several kinds of timber and undergrowth, in the order in which they predominate.

10. Bottom lands to be described as upland or swamp and overflowed, as contradistinguished under the law, noting the extent and approximate position of the latter, and depth of overflow at seasonal periods. The segregation of lands fit for cultivation without artificial drainage, from the swamp and overflowed lands, where the latter are subject to selection by the States, is always accomplished by legal subdivision, and any smallest legal subdivision is classified as all upland or all swamp and overflowed land accordingly as more than half of the same may be of the character of the one or of the other class of lands; bottom lands will be classified with special consideration to these matters.

11. Springs of water, whether fresh, saline, or mineral, with the course of the stream flowing therefrom. The location of all streams, springs, or water-holes, which because of their environment may be deemed to be of value in connection with the utilization of public grazing lands, and which may be designated as public watering places, will be specially noted.

12. Lakes and ponds, describing their banks, tributaries and outlet, and whether the water is pure or stagnant, deep or shallow.

13. Improvements; towns and villages; post offices; Indian occupancy; houses or cabins, fields, or other improvements, with owner's name; mineral claims; mill-sites; United States mineral monuments, and all other official monuments not belonging to the system of rectangular surveys; will be located by bearing and distance or by intersecting bearings from given points.

14. Coal banks or beds, all ore bodies, with particular description of the same as to quality and extent; all mining surface improve-

ments and underground workings; and salt licks. All reliable information that can be obtained respecting these objects, whether they be on the line or not, will appear in the general description.

15. Roads and trails, with their directions, whence and whither.

16. Rapids, cataracts, cascades, or falls of water, in their approximate position and estimated height of their fall in feet.

17. Stone quarries and ledges of rocks, with the kind of stone they afford.

18. Natural curiosities, petrifications, fossils, organic remains, etc.; also all archaeological remains, such as cliff dwellings, mounds, fortifications, or objects of like nature.

19. The general average of the magnetic declination in the township, with maximum known range of local attraction and other variations, will be stated in the general description, and the general average for the township, subject to local attraction, will be shown upon the plat.

20. *General description.*—The above information will be summarized by townships in a general description which will be made the concluding part of the field notes of every survey. The general description will be made to embrace many more comprehensive details in regard to the characteristics of the region than is feasible to cover as an intimate part of the technical record of the survey, as follows:—

Land.—A general outline of the drainage and topographical features of the township and approximate range of elevation above sea level.

Soil.—The prevailing and characteristic soil types. (See special reference to soil classification, Chap. VII.)

Timber.—The predominant forest species, age, size, condition, etc.

Evidence of mineral.—All known bodies of mineral, and lands whose formation suggests mineral-bearing characteristics, especially with reference to lands of volcanic or igneous origin, will be listed by appropriate legal subdivision, with brief description of the mineral indications. On the other hand, if the engineer finds no apparent indication of mineral deposits, a report to that effect will be embodied in the general description.

Watering places.—The areas embracing all streams, springs, or water holes as may be of special value as public watering places, in connection with the utilization of public grazing lands, will be listed by appropriate legal subdivision, with brief description of the nature of such water supply.

Settlement.—The extent of the settlement at the time of the survey.

Industry.—The industrial possibilities of the township, especially as to the adaptability of the region to agricultural pursuits, stock raising, lumbering, mining, or other profitable enterprise.

Special.—All exceptional steps in the technical process of the survey, and other special matters required in paragraphs Nos. 1 to 19, inclusive, of the above summary, not otherwise suitably recorded will be reported in the general description.

In addition to the field notes the engineers are required to prepare, as the work progresses, an outline diagram showing the course and length of all established lines with connections, and a topographical sketch embracing all features usually shown upon the completed official township plat. These maps will be made to scale, drawn in pencil only, if desired, and will be kept up with the progress of the field work. The interiors of the sections will be fully completed; the topographical features will be sketched with care while in the view of the engineer, and the position within the section of the various details which are to be shown on the completed plat will be located with an accuracy commensurate with their relative importance. The design of the specimen township plat will be followed closely in the preparation of the outline diagram and topographical sketch plat, except that it will generally be desirable to employ a separate sheet for each of the two purposes. These maps will then form the basis of the official plat, the ultimate purpose of which is a true and complete graphic representation of the public lands surveyed.

CHAPTER IV.

CORNER MONUMENTS.

THE LEGAL SIGNIFICANCE OF A CORNER MONUMENT.

237. It is one of the fundamental principles of the surveying laws that absolute permanency be attached to the public-land surveys when the lines have been officially established. The "survey" embraces certain definite technical procedure, heretofore described, also the marking of certain fixed points, as will be described in this chapter, though the establishment of a survey may not be termed "completed" until the field notes and plat and every detail of the technical operation constituting the survey have been finally accepted by the Commissioner of the General Land Office, all as contemplated by law. The law provides that the original corners established during the process of the survey shall forever remain fixed in position, even to disregarding technical errors in the execution of the survey—where discrepancies may have passed undetected prior to the acceptance of the survey and the opening of the lands to entry—and, as an aid to the matter of permanency, the Congress provides for the purchase of durable material for the corner monuments, also a penalty for the defacing of any marks relating to the locus of the survey. If it were possible to carry out the full intent of the surveying laws in regard to the aforementioned particulars, the most intricate of all technical and legal problems relating to surveys—the questions pertaining to the reestablishment of lost corners—would be avoided.

The courts attach major importance to authentic evidence relating to the original position of an official corner monument, such evidence being given far greater weight than the technical record relating to bearings and lengths of lines, and it is assumed in the first instance that the original corners shall serve every necessary purpose for the identification of the survey delineated upon the official approved plat, and of the lands which have passed into private ownership. The legal significance of the original monuments, as thus briefly outlined, makes it mandatory upon the engineer to exercise con-

stant diligence in the workmanlike construction of lasting corners, and alertness in skillfully connecting the same with natural objects or improvements, to the end that the greatest possible permanency may be secured for the public-land surveys.

238. Accordingly, if an engineer is called upon to alter the condition of a previously established point, the utmost regard should be shown for the evidence of the original location of the monument, and the corner will be carefully reconstructed by such additional means as may be appropriate, without destroying the evidence which served to identify its legal position. A complete record will be kept of the description of the old monument as identified, and all alterations and additions thereto.

239. Regulation monuments are employed to mark permanently the position of the quarter-section, section, township and meander corners, appropriate to the subdivision of the public lands, as described in Chapter III; also at such sixteenth-section corners as the requirements of the written special instructions or the exigencies of the survey of fractional sections may demand; also at all angle points along an irregular boundary line, and at intermediate intervals of 40 and 80 chains along such limiting boundary. A more extended discussion of the subject of "angle points" and other monuments to be established upon irregular boundaries will be found in Chapter VII.

240. The position of every corner monument will be "evidenced" by the best of such accessories as may be available, and where the corner point itself can not be marked in the usual manner an appropriate "witness corner" will be established. A "witness meander corner" will be established upon secure ground wherever the intersection of a surveyed line with the mean high-water elevation of a meanderable body of water falls at a point where the monument would be liable to destruction.

241. The field notes relating to the establishment of a corner monument will be introduced into the technical record of the survey at the logical place in the record where the true position for the corner is indicated as having been attained. The record of the monument itself will embrace a description of:

(a) The corner material, including its dimensions, in the order of length and diameter of an iron post; or length, width and breadth of a stone; or the breast height diameter of a tree; (b) the depth set in the ground, with mention of additional support if any; (c) the significance of its position; (d) the markings upon the monu-

ment; and (e) the nature of the accessories, including character, size, position, and markings.

CORNER MATERIAL.

242. The General Land Office has adopted a model iron post for monumenting the public-land surveys, which will be generally used unless exceptional circumstances warrant a departure from this rule. This practice is deemed so important that the engineer is not authorized to exercise an option in the matter, but he may refer the question to the proper supervising officer, who may grant authority for the use of other suitable material, provided the reasons for departing from the general rule are sufficient, in which case a brief statement of the facts will be given in the field notes, in the form of an explanation as to why the model iron posts were not employed.

The model iron post is made from commercial iron pipe, from 1 to 3 inches in diameter, which is cut into lengths of about 36 inches; one end of the pipe is split for a distance of about 4 or 5 inches, and the two halves are spread (when heated) to form flanges or foot plates, at right angles to the axis of the pipe; a brass cap is securely riveted to the opposite end of the pipe; and finally the pipe is filled with concrete. Unless otherwise provided in the written special instructions, the iron posts will be employed as follows: 3-inch, for standard and closing township corners, corners of one, two or four townships, and as required for mile corners and angle points of special boundary surveys; 2-inch, for standard and closing section corners, and corners of one, two or four sections; and, 1-inch, for quarter-section and meander corners, and as required for miscellaneous angle points, sixteenth-section corners and corners of special tract surveys. All witness corners are to be of the same size as would be used for the true corner.

243. The caps of the iron posts are to be suitably and plainly marked with steel dies at the time when used; the posts will be set in the ground about three-fourths of their length; and earth and stone, if the latter is at hand, will be tamped into the excavation to give the post a solid anchorage.

244. Durable native stone may be substituted for the model iron post, if the procedure has been duly authorized, but no stone will be used which measures less than 20 inches in length, or less than 6 inches in either of its minor dimensions, or less than 1,000 cubic inches in volume. A stone should always be selected with regard

to its durability when exposed to the usual weathering influences. Stone will not be used as a corner monument where its position falls among large quantities of loose surface stone or slide rock.

245. A stone will be suitably and legibly marked with a steel chisel or punch with such letters, figures, grooves or notches, as may be required, and will be set firmly in the ground about three-fourths of its length.

246. Both iron post and stone monuments will always be set the usual depth in the ground unless it is impossible to complete the excavation, in which case the monument will be planted as deep as conditions will permit, and the necessary support will be secured by a stone mound.

247. Where the corner point falls upon solid surface rock, preventing excavation, a cross (X) will be cut at the exact corner point, and, if feasible, the monument will be erected in the same position, supported by a large stone mound of broad base, so well constructed that it will possess thorough stability.

248. Where the corner point falls exactly at the position occupied by a sound living tree, which is too large to be removed, the tree will be appropriately marked for the corner.

WITNESS CORNERS.

249. Where the true point for a corner falls within a roadway in such a place as to interfere with travel, a marked (X) stone will be deposited in the ground at the true corner point and a witness corner will be established at some suitable point, preferably on a surveyed line, outside of the roadway.

250. Where the true point for a corner falls upon insecure ground, or in an inaccessible place, such as within an unmeandered stream, lake or pond, or in a marsh, or upon a precipitous slope or cliff, a witness corner will be established at some suitable point, preferably on a surveyed line, where the monument may be permanently constructed.

251. The engineer will be expected to exercise his best judgment in selecting the position for a witness corner, with a view to affording a definite and convenient connection from the witness corner to the true point for the monument, for use in subsequent surveys to recover the legal position of the true corner. Extra effort will be exerted to accomplish the permanent establishment of a monument at its true corner point, wherever this is feasible, in order to avoid as much as possible the confusion to settlers and others caused by witness corners.

252. Only one witness corner will be established in each instance, and the same will be placed upon any one of the surveyed lines leading to a corner, if a suitable place, within a distance of 10 chains, is available, but if there is no secure place to be found on a surveyed line within the stated limiting distance, the witness corner may be located in any direction within a distance of 5 chains. On the other hand, if there is no suitable place within the latter radius, one or more legal subdivisions will be eliminated from the survey as provided in Chapter VII.

253. All of the lines of a survey will be completed in the regular manner, if the true point for a corner is accessible, but where the true point can not be attained, a line connecting therewith may be returned as surveyed if the same has been completed by the projection and measurement of a suitable offset or traverse, resulting in a closed figure which approaches the true point for a monument within the limit prescribed for the establishment of witness corners.

254. The field notes will show every detail of the relation of a witness corner to the true point for a monument, and the direct connecting course and distance will be shown upon the plat of the survey.

MARKING CORNERS.

255. All classes of corner monuments are to be marked in accordance with a system hereinafter described which has been devised to furnish a ready identification of the character and position of the monument which bears the marks. Capital letters and Arabic figures are employed to mark iron post and tree corners, while upon stone corners certain additional marks termed "notches" and "grooves" are employed to convey the same information, but to lessen the labor incident to the marking process. The letters and figures upon a monument are designed to relate to the township, range and section to which the corner belongs; the notches and grooves upon a stone monument relate—in the case of an exterior corner—to the normal number of miles from the monument to the adjoining township corners, and—in the case of a subdivisional corner—to the normal number of miles from the monument to the township boundary lines, as hereinafter described, thus furnishing the means of ascertaining the appropriate section numbers.

256. All markings should be accomplished neatly, distinctly and durably; and the marks are to be carefully arranged. An assortment of steel dies, chisels, punches and timber scribes, in perfect condition for use, should always be at hand.

257. A witness corner and its accessories will be constructed and marked similarly to a regular corner for which it stands, with the additional letters "W C" to signify "witness corner."

258. The following schedule is an index of the ordinary markings common to all classes of corners and accessories:—

Marks.	To indicate.	Marks.	To indicate.
A M C	Auxiliary meander corner.	R	Range.
A P	Angle point.	S	Section.
B O	Bearing object.	S	South.
B T	Bearing tree.	S C	Standard corner.
C	Center.	SE	Southeast.
C C	Closing corner.	S M C	Special meander corner.
E	East.	SW	Southwest.
M	Mile.	T	Township.
M C	Meander corner.	TR	Tract.
N	North.	W	West.
NE	Northeast.	W C	Witness corner.
NW	Northwest.	W P	Witness point.
P L	Public land (unsurveyed).	$\frac{1}{4}$	Quarter section.
		$\frac{1}{16}$	Sixteenth section.

MARKS ON IRON POST MONUMENTS.

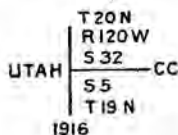
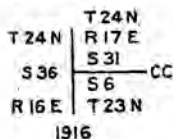
259. The markings upon the brass cap of an iron post should always be made to read from the south side of the monument, and all iron posts will be marked with the year number at the date when established.

260. *Standard township corners* are to be marked "S C" and the township on the north half, and the ranges and sections in the proper quadrants; as for example:

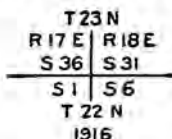
S C	
T 25 N	
R 17 E	R 18 E
S 36	S 31
1916	

261. *Closing township corners* are to be marked "C C" on the half from which the closing line approaches the monument, with the township (or range) on the same half, and the ranges (or townships) and sections in the proper quadrants; also (as far as known at the time) the township, range and section, or the initials or abbrevia-

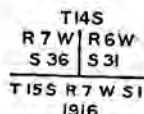
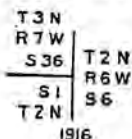
tion of the State, reservation, grant or private claim, upon which the township exterior closes; as for example:



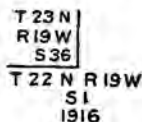
262. *Corners common to four townships* are to be marked with the townships on the north and south halves, the ranges on the east and west halves, and the sections in the four quadrants; as for example:



263. *Corners common to two townships only* are to be marked with the township (or range) common to both on the proper half, and the ranges (or townships) and sections in the proper quadrants; also (as far as known at the time) the township, range and section upon the opposite half; as for example:



264. *Corners referring to one township only* are to be marked with the township, range and section in the particular quadrant which is concerned; also (as far as known at the time) the township, range and section upon the opposite part; as for example:



265. *Standard section corners* are to be marked "S C" and the township and range on the north half, and the sections in the proper quadrants; as for example:

SC	
T 25 N	R 17 E
S 35	S 36
1916	

266. *Closing section corners* are to be marked "C C" and the township and range on the half from which the closing line approaches the monument, and the sections in the proper quadrants; also (as far as known at the time) the township, range and section, or the initials or abbreviation of the State, reservation, grant or private claim, upon which the section line closes, with the exception that in the case of an interior closing section corner, the township and range numbers will not be repeated; as for example:

T 25 N R 17 E	
S 35	
S 2	S 1
T 24 N	R 17 E
CC	
1916	

TR 48	
S 26	S 25
T 12 N	R 5 W
CC	
1916	

T 14 N	
S 16	S 10
S 15	R 16 E
CC	
1916	

267. *Corners common to four sections* are to be marked: (a) On an exterior, with the township (or range) common to the adjoining townships, the ranges (or townships) upon the opposite sides of the exterior, and the sections; and (b) a subdivisational corner, with the township, range and sections; all appropriately set forth as follows:

T 25 N	
R 17 E	R 18 E
S 12	S 7
S 13	S 18
1916	

T 26 N R 17 E	
S 35	S 36
S 2	S 1
T 25 N	
1916	

T 25 N R 17 E	
S 23	S 24
S 26	S 25
1916	

268. *Section corners common to two sections only* are to be marked with the township and range on the half facing the sections to which the corner belongs, and the sections in the proper quadrants; also (as far as known at the time) the township, range and section upon

the opposite half, except that in the case of an interior corner, the township and range numbers will not be repeated; as for example:

T 14 S	T 14 S
S 12	
S 13	R 18 E
R 17 E	S 7
	1916

T 27 N	R 17 W
S 31	S 32
T 26 N	R 17 W
	S 6
	1916

T 14 S	R 20 W
S 10	S 11
	S 14
	1916

269. *Section corners referring to one section only* are to be marked with the township, range and section in the particular quadrant which is concerned; also (if known at the time) the section upon the opposite part; as for example:

S 10
T 84 N
R 73 W
S 16
1916

T 27 N
R 16 W
S 17
S 20
1916

S 28
T 57 N
R 63 W
S 34
1916

270. *Standard quarter-section corners* are to be marked "S C $\frac{1}{4}$ " and the section, all on the north half; as for example:

S C
$\frac{1}{4}$ S 36
1916

271. *Quarter-section corners of maximum control* are to be marked (a) on a meridional line, " $\frac{1}{4}$ " on the north, and the sections on the east and west halves; and, (b) on a latitudinal line, " $\frac{1}{4}$ " on the west, and the sections on the north and south halves; as for example:

$\frac{1}{4}$
S 13
S 18
1916

$\frac{1}{4}$
S 21
S 28
1916

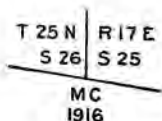
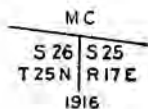
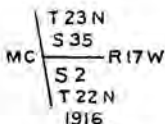
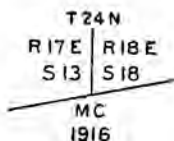
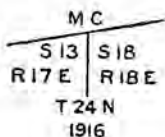
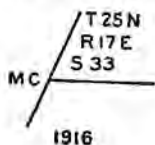
272. *Quarter-section corners of minimum control* are to be marked " $\frac{1}{4}$ " and the section, all on the half toward the particular section which is concerned; as for example:

$\frac{1}{4}$
S 4
1916

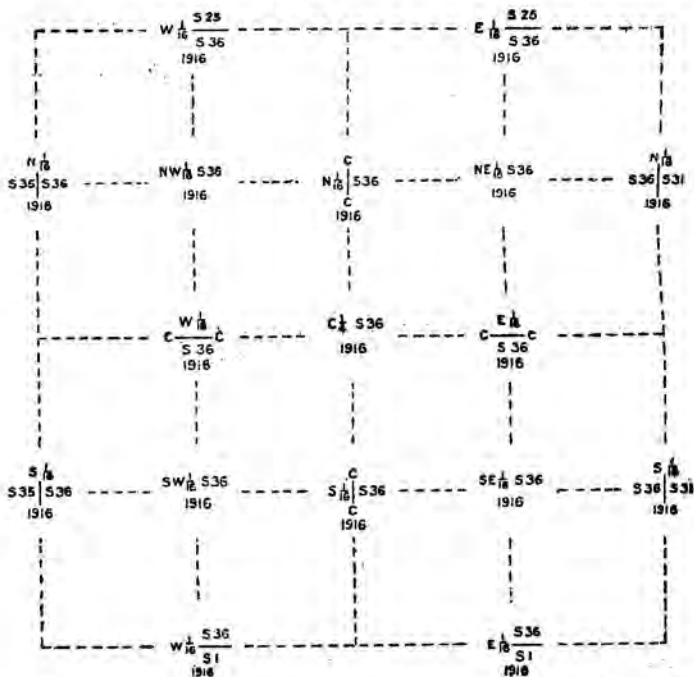
$\frac{1}{4}$ S 16
1916

$\frac{1}{4}$ S 7
1916

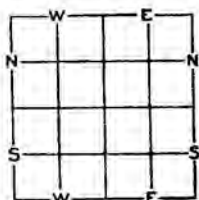
273. *Meander corners* are to be marked "M C" on the half toward the meanderable body of water, and the additional marks (a) on a standard parallel or other line controlling surveys to one side only, with the township, range and section toward the surveyed land; (b) on an exterior, with the township (or range) common to the adjoining townships, the ranges (or townships) upon the opposite sides of the exterior, and the sections; and, (c) on a subdivisional line, with the township, range and sections; all appropriately set forth as follows:



274. *The interior quarter-section and all sixteenth-section corners*, when required by the written special instructions, are to be marked in accordance with the scheme shown in the following diagram:



275. Sixteenth-section corners of minimum control are to be marked with a key letter (N, E, S or W), to indicate the position of the monument, and " $\frac{1}{16}$ " and the section, all on the half toward the particular section which is concerned; as for example:



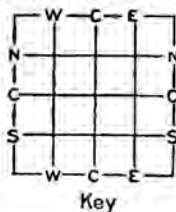
Key

$$\begin{array}{c} S \frac{1}{16} \\ S 36 \\ 1916 \end{array}$$

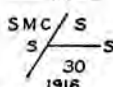
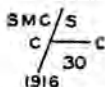
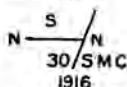
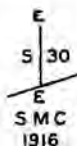
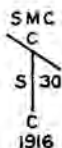
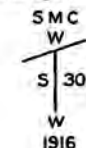
$$\begin{array}{c} E \frac{1}{16} \\ S 22 \\ 1916 \end{array}$$

276. *Special meander corners* are to be marked in accordance with the following scheme:

Key letters (N, E, S, W or C) will be used in pairs to indicate the position of the subdivision - of - section line.



The marks "S M C" will be placed on the half toward the meanderable body of water, and the section on the opposite half, as for example:

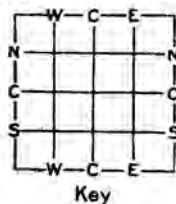


277. *Auxiliary meander corners* will be marked "A M C" and the township, range and section; as for example:

A M C
T 64 N R 37 W
S 29
1916

278. *Closing subdivision - of - section corners* are to be marked in accordance with the following scheme:

Key letters (N, E, S, W or C) will be used in pairs to indicate the position of the subdivision - of - section line.



The marks "C C" and the section will be placed on the half from which the closing line approaches the monument.

(The marks "B I R" indicate "Blackfeet Indian Reservation.")

$$\begin{array}{c} \text{P L} \\ \text{E} \\ \hline \text{C C} \mid \text{S 28} \\ \text{E} \\ \text{B I R} \\ 1916 \end{array}$$

$$\begin{array}{c} \text{P L} \\ \text{C} \\ \hline \text{C C} \mid \text{S 28} \\ \text{C} \\ \text{B I R} \\ 1916 \end{array}$$

$$\begin{array}{c} \text{P L} / \text{C C} \\ \text{C} / \text{S 28} \\ \text{B I R} \\ 1916 \end{array}$$

$$\begin{array}{c} \text{P L} \\ \text{W} \\ \hline \text{C C} \mid \text{S 28} \\ \text{W} \\ \text{B I R} \\ 1916 \end{array}$$

$$\begin{array}{c} \text{P L} / \text{C C} \\ \text{N} / \text{S 28} \\ \text{B I R} \\ 1916 \end{array}$$

$$\begin{array}{c} \text{P L} / \text{C C} \\ \text{S} / \text{S 28} \\ \text{B I R} \\ 1916 \end{array}$$

279. Markings for miscellaneous angle points along irregular boundaries:

$$\begin{array}{c} \text{T 27 N} \\ \text{S 13} \quad \diagup \quad \text{AP 4} \\ \quad \quad \quad \text{B I R} \\ \text{R 17 W} \quad \diagdown \\ 1916 \end{array}$$

For "angle point No. 4" on the boundary of the "Blackfeet Indian Reservation," falling on surveyed land.

$$\begin{array}{c} \text{A P} \\ \text{T 12 S R 30 W} \\ \text{S 33} \\ \hline 1916 \end{array}$$

For "angle point" on the south boundary of section 33, superseding an old standard corner on a defective line, not subject to rectification.

$$\begin{array}{c} \text{T 16 N R 7 E} \\ \text{S 14} \quad \left[\begin{array}{c} \text{A P 2} \\ \text{TR 37} \end{array} \right. \\ 1916 \end{array}$$

For "angle point No. 2" on the boundary of a private claim ("Tract No. 37") falling on surveyed land.

$$\begin{array}{c} \text{A P} \\ \text{12} \quad \diagup \quad \text{T 20 N} \\ \quad \quad \quad \text{R 5 W} \\ \quad \quad \quad \text{S 10} \\ 1916 \end{array}$$

For "angle point No. 12" on a reestablished meander line; the marks "A P" and the serial number will be placed on the half toward the land omitted from the original survey.

280. Markings for intermediate corners along irregular boundaries:

$\begin{array}{c} 139 \text{ M} \\ \hline \text{N MEX} \\ \hline \text{TEXAS} \\ 1916 \end{array}$	For "139th mile corner" on the boundary line between the States of "New Mexico and Texas."
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$\begin{array}{c} \text{BIR} \\ \hline 3 \text{ M} \\ \hline 1916 \end{array} \begin{array}{l} / \\ \text{PL} \end{array}$	For "3d mile corner" on the boundary of the "Blackfeet Indian Reservation," falling on unsurveyed land.
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$\begin{array}{c} \text{BIR} \\ \hline 13 \text{ M} \\ \hline 1916 \end{array} \begin{array}{l} / \\ \text{T 25 N} \\ \text{R 17 W} \\ \text{S 25} \end{array}$	For "13th mile corner" on the boundary of the "Blackfeet Indian Reservation," falling on surveyed land.
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MARKS ON STONE MONUMENTS.

281. Where a stone monument is established the letters, figures, and grooves will be cut on the exposed faces or sides of the stone, but not on its top or end; the notches will be cut upon the exposed vertical edges. Grooves are employed where the faces of a stone are oriented to the cardinal directions, and notches where the vertical edges are turned to the cardinal points. All marks will be made from 1 to 1½ inches in size, and will be plainly and permanently chiseled into the stone.

282. *Standard township corners* (oriented with the faces to the cardinal directions) are to be marked "S C" on the north face, with the township on the same face, and the ranges on the adjoining faces; as for example:

S C 25 N on N.,
 18 E " E., and
 17 E " W. face.

283. *Closing township corners* (oriented with the faces to the cardinal directions) are to be marked "C C" and with six (or fewer) grooves on the face from which the closing line approaches the monument—the grooves to indicate the normal number of miles (or fractional parts) from the monument to the adjoining township

corner—with the township (or range) on the same face, and the ranges (or townships) on the adjoining faces; also the initials or abbreviation of the State, reservation, grant or private claim, on the face toward such irregular tract as may be closed upon; as for example:

20 N on N.,
 C C 120 W and 5 grooves (on line between sections
 5 and 32) on E.,
 19 N on S., and
 UTAH " W. face.

284. *Corners common to four townships* (oriented with the edges to the cardinal points) are to be marked with the townships on the northeast and southwest faces, and the ranges on the southeast and northwest faces; as for example:

23 N on NE.,
 18 E " SE.,
 22 N " SW., and
 17 E " NW. face.

285. *Corners common to two townships only* (oriented with the faces to the cardinal directions) are to be marked with the township (or range) common to both on the face toward the townships, and the ranges (or townships) on the adjoining faces; as for example:

3 N on N.,
 2 N " S., and
 7 W " W. face.

286. *Corners referring to one township only* (oriented with the edges to the cardinal points) are to be marked with the township and range on the face toward the particular township; as for example:

23 N 7 W on NW. face.

287. *Standard section corners* (oriented with the faces to the cardinal directions) are to be marked "S C" on the north face, and with from one to five grooves on the east and west faces, the grooves

to indicate, respectively, the number of miles from the monument to the adjoining (regular) township corner; as for example:

S C on N.,
 1 groove on E., and
 5 grooves on W. face (standard corner of sections 35 and 36).

288. Closing section corners (oriented with the faces to the cardinal directions) are to be marked "C C" and with from one to six grooves on the face from which the closing line approaches the monument, and from one to five grooves on each of the adjoining faces—the grooves to indicate the number of miles (or fractional parts) from the monument to each of the three (regular) township boundary lines in the same directions, respectively—also the initials or abbreviation of the State, reservation, grant or private claim, on the face toward such irregular tract as may be closed upon; as for example:

2 grooves on E.,
 C C and 6 " " S., and
 4 " " W. face (on line between sections 2 and 3 closing on a standard parallel).

289. Corners common to four sections (oriented with the edges to the cardinal points) are to be marked (a) on an exterior, with from one to five notches each on two opposite edges, north and south on a meridional line, and east and west on a latitudinal line, each to indicate, respectively, the number of miles from the monument to the adjoining (regular) township corner; and (b) a subdivisional corner, with from one to five notches on the east and south edges, each to indicate, respectively, the number of miles from the monument to the (regular) east and south township boundary lines; the subdivisional section corners of a fractional township will be marked with reference to the theoretical position of normal east and south boundaries, whether surveyed or not; as for example:

2 notches on N. and 4 notches on S. edge (for corner of sections 7, 12, 13 and 18 on a range line).

2 notches on E. and 4 notches on W. edge (for corner of sections 2, 3, 34 and 35 on a township line).

2 notches on E. and 4 notches on S. edge (for corner of sections 10, 11, 14 and 15 of a subdivisional survey).

290. *Section corners common to two sections only* (oriented with the edges to the cardinal points) are to be marked with the sections on the faces toward the particular sections to which the corner belongs; as for example:

S 13 on SW., and

S 12 " NW. face (for corner of sections 12 and 13 on the east boundary of a township).

S 11 on NE., and

S 10 " NW. face (for corner of sections 10 and 11 of a subdivisional survey running north from the monument).

291. *Section corners referring to one section only* (oriented with the edges to the cardinal points) are to be marked with the section on the face toward the particular section which is concerned; as for example:

S 17 on NW. face (for southeast corner of section 17).

292. *Standard quarter-section corners* (oriented with the faces to the cardinal directions) are to be marked "S C $\frac{1}{4}$ " on the north face.

293. *Quarter-section corners of maximum control* (oriented with the faces to the cardinal directions) are to be marked (a) on a meridional line, " $\frac{1}{4}$ " on the west face; and (b) on a latitudinal line, " $\frac{1}{4}$ " on the north face.

294. *Quarter-section corners of minimum control* (oriented with the faces to the cardinal directions) are to be marked " $\frac{1}{4}$ " and the section, all on the face toward the particular section which is concerned; as for example:

$\frac{1}{4}$ S 4 on S. face (for quarter-section corner on the north boundary of section 4).

295. *Meander corners* (oriented with the faces to the cardinal directions) are to be marked "M C" on the face toward the meanderable body of water, and with from one to six grooves on each of the other faces, each to indicate the number of miles (or fractional parts) from the monument to the (regular) township boundary line in the same direction, respectively; as for example:

M C on N.,

6 grooves " E.,

4 " " S., and

6 " " W. face (for meander corner of fractional sections 13 and 18, on the south side of a meanderable body of water).

296. *Special and auxiliary meander corners* (oriented with the faces to the cardinal directions) are to be marked "S M C" or "A M C," as the case may be, on the face toward the meanderable body of water, and the section on the opposite face; as for example:

S M C on N., and

S 19 " S. face (for special meander corner on a meridional subdivision-of-section line in section 19, on the south side of a meanderable body of water).

S 20 on E., and

A M C " W. face (for auxiliary meander corner in section 20, on the east side of a meanderable body of water).

MARKS ON TREE MONUMENTS.

297. Where the true point for a corner is found to fall in the position occupied by a sound living tree, which is too large to be removed, the tree will be made the monument. A tree will be removed if it is too small to be marked, and a witness corner will be established in preference to marking an unsound tree, if the latter can not be removed.

298. The species of the tree and its diameter, breast height, will be noted, where a tree is to be made a monument, and the appropriate marks will be made upon the trunk of the tree immediately above the root crown. A series of marks to be made upon a particular side of a tree will be scribed in a vertical line reading downward.

299. In the case of certain trees, including the aspen, beech and locust (smooth, thin and permanently barked from sapling to maturity), the marks may be made preferably by scribing well into the bark and cambium (or live wood tissue) without blazing; the marks thus made will remain and be visible as long as the tree is sound; on the other hand, in the case of practically all rough barked trees, the marks should be scribed into a smooth, narrow, vertical blaze, specially prepared by removing just enough of the outer growth to expose a flat surface of the live wood tissue immediately underneath the bark; the marks thus made will remain as long as the tree is sound, but the blaze and marks will be covered by a gradual overgrowth, showing an outward scar for many years. In regions subject to heavy snowfall it is desirable to make a small additional blaze at a height of 6 or 8 feet above the ground, which will serve to attract attention to the tree during the winter season. The ends

of all blazes should be smoothed off gradually without making a sharp cut into the cambium. The lower end of the blaze upon which the marks are placed should be about 6 inches above the root crown, and its length should be just sufficient to take the marks.

The practice relating to the manner of marking trees, as above outlined, is designed to cause the least possible injury to the tree, by enabling a rapid overgrowth; also, to place the marks in a position where they will remain on the stump if the trunk should be removed. Various practices have obtained in the past in different localities, some of which are objectionable by causing unnecessary injury to a tree, or on account of the marks being placed in a position where there is danger of their removal with the trunk in case the tree is cut down.

300. The above theory applies equally to the marking of bearing trees, and the engineer is advised, when making retracements, re-surveys, etc., not to remove the overgrowth on a tree monument or bearing tree unless it is absolutely necessary to do so in order to identify positively the particular tree. In the case of trees which have been blazed before marking, the number of rings contained in the overgrowth (or its equivalent on the adjoining section of the tree) will furnish an exact count of the number of years (one annual ring for each growing season) from the date of original marking to the date when uncovered. After an old blaze has been uncovered, conditions are favorable for the decaying process to set in, and the engineer should adopt additional means to evidence the position of the corner.

301. *Standard township corners* are to be marked "S C" and the township on the north side, and the ranges and sections on the east and west sides; as for example:

S C T 25 N on N.,
 R 18 E S 31 " E., and
 R 17 E S 36 " W. side.

302. *Closing township corners* are to be marked "C C" and the township (or range) on the side from which the closing line approaches the monument, and the ranges (or townships) and sections on the adjoining sides; also the initials or abbreviation of the State, reservation, grant or private claim, on the side toward any irregular tract which may be closed upon; as for example:

R 18 E S 6 on E.,
 C C T 24 N " S., and
 R 17 E S 1 " W. side.

303. *Corners common to four townships* are to be marked with the township and section on the northeast and southwest sides, and the range and section on the southeast and northwest sides; as for example:

T 23 N S 31 on NE.,
 R 18 E S 6 " SE.,
 T 22 N S 1 " SW., and
 R 17 E S 36 " NW. side.

304. *Corners common to two townships only* are to be marked with the township, range and section on the sides toward the particular townships; as for example:

T 2 N R 7 W S 1 on SW., and
 T 3 N R 7 W S 36 " NW. side.

305. *Corners referring to one township only* are to be marked with the township, range, and section on the side toward the particular township which is concerned; as for example:

T 23 N R 7 W S 36 on NW. side.

306. *Standard section corners* are to be marked "S C" and the township and range on the north side, and the sections on the east and west sides; as for example:

S C T 25 N R 17 E on N.,
 S 36 " E., and
 S 35 " W. side.

307. *Closing section corners* are to be marked "C C" and the township and range on the side from which the closing line approaches the monument, and the sections on the adjoining sides; also the initials or abbreviation of the State, reservation, grant or private claim on the side toward any irregular tract which may be closed upon; as for example:

S 1 on E.,
 C C T 24 N R 17 E " S., and
 S 2 " W. side.

308. *Corners common to four sections* are to be marked (a) on an exterior, with the township (or townships), ranges (or range) and sections; and (b) a subdivisational corner, with the township, range and section; all appropriately set forth as follows:

T 25 N S 7 on NE.,
 R 18 E S 18 " SE.,
 R 17 E S 13 " SW., and
 S 12 " NW. side.

T 26 N S 36 on NE.,
 R 17 E S 1 " SE.,
 T 25 N S 2 " SW., and
 S 35 " NW. side.
 T 25 N S 24 on NE.,
 R 17 E S 25 " SE.,
 S 26 " SW., and
 S 23 " NW. side.

309. *Section corners common to two sections only* are to be marked with the township and section and the range and section on the sides toward the particular sections to which the corner belongs; as for example:

T 14 S S 11 on NE., and
 R 20 W S 10 " NW. side.

310. *Section corners referring to one section only* are to be marked with the township, range and section on the side toward the particular section which is concerned; as for example:

T 27 N R 16 W S 17 on NW. side.

311. *Standard quarter-section corners* are to be marked "S 0 $\frac{1}{4}$ " and the section, all on the north side; as for example:

S 0 $\frac{1}{4}$ S 36 on N. side.

312. *Quarter-section corners of maximum control* are to be marked (a) on a meridional line, " $\frac{1}{4}$ " and the section on the west side, and the section on the east side; and (b) on a latitudinal line, " $\frac{1}{4}$ " and the section on the north side, and the section on the south side; as for example:

S 18 on E., and
 $\frac{1}{4}$ S 13 " W. side.
 $\frac{1}{4}$ S 21 on N., and
 S 28 " S. side.

313. *Quarter-section corners of minimum control* are to be marked " $\frac{1}{4}$ " and the section, all on the side toward the particular section which is concerned; as for example:

$\frac{1}{4}$ S 7 on E. side (for quarter-section corner on the west boundary of section 7).

314. *Meander corners* are to be marked "M C" on the side toward the meanderable body of water, and the additional marks (a) on a standard parallel or other line controlling surveys to one side only, with the township, range and section on the side toward the sur-

veyed land; (b) on an exterior, with the township (or range) common to the adjoining townships on the side opposite the meanderable body of water, and the ranges (or townships) and the sections on the adjoining sides; and, (c) on a subdivisional line, with the township and range on the side opposite the meanderable body of water, and the sections on the adjoining sides; as for example:

M C on E., and
 T 25 N R 17 E S 33 " NW. side (for meander corner on a
 standard parallel, on the
 west side of a meander-
 able body of water).

T 24 N on N.,
 R 18 E S 18 " E.,
 M C " S., and
 R 17 E S 13 " W. side (for meander corner on a range line,
 on the north side of a meanderable
 body of water).

T 23 N S 35 on N.,
 M C " E.,
 T 22 N S 2 " S., and
 R 17 W " W. side (for meander corner on a township
 line, on the west side of a mean-
 derable body of water).

S 23 on N.,
 T 25 N R 17 E " E.,
 S 26 " S., and
 M C " W. side (for meander corner on a lati-
 tudinal section line, on the
 east side of a meanderable
 body of water).

M C on N.,
 S 9 " E.,
 T 4 N R 7 W " S., and
 S 8 " W. side (for meander corner on a meridional
 section line, on the south side of
 a meanderable body of water).

315. *Special and auxiliary meander corners* are to be marked "S M C" or "A M C", as the case may be, on the side toward the meanderable body of water, and the section on the opposite side; as for example:

S M C on E., and
 S 14 " W. side (for special meander corner on a latitudinal subdivision-of-section line in section 14, on the west side of a meanderable body of water).

A M C on N., and
 S 9 " S. side (for auxiliary meander corner in section 9, on the south side of a meanderable body of water).

CORNER ACCESSORIES.

316. The purpose of a corner accessory is to evidence the position of the original monument. A connection is made from the monument to fixed natural or artificial objects in its immediate vicinity, whereby the former may be relocated from the latter, thus in the event of the destruction or removal of the corner monument, its original position may be identified as long as any part of the accessories remains in evidence. The accessories consist of three general classes, one or more of which are to be employed at each and every corner established in the public-land surveys, preference being given to the same in the order of their permanency conditional upon the character of the ground in the locality of the monument, as follows:

(a) Bearing trees, or other natural objects such as notable cliffs and boulders; permanent improvements; and memorials; (b) mound of stone; and (c) pits.

317. The engineer can not perform any more important service in connection with his official duties than to employ whatever means may be necessary permanently and accurately to evidence the location of the legal corners established in his survey, and where the usual accessories, or combinations of the same, can not be employed, such other means should be adopted as will best serve the purpose.

318. The accessories for witness corners will be the same as though the corner were established at its true point, but the marks upon the bearing trees or other objects will be preceded by the letters "W C", and the section number will be made to agree with the section in which the tree or object actually stands.

BEARING TREES, BEARING OBJECTS, AND MEMORIALS.

319. Bearing trees, or other natural objects, are to be selected for marking when the same are available within a distance of 5 chains of the corner monument, and where the regular quota, hereinafter described, is not available, one tree or object will be marked in each section affording such accessory. A full description of the tree or object will be embodied in the field notes as a part of the record of the corner monument. One tree, or object, will be marked in each section cornering at the monument, when available, and the true course and horizontal distance from the exact corner point to the center vertical axis of the tree at its root crown, or to the cross (X) upon a marked object, will be carefully determined and recorded with the description of the tree, or object, and its marks. The species of a tree and its diameter, at breast height, will be recorded; and, in the case of a cliff or bowlder, the description will embrace such essential details as may be necessary to serve for its ready identification.

320. The marks upon a bearing tree will be made upon the side facing the corner and will be scribed in the manner already outlined for marking tree corner monuments. The marks will embrace the information suggested in the schedule hereinafter given, with such letters and figures as may be appropriate for a particular corner, and will include the letters "B T"; a tree will always be marked to agree with the section in which it stands, and will be marked in a vertical line reading downward, ending in the letters "B T" at the lower end of the blaze approximately 6 inches above the root crown.

321. There is a great difference in the longevity of trees, and in their rate of decay, etc.; trees should therefore be selected, if possible, with a view to the length of their probable life, their soundness, favorable site conditions and size. Sound trees from 6 to 8 inches in diameter, of the most hardy species, favorably located, are to be preferred for marking. Trees less than 4 inches in diameter will not be selected for marking if larger trees are available, and it is generally better to avoid marking fully matured trees, especially those showing signs of decay. Trees less than 4 inches in diameter, if no better trees are available, will be marked with the letters "B T" only. The species, size and exact position of the bearing trees are of vital importance, as this data will generally serve to identify a bearing tree without uncovering the marks, or even to identify two or more stumps after all evidence of the marks has disappeared.

322. Generally only one tree will be marked in each section at a particular corner, but in certain instances, hereinafter described, two trees are required in a section. In such cases it is better to select trees of different species, or of widely different size, direction or distance, if the trees are of the same species, in order that confusion may be avoided in the future identification of a remaining tree where the companion tree has disappeared.

323. A cross (X) and the letters "B O" and the section number will be chiseled into a bearing object, if it is of rock formation, and the record should be such as to enable another surveyor to determine where the marks will be found.

324. A connection to any permanent artificial object or improvement may be included in this general class of corner accessories. The field notes should be explicit in describing such objects, and should indicate the exact point to which a connection is made, as "southwest corner of foundation of Smith's house," "center of Smith's well," "pipe of Smith's windmill," etc. No marks will be made upon private property.

325. In every case where it is impossible to make a single connection to a bearing tree or other bearing object, as above described, and where a mound of stone or pits are impracticable, a suitable memorial will be deposited at the base of the monument. A memorial may consist of any durable article which will serve to identify the location of the corner in case the monument is destroyed. Such articles as glassware, stoneware, a marked (X) stone, a charred stake, a quart of charcoal, or pieces of metal will constitute a suitable memorial. A full description of such articles will be embodied in the field notes wherever they are employed as a corner accessory.

MOUND OF STONE.

326. Where native stone is available and the surface of the ground is favorable, a mound of stone will be employed as an accessory to a corner monument, provided that a full quota of trees or other bearing objects can not be utilized. A mound of stone erected as a corner accessory will be built as stably as possible, will consist of not fewer than five stones, and will be not less than 2 feet base and 1½ feet high. In stony ground the size of the mound will be sufficiently increased to make it conspicuous. The position of the mound will be as shown in the schedule hereinafter stated, and the nearest point on its base will be separated about 6 inches distant from the monument. The field notes will show the size and position of the mound.

327. Where it is necessary to support a monument in a stone mound, no additional mound will be employed as an accessory; and, if bearing trees or other objects are not available, a marked (X) stone or other memorial will be deposited at the base of the monument.

PITS.

328. Where the full quota of trees or other bearing objects are unavailable for marking, the position of the monument will, under certain favorable conditions, be evidenced by pits. No pits should be dug in a roadway, or where the ground is overflowed for any considerable period, or upon steep slopes, or where the earth will wash, or in a loose or light soil, or where there is no native sod, or where suitable stone for a mound is at hand.

A firm soil covered with a healthy native sod is most favorable for a permanent pit. Under such conditions the pits will gradually fill with a material slightly different from the original soil, and a new species of vegetation will generally take the place of the native grass; these characteristics, under favorable conditions, make it possible to identify the original location of the pits after the lapse of many years.

329. All pits will be dug 18 inches square and 12 inches deep, with the nearest side 3 feet distant from the corner monument, oriented with a square side (and not a corner) towards the monument, arranged as shown in the schedule hereinafter given; the earth removed will be scattered in such a way that it will not again fill the pits. A description of the pits will be embodied in the field notes, and will include, in every instance, a statement of their size and position; this is particularly important in view of the fact that the practice herein outlined differs materially (in the interest of simplicity) from that set forth in earlier editions of the Manual.

ARRANGEMENT AND MARKING OF CORNER ACCESSORIES.

330. *Standard township corners.*

Standard section corners.

Two bearing trees, one in each section north of the standard parallel, each marked "S C" and the township, range and section; as

T 25 N R 18 E S 31 S C B T.

Mound of stone, north of corner.

Three pits, one each on line north, east and west.

331. Closing township corners.*Closing section corners.*

Two bearing trees, one in each section to the right and left of the closing line, each marked "C C" and the township, range and section; as

T 24 N R 18 E S 6 C C B T.

Mound of stone, on the closing line.

Three pits, one on the closing line and one each to the right and left on the line closed upon.

332. Corners common to four townships.

Four bearing trees, one in each section, each marked with the township, range and section; as

T 22 N R 17 E S 1 B T.

Mound of stone, south of corner.

Four pits, one each on line north, east, south and west.

333. Corners common to two townships only.

Two bearing trees, one in each section cornering at the monument, each marked with the township, range and section; as

T 2 N R 7 W S 1 B T.

Mound of stone, on the line between the two townships cornering at the monument.

Three pits, one each on the three lines connecting at the monument.

334. Corners referring to one township only.

Two bearing trees, both in the township cornering at the monument, each marked with the township, range and section; as

T 23 N R 19 W S 36 B T.

Mound of stone, in the township cornering at the monument, at 45° from cardinal direction at the monument.

Two pits, one each on the two lines connecting at the monument.

335. Corners common to four sections.

Four bearing trees, one in each section, each marked with the township, range and section; as

T 26 N R 17 E S 35 B T.

Mound of stone, west of corner.

Four pits, one in each section northeast, southeast, southwest and north west.

336. Section corners common to two sections only.

Two bearing trees, one in each section cornering at the monument, each marked with the township, range and section; as

T 14 S R 17 E S 12 B T.

Mound of stone, on the line between the two sections cornering at the monument.

Two pits, one in each section at 45° from cardinal direction at the monument.

337. *Section corners referring to one section only.*

Two bearing trees, both in the section cornering at the monument, each marked with the township, range and section; as

T 27 N R 16 W S 17 B T.

Mound of stone, in the section cornering at the monument, at 45° from cardinal direction at the monument.

Two pits, one 3 feet and one 6 feet distant, both in the section cornering at the monument, at 45° from cardinal direction at the monument.

338. *Standard quarter-section corners.*

Two bearing trees, both north of the standard parallel, each marked " $\frac{1}{4}$ " and "S C" and the section; as

$\frac{1}{4}$ S 36 S C B T.

Mound of stone, north of corner.

Two pits, one each on line east and west.

339. *Quarter-section corners of maximum control.*

Two bearing trees, one in each section, each marked " $\frac{1}{4}$ " and the section; as

$\frac{1}{4}$ S 16 B T.

Mound of stone: (a) On a meridional line, west of corner; and, (b) on a latitudinal line, north of corner.

Two pits, one in each direction on the line passing through the monument.

340. *Quarter-section corners of minimum control.*

Two bearing trees, both in the particular section which is concerned, each marked " $\frac{1}{4}$ " and the section; as

$\frac{1}{4}$ S 7 B T.

Mound of stone, in the particular section which is concerned, in a cardinal direction from the monument.

Two pits, one in each direction on the line passing through the monument.

341. *Meander corners.*

Two bearing trees: (a) On a standard parallel or other line controlling surveys to one side only, both in the particular section which is concerned; and (b) on all other lines, one in each section

to the right and left of the line; all marked "M C" and with the township, range and section; as

T 25 N R 14 E S 32 M C B T.

Mound of stone, on the surveyed line on the opposite side of the monument from the meanderable body of water.

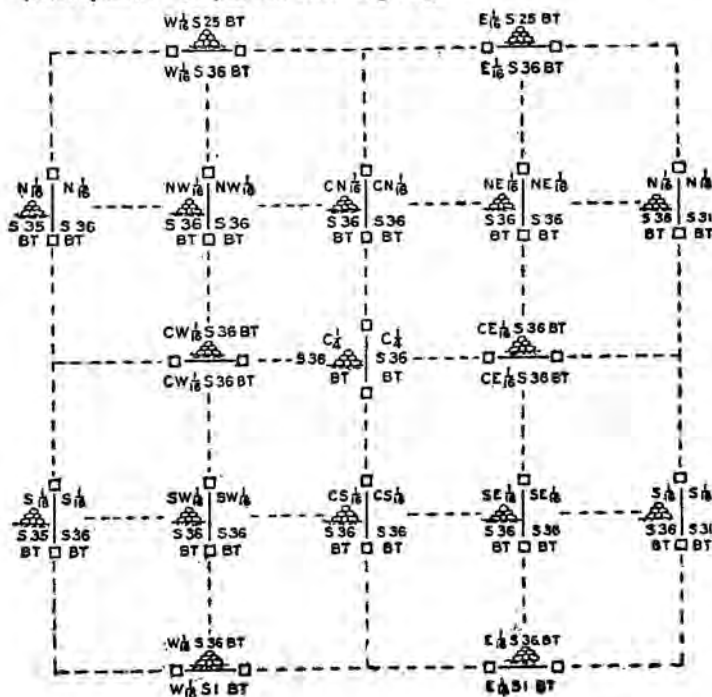
Two pits, one 3 feet and one 6 feet distant, on the surveyed line on the opposite side of the monument from the meanderable body of water.

842. *The interior quarter-section and all sixteenth-section corners, when required by the written special instructions.*

Two bearing trees, marked (with letters and figures ending in "B T") as shown in the following diagram:

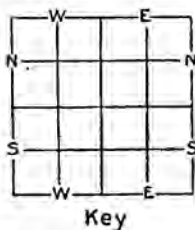
Mound of stone, in a cardinal direction from the monument, as shown (with symbol "☸") in the following diagram:

Two pits, in a cardinal direction from the monument, as shown (with symbol "□") in the following diagram:



343. *Sixteenth-section corners of minimum control.*

Two bearing trees, both in the particular section which is concerned, each marked with a key letter (N, E, S or W) to indicate the position of the monument, and " $\frac{1}{16}$ " and the section; as



N $\frac{1}{16}$ S 18 BT

Mound of stone, in the particular section which is concerned, in a cardinal direction from the monument.

Two pits, one in each direction on the section line passing through the monument.

344. *Special and auxiliary meander corners.*

Two bearing trees, each marked "S M C" or "A M C," as the case may be, and the section; as

S 14 S M C B T, or
S 14 A M C B T.

Mound of stone, on the opposite side of the monument from the meanderable body of water.

Two pits, one 3 feet and one 6 feet distant, on the opposite side of the monument from the meanderable body of water.

345. *Closing subdivision-of-section corners.*

Two bearing trees, both in the particular section which is concerned, each marked "C C" and the section; as

S 9 C C B T.

Mound of stone, on the closing line.

Three pits, one on the closing line and one each to the right and left on the line closed upon.

346. *Miscellaneous angle points along irregular boundaries.*

(a) Two bearing trees, where the monuments are less than 1 mile apart, one on each side of the boundary; and (b) four bearing trees, where the monuments are 1 mile or more apart, two on each side of the boundary; each marked "A P" and a serial or section number.

or both, also the initials or abbreviation of the State, reservation, grant, private claim or public land, as appropriate; as

A P 2 TR 37 B T, and

A P S 14 B T (for "angle point No. 2" on the boundary of a private claim "Tract No. 37" falling on surveyed land).

Mound of stone, on the medial line between the boundary lines intersecting at the monument, and in the direction toward the State, reservation, grant or private claim.

Two pits, one in each direction on the lines intersecting at the monument.

347. Intermediate corners along irregular boundaries.

(a) Two bearing trees, where the monuments are less than 1 mile apart, one on each side of the boundary; and (b) four bearing trees, where the monuments are 1 mile or more apart, two on each side of the boundary; each marked with the number of the mile or half-mile corner and the letter "M" (to indicate "mile corner"), and the initials or abbreviation of the State, reservation, grant, private claim or public land, as appropriate; as

47 M COLO BT, and

47 M OKLA BT (for "47th mile" corner on the boundary line between the States of "Colorado" and "Oklahoma").

Mound of stone, on a line at right angles to the boundary, and in direction toward the State, reservation, grant or private claim.

Two pits, one in each direction on the boundary.

TABLETS IN CONCRETE MONUMENTS AND IN ROCK OUTCROP.

347-A. Brass tablets are supplied for use in making concrete monuments and for placing in rock outcrop. Concrete monuments, with the tablet imbedded in the top, are employed in special situations where a superior corner construction is required and as authorized by the proper supervising officer. The tablet is $3\frac{1}{2}$ inches in diameter and has a stem 3 inches long; the top bears the same inscription as that placed on the cap of all iron-post monuments. The design and dimensions of concrete monuments may be varied to suit the site conditions and the special requirements for a superior monument. The tablet may be used for marking corners which fall upon rock outcrop at any

time without special authorization in lieu of an iron post supported by a stone mound and on slopes where a mound would be impracticable; a drill hole is made to receive the stem and a recess is made for the top so that the tablet may be securely cemented in place and sealed against moisture entering below the top. All cementing and concrete construction to be permanent must be done with clean first-class materials, carefully proportioned. The corner marks to be made upon the tablet, and the selection and marking of the accessories will be the same as for iron-post monuments.

CHAPTER V.

RESTORATION OF LOST CORNERS.

IDENTIFICATION OF EXISTENT CORNERS.

348. It is the purpose of this chapter of the Manual to outline the guiding principles which are to be observed in the identification of existent corners, and thereafter to set forth the particular rules which are to be applied in the recovery of the position of lost corners originally established in the execution of the United States rectangular surveys.

All surveyors, whether employed by the United States or not, are cautioned to note the difference between the regulations pertaining to the establishment of the original surveys of the public lands and those relating to the subsequent identification of said official surveys and the replacement of missing monuments thereof.

In the extension of the rectangular surveys it devolves upon the United States surveyor to identify the initial lines of his group and to replace all lost corners thereof. On the other hand in the subdivision of sections and in the location of property lines generally, it falls to the county or other local surveyor to identify the official corners, and where a required corner is missing the local surveyor will be called upon to recover the point. Thus it will be seen that local as well as United States surveyors are constantly called upon to search for existing evidence of original monuments, and in this work the surveyors will be guided by the same general methods. Should the search for a monument result in failure, the appropriate restorative surveying process to be observed by either surveyor will be based upon the same rules as hereinafter outlined. The text that follows draws no distinction between the duties of the two classes of surveyors.

349. The terms "corner" and "monument" are used largely in the same sense, though a distinction should be noted to clarify the subject matter of this chapter. The term "corner" is employed to denote a point determined by the surveying process, whereas the "monument" is the physical structure erected for the purpose of marking the corner point upon the earth's surface.

350. An existent corner is one whose position can be identified by comparing the evidence of the monument or its accessories on the ground, with the record contained in the field notes of the original survey, or where the point can be determined otherwise by suitable testimony.

351. The process of again bringing to light the physical evidence of an original monument is founded on the principle of intelligent search for the calls of the field notes of the original survey, guided by the controlling influence of known points. The problems incident to the search are vastly simplified whenever a retracement may be projected from known points, and the final search for a monument should cover the zone surrounding one, two, three or four temporary points as may be determined by connections with known corners in one, two, three or four directions, according to the number of points which will ultimately control the relocation in case the corner in question should be declared lost.

352. The character of the original monument is the most important factor in regard to its lasting qualities, and the search should be directed to an examination for such evidence as may reasonably be expected to remain. The evidence is bound to range from that which is least conclusive to that which is unquestionable, and the requisite support of corroborative evidence is necessary in direct proportion to the uncertainty of any feature regarding whose authenticity there may be danger of dispute.

A stone, wooden post, tree corner, deposit corner, and the modern iron post monument are all subject to more or less deteriorating changes through various influences, depending upon the character of the original monument, its local site conditions, and the lapse of time, and all such factors should be taken into consideration when comparing the particular evidence in question with the description contained in the original field notes.

353. If the evidence of the monument is not fully conclusive, the engineer's attention will be directed at once to the record accessories; this step is so generally necessary that it should be considered simultaneously with the search for the monument; in fact, in their broader significance the accessories are a part of the monument.

The underlying principles relating to the identification of the corner accessories, subject to the changes which may be expected in the period intervening after the date of the original survey, have already been fully outlined in Chapter IV. It will suffice to state

that the evidence of the accessories should agree with the record contained in the field notes of the original survey, subject only to such changes as may reasonably be expected.

354. In case of material disagreement between the particular evidence in question and the record calls, the process of elimination of those features regarding which there may be doubt, after making due allowance for natural changes, will serve a most useful purpose, as follows:

(a) The character and dimensions of the monument in evidence should not be widely different from the record;

(b) The markings in evidence should not be inconsistent with the record; and,

(c) The nature of the accessories in evidence, including size, position and markings, should not be greatly at variance with the record.

A certain measure of allowance for ordinary discrepancies should enter into the consideration of the evidence of a monument and its accessories, and no definite rule can be laid down as to what shall be sufficient evidence in such cases. Much must be left to the skill, fidelity and good judgment of the engineer in the performance of his work, ever bearing in mind the relation of one monument to another, and the relation of all to the recorded natural objects and items of topography.

355. A corner will not be considered as lost if its position can be recovered satisfactorily by means of the testimony and acts of witnesses having positive knowledge of the precise location of the original monument. The expert testimony of surveyors who may have identified the original monument prior to its destruction and thereupon recorded new accessories or connections, etc., is by far the most reliable, though landowners are often able to furnish valuable testimony. The greatest care is necessary in order to establish the bona fide character of the record intervening after the destruction of an original monument. Full inquiry may often serve to bring to light various records relating to the original corners, and memoranda of private markings, etc., and the engineer should make use of all such sources of information. The matter of boundary disputes should be carefully looked into in so far as adverse claimants may base their contentions upon evidence of the original survey, and if such disputes have resulted in a boundary suit, the record testimony and the court's decision should be carefully examined

relative to any information which may shed light upon the position of an original monument.

The testimony of individuals may relate to knowledge of the original monument or the accessories, prior to their destruction, or to any other marks fixing the locus of the original survey, and the value of such testimony may be weighted in proportion to its completeness and agreement with the calls of the field notes of the original survey, also upon the steps taken to preserve the location of the original marks. All such evidence should be put to the severest possible tests by confirmation relating to known original corners and other calls of the original field notes, particularly to line trees, blazed lines and items of topography.

It is impossible to outline a definite rule for the acceptance or non-acceptance of the testimony of individuals. Corroborative evidence becomes necessary in direct proportion to the uncertainty of the particular statements advanced by the individual who testifies. It will be well for the engineer to bear in mind that conflicting statements and contrary views of interested parties are fruitful of boundary disputes.

356. In those cases where witness corners were established in the original survey, the true point for the corner will be controlled by such witness corner, when the latter can be identified, by reference to the record in accordance with the general plan of the survey. The usual diligent search will be made for witness corners, but where the same can not be identified the position of the true point for the corner will usually be of major importance, rather than the point for the witness corner, and in such instances the engineer will proceed directly to the re-determination of the true corner position, adopting the particular methods which should govern the case in hand. Should it become necessary to restore a lost witness corner the general principles hereinafter outlined will be observed.

357. In the absence of an original monument, a line tree, or a definite connection to natural objects, or to improvements, which can be identified, may each fix a point of the original survey for both latitude and departure. The mean position of a blazed line, when identified as the original line, may sometimes help to fix a meridional line for departure, or a latitudinal line for latitude. Other calls of the original field notes in relation to various items of topography may assist materially in the recovery of the locus of the original survey. Such evidence may be developed in an infinite variety.

It may be only such as to disprove other questionable features, or it may guide the engineer in a general way in arriving at the immediate vicinity of a line or corner, or in its best phases may be such as to fix the position of a line or corner beyond any doubt.

358. A certain measure of allowance should be made for ordinary discrepancies in the calls relating to items of topography. Such evidences should be considered more particularly in the aggregate, and when they are found to be corroborative an average may be secured to control the final adjustment, which will be governed largely by the evidences nearest the particular corner in question, giving the greatest weight to those features which agree most harmoniously with the record, and to such items as afford definite connection. A careful analysis will generally reveal the merits of authentic evidences as opposed to unreliable features bearing resemblance to the calls of the field notes, and in this matter the engineer will find an opportunity to exercise his skill to the fullest capacity.

359. It is a matter of utmost importance to determine where an identified call of the original field notes shall operate to control for both latitude and departure, or for either coordinate by itself, and finally as to the necessity for applying the rules for proportionate measurement where the distance between the identified points is considerable.

RESTORATION OF LOST CORNERS.

360. A lost corner is a point of a survey whose position can not be determined, beyond reasonable doubt, either from original traces or from other reliable evidence relating to the position of the original monument, and whose restoration on the earth's surface can be accomplished only by means of a suitable surveying process with reference to interdependent existent corners.

361. The engineer is not prepared to consider the restoration of a lost corner until he has exhausted every other means of identifying its original position, and at this stage of his work he should have determined upon an approximate position of the original monument based upon his findings resulting from retracements leading from known corners to the lost corner, from one, two, three, or four directions in accordance with the plan of the original survey. The principle of proportionate measurement, which most nearly harmonizes surveying practice with the legal and equitable considerations involved in controversies concerning lost land boundaries, enters

into the problem at this stage, and this plan of relocating a lost corner will always be employed unless outweighed to the contrary by physical evidence of the original survey. In cases where the relocated corner can not be made to harmonize with all the calls of the original field notes, due to unexplained discrepancy which is made apparent by the retracement, the engineer is required to determine which calls will be given major control, and those which must be subordinated.

362. The preliminary retracements furnish the only possible means of arriving at the discrepancies of the courses and distances of the original survey as compared with those derived in the process of re-running the lines, and the whole problem of proportionate measurement is one involving the adjustment of said discrepancies. The restoration of the lost corners can not proceed until the retracement of the original survey has been completed. The retracement will be based upon the courses and distances returned in the field notes of the original survey, or the equivalent by calculation, initiated and closed upon known original corners. Temporary stakes for future use in the relocation of all lost corners may be set when making the retracements.

363. As has been observed, existing original corners can not be disturbed; consequently discrepancies between the new and the original record measurements of the line connecting the identified original corners will not in any manner affect measurements beyond said corners, but the differences will be distributed proportionally within the several intervals embraced in the line in question.

364. A proportionate measurement is one resulting in concordant relation between all parts of an original record length of a line and the new distances given to the several parts as determined by the re-measurement, in such a manner that the new distance given to any part of a line shall bear the same relation to the original record length of that part of the line as the new measurement of the whole line bears to the original record length of said line. The ordinary field problem consists in distributing the excess or deficiency determined by comparing the new measurement with the record distance between two original existent monuments, in such a manner that the amount of excess or deficiency given to each interval shall bear the same proportion to the whole difference as the record length of the interval bears to the whole record distance. After having applied the proportionate difference to the record length of

each interval the sum of the adjusted lengths will equal the new measurement of the whole distance.

365. The term "single proportionate measurement" is applied to a new measurement made on a single line to determine the position thereon for restoring a lost corner, for example, a quarter-section corner on line between two original section corners. The term "double proportionate measurement" is employed to signify new measurements made between four original corners on intersecting meridional and latitudinal lines for the purpose of fixing by relation to both lines the position of a lost corner, for example, a corner common to four sections or four townships.

366. It will almost invariably happen that discrepancies will be developed between the new measurements and the original measurements recorded in the field notes. When these differences occur the engineer will generally be required to adopt a proportionate measurement based upon a process conforming to the method followed in the original survey. The principle of the preponderance of one line over another of less importance is recognized, in order to determine upon the procedure relative to single or double proportionate measurement, or other rule to be adopted in order to limit the control and at the same time harmonize the restorative process with the method followed in the original survey. Thus standard parallels will be given precedence over other township exteriors, and the latter will be given precedence over subdivisional lines; section corners will be relocated before the position of lost quarter-section corners can be determined.

PRIMARY METHODS.

(a) DOUBLE PROPORTIONATE MEASUREMENT.

367. The method of double proportionate measurement is generally applicable to the restoration of lost corners of four townships and of lost interior corners of four sections. It is the best example of the basic principle that monuments north and south should control the latitudinal position of a lost corner, and monuments east and west should control the longitudinal position of a lost corner, upon a plan by which the influence of one identified original corner is balanced by the control of a corresponding original corner upon the opposite side of a particular missing corner which is to be restored, each identified original corner being given a controlling weight inversely proportional to its distance from the lost corner.

368. In order to restore a lost corner of four townships where all of the connecting lines have been established in the field, a retracement will first be made between the nearest identified original corners on the meridional line, north and south of the missing corner, upon which line a temporary stake will be placed at the proper proportionate distance. This will determine the latitude of the lost corner. Next, the nearest original corners on the latitudinal line will be connected and a point thereon will be determined by proportionate measurement in a similar manner, independent of the temporary stake on the meridional line. The second temporary point will determine the position of the lost corner in departure. Then through the first temporary stake run a line east or west, and through the second temporary stake a line north or south, as relative situations may determine. The intersection of the two lines last run will define the position of the restored corner by "double proportionate measurement."

369. In the accompanying diagram the points "A," "B," "C" and "D" (on the small scale) represent four original corners; and (on the large scale) "E" represents the proportional point between "A" and "B," for measurement only, and similarly, "F" represents the proportional point between "C" and "D." The point "X" satisfies the first control for latitude, and the second control for departure.

370. The plan of double proportionate measurement will be applied to the restoration of lost corners of four townships where all the lines therefrom have been run. Lost interior corners of four sections, where all the lines therefrom have been run, will also be reestablished by double proportionate measurement, *after* first relocating the required lost section corners on the township exteriors. When a number of corners of four sections, and the intermediate quarter-section corners, are missing on all sides of the one sought to be reestablished, the entire distance must, of course, be re-measured between the nearest identified corners both north and south, and east and west, in accordance with the rule laid down.

371. Where one of the connecting lines has not been established in one direction from the missing township or section corner, the record distance to the nearest identified corner in the opposite direction will prevail in lieu of a proportional measurement. Thus, in the same diagram, if the latitudinal line in the direction of the point "D" had not been established in the original survey, the

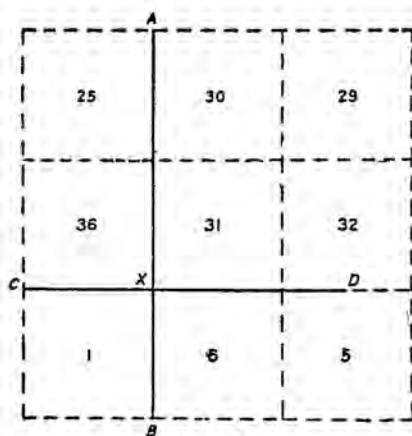
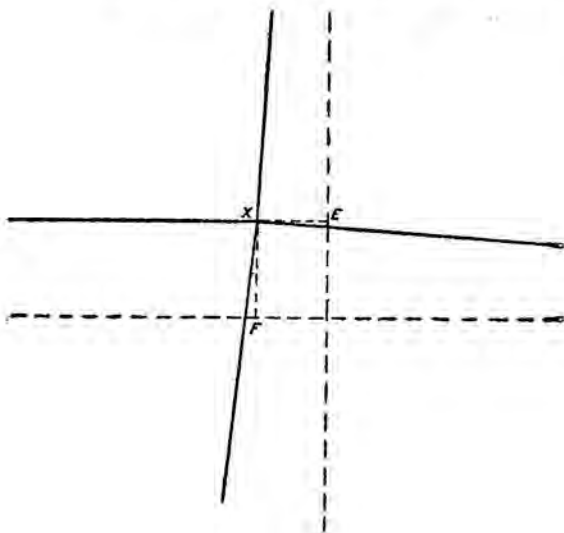


Fig.67.

position of the point "F" in departure would have been determined by reference to the record distance from the point "C," whereupon the point "X" would have been fixed by cardinal offsets from the points "E" and "F" as before. Again, in rare instances, where the intersecting lines have been originally established in only two of the directions, the record distances to the nearest identified corners on the two lines will control the position of the temporary points from which the cardinal offsets are to be made.

(b) SINGLE PROPORTIONATE MEASUREMENT.

372. The method of single proportionate measurement is generally applicable to the restoration of lost corners on standard parallels and other lines established with reference to definite alinement in one direction only. Intermediate corners on township exteriors and other controlling boundary lines are to be included in this class.

373. In order to restore a lost corner by single proportionate measurement, a retracement will be made connecting the nearest identified regular corners upon the particular line in question, the record of which shows no deflection in alinement; a temporary stake will be set on the preliminary line at the original record distance; the total distance will be measured, also the falling at the objective corner. The temporary stake will then be adjusted for the proportional part of the difference between the record distance and the re-measurement, also for its proportional part of the falling. Thus the adjusted position will fall on the true line connecting the nearest identified corners, and at the same proportional interval from either as existed in the original survey. Any number of lost points, on the same straight line, may be recovered by the same plan, setting a temporary corner for each at the time when making the retracement. On the retracement of an east and west line, the proper adjustments to secure the true latitudinal curve should be allowed for as outlined in Chapter II.

374. Lost standard corners will be restored to their original positions on a base line, standard parallel or correction line, by single proportionate measurement on the line connecting the nearest identified original standard corners on opposite sides of the missing corner or corners, as the case may be. The term "original standard corners" will be understood to designate standard township, section and quarter-section corners, meander corners terminating the survey of a standard parallel, and closing corners in those cases where they were originally established during the survey of a

standard parallel as corners from which to project surveys to the south. No other meander or closing corners along a standard parallel will control the restoration of lost standard corners.

375. All lost exterior section and quarter-section corners will be restored by single proportionate measurement between the nearest identified corners on opposite sides of the missing corner, north and south on a meridional line, or east and west on a latitudinal line, *after* the township corners have been identified or relocated. An exception to this rule will be noted in the case of any exterior the record of which shows irregularities in alinement between the terminal township corners. (See sec. 380.)

376. All lost interior quarter-section corners will be restored by single proportionate measurement between the adjoining section corners, *after* the section corners have been identified or relocated.

377. Lost meander corners, originally established on a line projected across the meanderable body of water and marked upon the opposite side thereof will be relocated by single proportionate measurement, *after* the section or quarter-section corners upon the opposite sides of the missing meander corner have been duly identified or relocated.

(c) CLOSING CORNERS.

378. In order to reestablish a lost closing corner on a standard parallel or other controlling boundary, the line closed upon will be retraced, beginning at the corner on the standard parallel or other controlling boundary from which the connecting measurement was originally made, itself properly identified or relocated; a temporary stake will be set at the original record connecting distance, and the total distance and falling will be noted at the next regular corner on the opposite side of the missing closing corner. The temporary stake will then be adjusted as in single proportionate measurement, i. e., the closing corner will be reestablished on the true line closed upon at the proper proportional interval between the nearest regular corners to the right and left. An identified closing corner not actually located in the line closed upon will determine the direction of the closing line, but not its legal terminus; the latter is bound to fall at the true point of intersection of the two lines. The position of a restored closing corner should be verified by a retracement of the line whose terminus it was designed to mark. (See sec. 384.)

SECONDARY METHODS.

879. The following methods involve special applications of the general rules of proportionate measurement for adoption in unusual cases where the ordinary control can not be obtained.

(d) BROKEN BOUNDARIES.

880. In order to restore one or more lost corners on a broken or irregular township exterior, or other controlling boundary, a retracement

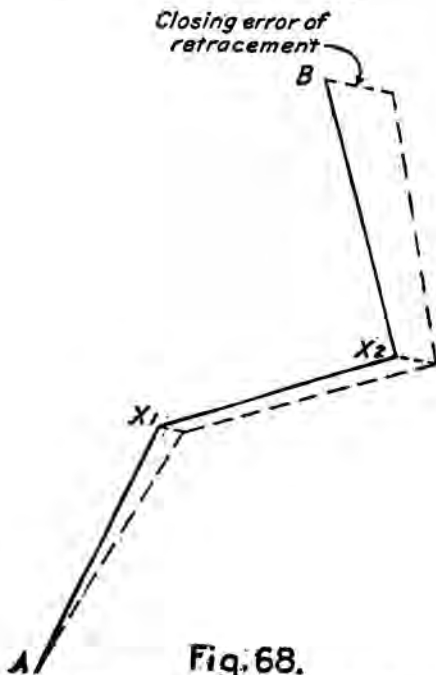


Fig. 68.

ment will be initiated at the nearest identified original corner on the boundary, following out the record courses and distances, or the equivalent by calculation, setting a temporary stake for each missing corner or angle point, until the next identified original corner has been attained, where a final temporary stake will be set at the record distance of the last course of the retracement. The closing error will

then be determined for course and distance from the last temporary stake to the objective original corner, and each temporary stake will thereafter be adjusted on the bearing of the closing error, a proportional amount of the length of the closing error equal to the proportional part of the distance of the temporary stake from the initial point of the retracement, i. e., the particular distance to be measured at any temporary stake, on the bearing of the closing error, is to the whole length of the closing error as the distance of the particular temporary stake from the initial original corner is to the whole length of the retracement. Angle points and intermediate corners will be treated alike.

(e) ORIGINAL CONTROL.

381. Where a line has been terminated with reference to a measurement in one direction only, a lost corner will be restored by reference to the original record bearing and distance, counting from the nearest regular corner, the latter having been duly identified or restored. Examples will be found where lines have been discontinued at the intersection with large meanderable bodies of water, or at the border of what was classed as impassable ground.

(f) INDEX CORRECTION FOR AVERAGE ERROR IN ALINEMENT AND MEASUREMENT.

382. In unusual cases where a retracement has been made of many miles of the original lines, between identified original corners, and there has been developed a definite surplus or deficiency in measurement, or a definite variation in alinement, characterizing the original survey, it will be proper to make allowance for such average "index error." Such adjustment will be taken care of automatically in all cases where there exists a suitable basis for proportional measurement, but in any case where such control is lacking, an index error, if conclusive, will be made use of by applying the determined correction to the record courses and distances. If there is not conclusive evidence of such index error the record courses and distances will be allowed to prevail.

SPECIAL CASES.

383. Examples of special cases could be set forth almost indefinitely, but without bringing out important new principles. In some respects the treatment of a large number of special examples would serve to confuse the subject by seeming to warrant certain procedure as a general rule which in fact would not be proper were

the conditions altered; the latter occur in an infinite variety. Ample provision has been made for the United States surveyor to call upon a supervising officer for advice in difficult cases, and where necessary the latter is in a position to direct the surveyor to proceed with additional retracements in order to develop any data which should be considered before a decision is rendered. In trials of boundary suits the court will generally consider many additional questions besides those concerned in the technical problem, and in such instances an academic study of hypothetical examples might serve to cloud the real issue. It would be beyond the purpose of the Manual to invade the realm of non-technical matter while attempting to lay down the general principles involved in the restoration of lost corners.

384. In all unusual instances, where on account of manifest distortion, or through extensive obliteration resulting in great distances between existing corners, or otherwise, the evidence of a survey can not be identified with sufficient certainty to enable a suitable application of the various rules relating to the restoration of lost corners, the engineer is again advised to report the facts to the proper supervising officer. In the same connection, it is important that the engineer should not be confused with the notion that he is required, or has any authority, to revert to the principles relating to the establishment of original surveys as an alternative in such cases. The methods incident to resurveys, as outlined in the next chapter, are designed to rectify unusual conditions which are widely at variance with the representations of the original approved plat and field notes.

(g) MISCELLANEOUS CONTROL.

385. It will be apparent to the experienced engineer that actual field conditions do not always furnish the basis for the application of the rules heretofore set forth, and while developing a consistent theory to apply in unusual cases the engineer will at once note that the first consideration relates to a more or less arbitrary limitation of the control to be adopted. No definite rule can be laid down, except that there should be the closest possible adherence to the basic examples already given in the text. The methods heretofore outlined readily harmonize surveying practice with legal decisions concerning the restoration of lost corners. A strictly consistent mathematical recovery of a lost corner, not based upon any known legal decision, may be obtained by allowing every known corner within a reason-

able radius to enter into the control, each original corner being given a weight inversely proportional to its distance from the missing corner, and though the principle will lead to the same result in some cases as by the methods previously outlined, it will yield a slightly different result under other regular circumstances. For the latter reason a miscellaneous control based upon such mathematical principle will not be adopted except as specifically approved by the proper supervising officer after due consideration of the facts in regard to the applicability of the method in the absence of a suitable basis for a regular control.

386. Having thus safeguarded the application of the following method, the problem in the field will be developed by a series of retracements each beginning at an accepted corner, thence following out the record courses and distances, each retracement terminating at a temporary stake in the vicinity of the objective lost corner. Each stake will be given a weight inversely proportional to the distance from the accepted corner to which it is related. The several temporary stakes will then be combined; the first two to be resolved into a point on the line between them, dividing the whole distance into two parts that will make the interval from either stake inversely proportional to the weights previously assigned, and the latter point will be given their combined weights. The last point will then be correlated with the third temporary stake on a similar plan. Three or more original corners will thus exercise their influence upon the final resultant position for the corner which is to be restored. The result will be the same no matter what the order of connecting the temporary stakes may be, but the omission of any element of the control or the introduction of an additional original corner will alter the final position. The field of influence should accordingly be selected with a view to obtaining a resultant balanced position which can not be materially changed by the introduction of other known points of control.

CHAPTER VI.

RESURVEYS.

JURISDICTION.

387. Certain important considerations are involved in the execution of Government resurveys of an entirely different character from those relating strictly to the making of original surveys; these considerations present matters not referred to in Chapter V. There is a twofold object of a resurvey: First, the adequate protection of existing rights acquired under the original survey in the matter of their location on the earth's surface, and, second, the proper marking of the boundaries of the remaining public lands.

388. As already noted in Chapter I, the Congress has authorized, under certain conditions, the re-marking of the public-land surveys. The acts relating to resurveys contemplate a restoration of the corners of the original surveys in those townships, (a) where the obliteration of the original monuments or other evidence of the position of the original lines has become so advanced that the land boundaries can be identified only through extensive retracements by experienced engineers of the General Land Office, and (b) where field investigation shows that conditions on the ground disagree with the representations upon the original plat to such an extent that the land boundaries can not be identified positively in one position to the exclusion of another, in consequence of which said plat should be disqualified as a basis for the disposal of remaining public land. While the Government may initiate a resurvey in the absence of any application therefor, as a rule, the steps preliminary to the authorization of a resurvey will be taken by the settlers interested in the land, through a showing of facts made to the proper supervising officer, setting forth the existing conditions with respect to the original survey and status of ownership of the lands.¹

¹ See current circular governing applications for resurveys.

389. The engineer is advised to bear in mind the fact that in localities where resurveys are necessary the occasion for boundary disputes is ever present; he should accordingly exercise the greatest care in his technical work in the field and in the record thereof, so that the result of the resurvey shall relieve existing difficulties as far as possible without introducing new complications. As in the case of original surveys, the records of all resurveys must form an enduring basis upon which depends the security of the title to all lands acquired thereunder, and the field notes should be so prepared that under the test of the closest possible scrutiny at all times, present and future, the record can be regarded as conclusive in the matter of the location of such rights.

390. The General Land Office has exclusive jurisdiction over all matters pertaining to surveys and resurveys affecting the public lands; as between private owners of lands the title to which has passed out of the United States, final determination in the matter of fixing the position of disputed land boundaries rests with the local court of competent jurisdiction. The rules of procedure laid down by the General Land Office to guide its engineers in the re-marking of lines of previous surveys are intended to be in harmony with the leading court decisions in suits involving boundary disputes, and said rules should be so applied that the courts may, with security, accept without question the boundaries thus determined in so far as they represent the true location of a particular tract intended to be conveyed by a patent. Government resurveys are undertaken only by duly appointed United States surveyors acting under the authority of the Secretary of the Interior through the Commissioner of the General Land Office and under the immediate direction of subordinate supervising officers.

LIMIT OF AUTHORITY OF ENGINEER.

391. There are certain questions of a purely judicial nature involved in resurveys of every description where the decision is to be reserved to the General Land Office, particularly those relating to compliance with the general laws in respect to the entry of the public lands. Thus it comes within the realm of the surveying process to identify and mark out on the ground the various legal subdivisions of the public domain, but it is a judicial question beyond the function of the engineer to determine whether or not specified lands have been duly earned under a certain entry. In

the resurvey process the engineer will determine whether or not lands embraced within a claim as occupied have been correctly related in position to the original survey, and where the demonstration of this question may be one involving more or less uncertainty, as is often the case, the engineer will examine and weigh the evidence relating strictly to the surveying problem involved, and he will interpret the evidence in respect to its effect upon the manner in which the resurvey shall be executed looking to the protection of the valid rights acquired under the original survey. The engineer has no authority to enter into any agreements looking to the exchange of one subdivision for another, or to bind the General Land Office in this particular.

BONA FIDE RIGHTS OF CLAIMANTS.

392. In order to carry out the provisions of the laws relating to resurveys, the engineer should understand fully the meaning of the words "bona fide rights" and under what circumstances it will be held that such rights have been impaired by a resurvey. In this connection attention is again directed to the clause contained in the act of March 3, 1909 (35 Stat., 845), as amended by joint resolution approved June 25, 1910 (36 Stat., 884), which reads as follows:

"That no such resurvey or retracement shall be so executed as to impair the bona fide rights or claims of any claimant, entryman, or owner of lands affected by such resurvey or retracement."

The rights of claimants are to be given similar protection under the provisions of the act of September 21, 1918 (40 Stat., 965).

393. It will be understood that bona fide rights are those acquired in good faith under the law. Rights of this character can be affected by a resurvey only in the matter of POSITION or LOCATION on the earth's surface, and the engineer will be concerned only with the question as to whether lands covered by such rights have been actually LOCATED in good faith. Other questions of good faith, such as priority of occupation, possession, continuous residence, value of improvements, and cultivation, when considered apart from the question of the position of the original survey, do not in any manner affect the problem of resurvey.

It is evident that the resurvey must afford adequate protection to bona fide rights vested in both improved and unimproved lands. In the final determination of the true position of all lands, whether

improved or unimproved, in the absence of original corners, the necessity for more or less flexibility of method must be recognized, as the value of both of these classes of lands *may* be vitally affected by an arbitrary process of resurvey which is rigid in its application. Unimproved lands, however, where no apparent attempt has been made on the part of the owner to identify the same under their original descriptions (and where the inherent value of the lands in question is the same), are not *necesssarily* affected in the same manner, and such unimproved lands may be adjusted to a position found by the engineer to be conformable to adjoining or near-by tracts, where all may be held to qualify under the rule of acceptable location.

394. The question arises whether the technical rules for the restoration of lost corners are to be rigidly applied in all cases regardless of their effect on the position of improvements, or whether the position of all improvements is to be accepted without question regardless of the relation or irrelation of such improvements to the existing evidence of the original survey and to the description contained in the entry. Manifestly these opposite extremes are equally unacceptable. Somewhere between them, therefore, will be found the basis for a determination of the question as to when lands so improved are to be regarded as having been LOCATED in good faith or otherwise. It is clear that no definite specific set of rules can be laid down in advance for the determination of this question. This is a problem the solution of which must be found on the ground by the engineer; it is upon his judgment primarily that the responsibility for a determination of the question of good faith as to LOCATION must rest. The engineer may err in his judgment, but once this question is settled to his own satisfaction, the *procedure* to be adopted in the matter of the application of resurvey rules is no longer in doubt.

395. It may be held generally that an entryman has located his lands in good faith (referred to herein as an acceptable location of a claim or of a local point), when it is evident that his interpretation of the record of the original survey as related to the nearest existing corners at the time the lands were located (as defined by his fencing, culture, or other improvements) is indicative of such a degree of care and diligence upon his part, or that of his surveyor, in the ascertainment of his boundaries, as might be expected in the exercise of ordinary intelligence under existing conditions. From this it

follows that lack of good faith is not necessarily chargeable against an entryman if he has not located himself according to a rigid application of the rules laid down for the restoration of lost corners, where complicated conditions involve a double set of corners, both of which may be regarded as authentic; or where the nearest existing corners in one or more directions are an excessive distance away; or are improperly related to each other to an extraordinary degree; or where all evidences of the original survey which had been adopted by the entryman as a basis for his location have been lost before the resurvey is undertaken. Furthermore, the extent of recognition given by neighboring claimants to a local point used for the control of the location of claims very often carries with it the necessity for a consideration by the engineer of its influence in the matter of the acceptability of such locations under the foregoing rule of good faith.

396. In cases involving extensive obliteration at the date of entry, the entryman or his successors in interest may be charged with the knowledge that the boundaries of the claim will probably be subject to more or less adjustment in the event of a resurvey, and that in the process of fixing the boundaries of groups of claims a general control applied to all must be favored as far as possible in the interest of equal fairness to all and of simplicity of resurvey. Even in the presence of extensive obliteration of the original survey, a claim which manifestly shows that no attempt has been made to relate the same in some manner to the original survey can not generally be regarded as having been located in good faith.

397. Cases will arise where it may be evident that lands have been OCCUPIED in good faith, but whose boundaries as occupied are clearly in disagreement with the demonstrated position of the legal subdivisions called for in the description. Obviously the rule of good faith as to location can not apply, and relief must be sought through the process of amended entry (act of Feb. 24, 1909, 35 Stat., 645) to cover the legal subdivisions actually earned, rather than through an alteration of the position of established lines. This is a process of adjudication rather than one of resurvey. A case of this character should be regarded as an "erroneous location," in precisely the same manner as would obtain if the question of resurvey were not involved.

398. The recognition of the principle that the restoration of a corner may be influenced by the position of one or more existing claims

warrants, within suitable limits, the acceptance of an unofficial determination, in the manner hereinafter stated, which would not necessarily agree with that resulting from a rigid application of arbitrary rules laid down for the restoration of lost corners.

GENERAL FIELD METHODS.

399. There are two recognized methods of making Government resurveys—DEPENDENT and INDEPENDENT—and in general, any field condition that may arise can be taken care of by the application of one or the other method.

400. The DEPENDENT resurvey is designed to accomplish a restoration of what purports to be the original conditions according to the record, based, first, upon identified existing corners of the original survey and other recognized and acceptable points of control, and, second, upon the restoration of missing corners by proportionate measurement in harmony with the record of the original survey. This type of resurvey is applicable to those cases showing fairly concordant relation between conditions on the ground and the record of the original survey. Titles, areas and descriptions should remain absolutely unchanged in the typical dependent resurvey.

401. The INDEPENDENT resurvey provides methods adapted to considerable areas of public land where the original survey can not be identified with any degree of certainty in accordance with the representations of the approved plat and field notes, and where the prevailing conditions are such that strictly restorative processes, when applied as an inflexible rule between existing monuments or adopted corner positions, are either inadequate or lead to unsatisfactory results. This type of resurvey provides for the segregation of individual tracts when necessary, or a conformation of individual tracts to the subdivisions of the resurvey if suitable. These processes are found to be more flexible in their application than those of the strictly dependent type, but at the same time they duly protect all private rights which have been acquired upon the basis of the original approved survey and plat. With respect to the identification and description of the public lands involved, the independent type of resurvey supersedes the record of the original survey. This will be made apparent by the representations of the approved resurvey plat.

402. The basic principle, with respect to the protection of bona fide rights, involved in one type of resurvey is identical with that of the other type, whether dependent or independent; they are both

to be regarded as a demonstration, on the part of the General Land Office, in the light of the *best evidence available*, by means of the legal subdivisions of a dependent resurvey or by the tract segregations of an independent resurvey, of the *original* position of entered or patented legal subdivisions or lots included in the *original* description when related to the *original* survey. There is no legal authority for the substitution of the methods incident to an independent resurvey in disregard of identified evidence of the original survey.

403. The necessity for both types of resurvey is encountered in the field; the applicability of one or the other method is altogether a question depending upon local conditions, such as extent of obliteration, relative harmony of identified and recognized points, and extent of disposals by the Government. These questions should not be judged in advance of a comprehensive field examination.

404. In general, a preliminary field examination will be required and authorized before the resurvey is to be undertaken.

The purpose of an investigation is to develop the extent of the obliteration of the evidence of the original survey, the extent of settlement, the agricultural possibilities of the township, and any other information from which the necessity for, and the propriety of, the proposed resurvey may be determined.

A second purpose to be subserved by an investigation is the assembling of sufficient data concerning the local survey conditions to permit a proper type selection; and with this end in view the examining engineer should investigate and report upon the relative position of the evidence of the original survey; the degree to which identified points are concordant or the reverse; the extent to which corners discordantly related have been made the basis of claim locations; the presence of one or more systems of unofficial local surveys which have been recognized and adopted by the claimants in fixing their boundaries; and the degree to which conflicts are to be anticipated.

405. The proper supervising officer will provide the examining engineer with suitable instructions in which the scope of the examination will be indicated and attention will be directed to the particular considerations which should receive attention. During the progress of the investigation interested parties should be informed, upon inquiry, that the work then in progress is merely preliminary and only for the purpose of gaining information, and that if resurvey is ultimately authorized all valid rights will then be protected as required by law.

406. The examiner's report should contain definite recommendations concerning the type of resurvey which, in his judgment, should properly be applied in view of the prevailing conditions.

When the report and recommendations of the examiner, with those of the supervising officer, have been received by the General Land Office, the situation will be considered, the appropriate type of resurvey will be determined, and the preparation of special instructions for the resurvey will be authorized.

407. The special instructions, which must of necessity be based largely upon the data provided by the examination, will indicate the scope of the work, and, regardless of whether the lands are to be dependently or independently resurveyed, the necessary retracements will be made to fix the outboundaries of the township or townships designated for resurvey. With the limiting boundaries once restored so as to protect under the rules already laid down all existing property rights in the adjoining lands not to be resurveyed, the plan of procedure outlined in the instructions should, under the known conditions, produce satisfactory results, and adherence thereto is expected. If, however, unforeseen conditions are developed in the progress of the resurvey, which may apparently render the special instructions inapplicable or likely to produce inconsistent or unsatisfactory results, it is of the utmost importance that the engineer suspend further monumentation of the corners; and after such additional retracement and investigation as may be necessary to a proper understanding of the situation, he should report the facts to the proper supervising officer and request further instructions.

408. During the progress of the resurvey the engineer should advise all interested parties, as occasion and opportunity may offer, that the resurvey is not to be regarded as official or binding upon the United States until duly accepted by the Commissioner of the General Land Office, as provided by law, and that no contemplated alteration in the position of improvements or claim boundaries should be made in advance of the official acceptance of the resurvey.

THE DEPENDENT RESURVEY.

GENERAL CONTROL.

409. A dependent resurvey is an official re-marking of the original lines upon a plan whereby existing evidence of the original survey is given primary control over the position of the lines to be reestablished. A certain amount of flexibility (as hereinafter described)

is allowable in the dependent resurvey when necessary for the protection of bona fide rights of claimants, particularly in those cases where no objection is found to adopting a point acceptably located under the rule of good faith already laid down, when only slightly at variance with the theoretical position of the same.

410. In theory the process consists, first, in the retracement and reestablishment of the township exteriors; second, the identification of all existing interior corners or other evidence of the original survey; and, third, the determination, by a *suitable field procedure*, of the theoretical position of all missing corners as indicated by a proper interpretation of the record of the original survey in relation to such existing evidence. The actual field process may be varied to some extent in order to meet local conditions or to suit the convenience of the engineer, but the theoretical position finally determined must be identical with that which would result from a strict application of the principles of proportional measurement. When this has been accomplished, attention should be given to the adoption, as an integral part of the resurvey system, of corner positions determined by the evidences, of whatever character, of acceptable claim location. Such evidences may, for convenience, be termed "collateral evidence" as distinguished from direct evidence of the original survey.

411. The process of the dependent resurvey differs in scope from that applied for the usual restoration of one or more lost corners, and the rules governing a resurvey bring into consideration in a more comprehensive manner the position of recognized land boundaries, in the absence of evidence of the original corners. The engineer has noted the detailed instructions set forth in Chapter V looking to the identification of existing evidence of the original survey and the application of the rules of proportionate measurement for the determination of the theoretical position of lost corners. These rules will be applied in the dependent resurvey generally with respect to the township as a unit, wherein the means of identification of each and every existent corner will be exhausted and the theoretical position determined for each lost corner. The former are to be considered as fixed points (except in most unusual cases) and may be monumented at any time; the latter will be subjected to the possible influence of points which may afterwards be determined to be acceptably located under the same rule of good faith, and will be marked only as temporary points until this question has been disposed of.

412. A complete retracement of the original survey will be made, based upon known corners, it being assumed that the exterior boundaries of the township to be resurveyed have been identified or restored under the rules already laid down in Chapter V, and under those relating to the acceptability of a local point or claim location. It is not usually possible to follow the method and order of procedure shown in the record of the original survey (owing to missing corners), but the complete system of lines will be run out by preliminary retracement, usually beginning with the meridional lines between known corners, followed by the latitudinal lines between known corners, noting the intersections with the said meridional lines. The engineer must be supplied with a complete copy of the record of the original survey, and temporary reference stakes may be set on the meridional lines at the record measurement for each corner point.

413. The preliminary retracements will lead at once to the identification of the prominent evidence of the original survey and a trial calculation will follow as to the latitudinal and longitudinal adjustments at each missing corner, to suit the proportions which may be derived when based upon these known corners. A second and more exhaustive search will then follow within the zone of the probable location of each missing corner for the more obscure evidence of the original survey. At this stage of his field work the engineer should exhaust every possible means of identifying the existent corners of the original survey. In many respects, the engineer will be compelled to devise his own methods as the actual field conditions seem to warrant, and his skill and judgment as an engineer should function to the fullest capacity.

If additional evidences of the original survey are found by this process, a second trial calculation will then be made as to the latitudinal and longitudinal adjustments of the temporary reference stakes previously set at each missing corner, to suit the proportional measurements derived from all of the known original corners—exactly as outlined in Chapter V. These calculated adjustments will determine the theoretical location of each lost corner with reference to all existing evidence of the original survey.

In the absence of other considerations, the theoretical points thus determined by proportionate measurement, based upon existing original corners, are fixed to a mathematical certainty, and when these points have been determined, the evidence of the original

survey and the record thereof have served their primary purpose. Then, and not until that time, is the engineer prepared to consider the weight of such collateral evidence as may be available.

414. The question now to be determined is whether the position of the lands claimed, occupied or improved is to be adopted under the rule of good faith as to location, and whether, if so adopted, the claims thus acceptably located can all be properly protected by the dependent plan of resurvey. If the position of any claim fails to qualify under the said rule of good faith it may be disregarded as to the effect produced thereon by the plan of dependent resurvey. On the other hand, if these claims are held to be acceptably located under the same rule, they may be adopted as the determining factor in the position of the missing corner or corners; and if the claims are in such concordant relation to each other and to the identified evidences of the original survey as to receive full protection by the dependent plan of resurvey, the engineer may proceed with full assurance of the adequacy of the plan. Otherwise, the question of other processes analogous to those of an independent resurvey (as hereinafter explained) must be considered.

If two or more claims are acceptably located, but are discordantly related to each other to a considerable degree (by virtue of irregularities in the original survey), it will be clear that the general plan of dependent resurvey may not afford protection to such claims; whereupon the influence thereof must be rejected in favor of the theoretical point previously determined by proportional measurement. In this case, as before stated, some other process must be adopted to protect the acceptably located claims.

415. These acceptably located points for the missing corners will receive all the authority and significance of an identified original corner, and when the influence thereof on the dependent plan of resurvey has been combined with that of the existing original corners previously identified, the latitudinal and longitudinal adjustments of the temporary points on the meridional lines may be made accordingly.

416. In cases of distortion, if the distorted lines are to be adopted in the plan of dependent resurvey, it should be remembered that the lengths of lines, when subject to double proportion, are comparable only when reduced to cardinal equivalents or to equivalents along the direct lines between the nearest existing corners.

417. Many situations will arise where it will be manifest to the engineer that it is better to accept a position based upon local interpretation rather than to disturb satisfactory existing conditions. The engineer will endeavor to avoid disturbing the position of locally recognized lines when such action may adversely affect improvements, and at the same time extreme caution will be exercised in the matter of adopting local points of control, which when accepted must be given, as above stated, a significance similar to that of an original corner and be allowed to function on an equality therewith. The acceptance of duly qualified and locally recognized points of control should aid materially in obtaining simplicity of resurvey and avoid the need for special metes-and-bounds surveys (as hereinafter described), which would differ only slightly in position from the regular lines of the resurvey. In this manner a flexibility will be introduced in the application of a dependent resurvey, at least to the point of protecting satisfactory local adjustments.

418. The engineer should fully understand that the field of influence to be exercised by any acceptable location must be restricted to that already covered in a larger way by the existing evidences of the original survey, and that the adjustive process is of more or less local application. In this connection, it should be noted that the record of the original survey can not be abandoned in favor of an *indiscriminate* adoption of property corners, all or a portion of which fail to qualify as aforesaid, nor is it to be assumed that because a large number or all of the claims within a township are consistently related among themselves to an arbitrary system of control which is itself altogether unrelated to the original survey, that such system is qualified for adoption as the basis of a dependent resurvey.

419. Thus where bona fide rights, as defined hereinbefore, are found to have been definitely established with reference to the location of lands the position of which can not otherwise be fully demonstrated by existing evidence of the original survey, the engineer engaged in the resurvey will reject the theoretical point determined by the primary control in favor of a near-by *duly qualified* corresponding point, the position of which has been agreed upon by the adjoining property owners. Such a point may be recognized as the best available evidence of the true position for a corner; as previously stated its acceptance by the engineer confers upon the

point a significance similar to that of an original corner position, and thus avoids disturbing satisfactory local adjustments. Chief among this class of evidence forming the basis of the recognized position of land boundaries are recorded monuments established by local surveyors, duly agreed upon by the interested property owners; the position of boundary fences determined in the same manner; and the center lines of public roads and drainage or irrigation ditches, when intended to be located on the subdivisional lines of the public-land surveys. The local record in these cases, when available, may furnish the connecting link to the previously identified evidence of the original survey, but even in the absence of a conclusive record, if a point qualifies as above outlined, the presumption is strong that its position bears satisfactory relation to the original survey and that its correctness can not be successfully disputed. Points which actually qualify as aforesaid may be accepted as the best available evidence of the true position of the original survey.

420. The technical record of the resurvey should clearly set forth the reasons for the acceptance of a local point, where unofficial determinations of the above character do not represent actual marks of the original survey. Such recognized and acceptable local marks will be preserved, and described in the record of the resurvey. New monuments will be established as required, in addition to, but without destroying the evidence of, the local marks.

REESTABLISHMENT OF TRUE LINES.

421. As already stated, with the combined control of the dependent resurvey fully determined, the final calculation will be made as to the latitudinal and longitudinal adjustments of the temporary reference stakes previously set at the remaining missing corners. The final calculations will be based upon the known position of the corners of the general control as thus adopted, upon the plan of proportionate measurement, all as provided in Chapter V. The result of this process balances in regular proportion the differences between the measurements shown in the record of the original survey and those derived in the retracement. Thus the true lines of the dependent resurvey are finally determined through the influence exercised by the identified existent corners of the original survey and every other identified call of the record thereof, and

such other collateral evidence of the position of recognized land boundaries as may be properly adopted for such influence.

422. The field procedure incident to the running and measurement of the true lines of the dependent resurvey will conform to the requirements of Chapter II, while the marking of lines between corners and the notation of objects to be recorded will conform to the provisions of Chapter III, and the monumentation of the survey will comply with Chapter IV. The technical record of the resurvey will be broadened to show the relationship between the original survey and its reestablished lines.

423. The field note description of an identified or accepted corner will be introduced into the technical record of the resurvey at the place in the true line notes where the position for the corner is indicated as having been attained. The record will embrace:

(a) A complete description of the remaining evidence of the original monument;

(b) A complete description of the new monument;

(c) A complete description of the original accessories as identified;

(d) A complete description of the new accessories;

(e) A concise statement relating to the recovery of a corner based upon identified line trees, blazed lines, items of topography, or other calls of the field notes of the original survey, in the absence of evidence of the monument or its accessories; and,

(f) A statement of fact relating to the relocation of an obliterated monument; or a statement of the determining features leading to the acceptance of a recognized local corner.

424. General titles (in addition to the regular page heading) will be inserted in the field notes of dependent resurveys to indicate the character of the resurvey, the technical record of which follows. Such titles will be inserted in the body of the field notes, as appropriate, and will show the name of the original surveyor and the year in which the original survey was executed; as, for example:

“Reestablishment of the surveys executed by John B. Smith, U. S. Surveyor, in 1842,”

and additional memoranda will be added as appropriate, explanatory of the method of control adopted in the restoration of one or more lost corners.

425. In addition to the usual showing of data upon the township plat, the plat of a dependent resurvey should carry a memorandum

for the information of the public to the effect (modified as special circumstances may warrant) that—

“This plat of the resurvey of T. —, R. —, delineates a retracement and reestablishment of the lines of the original survey as shown upon the plat approved ——— (date), in their true original position according to the best available evidence of the position of the original corners; all differences between the measurements shown on the original plat and those derived in the retracement have been distributed proportionally between accepted corners in accordance with surveying rules; reference will be made to the original plat for the showing of the areas and more detailed descriptions of the various smaller subdivisions.”

ADDITIONAL METHODS FOR THE PROTECTION OF BONA FIDE RIGHTS.

426. In the execution of a dependent resurvey there may possibly arise rare cases where locally established corners controlling valuable improvements are so discordantly related to the existing authentic evidences of the original survey that such local corners can not qualify for adoption as acceptable collateral evidence (secs. 414 and 417), there being no legal authority for a disregard of the identified evidence of the original survey (secs. 395, 397, and 402). The usual appropriate treatment of this situation, where possible of application, consists in an amendment of the entry (sec. 397) from the entered to the occupied legal subdivisions in terms of the original survey. These cases are decidedly exceptional in any township where regular control has been developed by careful retracement and thorough search. No general remedy has been devised other than that of amendment of entry, and where such method appears to be impracticable the engineer will submit a detailed report of the conditions found, with recommendation for procedure suited to the particular situation to be dealt with and designed for protection to the claimant's improvements, but on a plan that will not disturb those who have acquired legal rights in the matter of consistent location.

EXAMPLE.

427. A hypothetical example of a dependent resurvey follows in the text, wherein a showing of typical conditions will be presented. In this connection it will be observed that the application of the rules for the execution of a dependent resurvey is generally made with respect to the township as a unit. In this hypothetical case it is presumed that a sufficient number of original corners can be identified to enable the restoration of the township exteriors resulting in a satisfactory closure. Upon retracement of the interior lines, some evidence of the original survey is developed, also certain

recognized and acceptable corners. All claims are found to be conformable.

The engineer will proceed with the complete retracement of the interior section lines. In this process he will employ instrumental methods and make the measurements as provided in Chapter II. He will be guided by the suggestions given in Chapter V in regard to the search for evidence of the original survey, and beyond that he will devise his own methods in the search as the actual field conditions seem to warrant. Temporary reference stakes will be set where the original corners are not at once identified (though the use of local reference points will be unobjectionable). It will be assumed that a single system of reference stakes has been employed, as this scheme lends itself more readily to theoretical discussion, as well as practical utility in the field, and allows the utmost freedom as to the order in which the retracements are made.

Having completed the reestablishment of the township exteriors and the retracement of the interior lines, the engineer will be concerned with the two primary considerations, heretofore discussed, which it is his duty to harmonize: First, the restoration of what the record purports to be original conditions; and, second, the protection of the bona fide rights of claimants in the matter of location. The first requirement must be fulfilled with reference to the evidence of the original survey, and the discovery and identification of actual original corners is paramount, bearing in mind that the development of a single additional original corner adds manifest conclusiveness to the work. These identified points when combined with those acceptably located constitute the general control. The second item, which does not directly affect the technical procedure, has been fully discussed hereinbefore.

KEY TO DIAGRAM, FIG. 69.

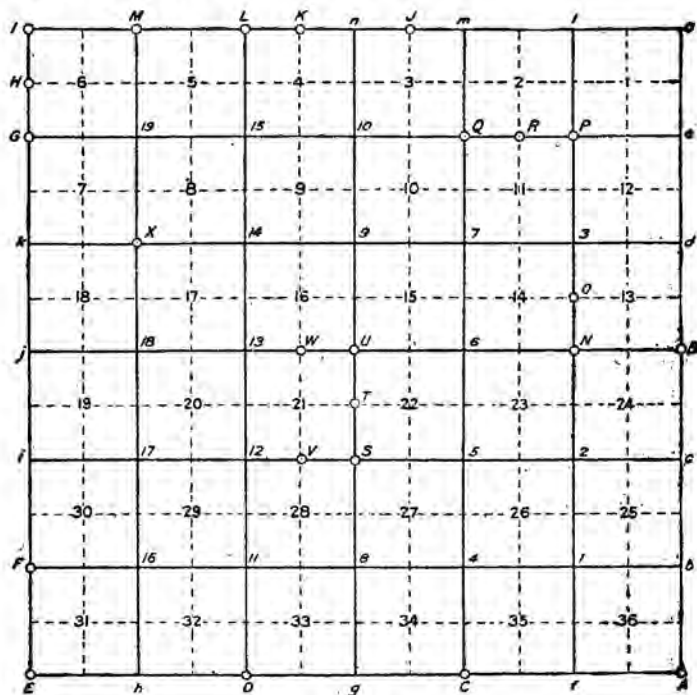
- A. Identified original corner.
- B. Intersection of center lines of public crossroads, intended to be located at section corner and generally so recognized; accepted as best available evidence of corner.
- C and D. Identified original corners.
- E. Corner established by local surveyor; record shows proper application of the method of double proportionate measurement; generally recognized as correct position of corner; accepted on an equality with an identified original corner.
- F-M, inclusive. Identified original corners.
- N. Same as B.
- O. Identified original corner.
- P. Intersection of mean position of meridional and latitudinal blazed lines through virgin timber; age count on overgrowth qualifies for date of original survey.
- Q. Restored corner based upon control furnished by latitudinal position of blazed line as above and fixed in departure by distance to original line tree.
- R. Identified original corner.

S. Same as E.

T. Position determined by location of improvements; point agrees approximately with the theoretical position and it is recognized by adjoining claimants; improvements would be adversely affected by change of point.

U. Same as E.

V and W. Same as T.



○ Employed for general control.

+ Theoretical position.

Fig. 69.

X. Identified original corner.

a. Duly restored by double proportionate measurement and thereafter employed for general control on an equality with an identified original corner.

b-n, inclusive. Theoretical true line position, duly restored by single proportionate measurement.

METHOD.

After completing all retracements and having determined upon the general control to be adopted, as indicated in the diagram and accompanying key, the true lines of the dependent resurvey, beginning at the southeast corner of the township, will be reestablished as follows:

SINGLE PROPORTIONATE MEASUREMENT.

Lines: A-B, B-a, A-C, C-D, D-E, E-F, F-G, G-H, H-I, a-J, J-K, K-L, L-M, and M-I.

DOUBLE PROPORTIONATE MEASUREMENT.

Section corners: 1, f-N and b-F; 2, f-N and c-S; 3, O-P and d-X; 4, C-Q and b-F; 5, C-Q and c-S; 6, C-Q and N-U; 7, C-Q and d-X; 8, g-S and b-F; 9, U-n and d-X; 10, U-n and Q-G; 11, D-L and b-F; 12, D-L and V-i; 13, D-L and W-j; 14, D-L and d-X; 15, D-L and Q-G; 16, h-X and b-F; 17, h-X and V-i; 18, h-X and W-j; 19, X-M and Q-G.

INTERIOR QUARTER-SECTION CORNERS.

All missing interior quarter-section corners by single proportionate measurement on line between the adjoining section corners as above determined.

FIELD DATA.

The retracements develop the following data in regard to the relative position of certain points of control and the temporary stakes:

Beginning at f, North, 40.00 chains, set temporary stake; 80.00 chains, set temporary stake; 120.00 chains, set temporary stake; 160.00 chains, set temporary stake; 200.00 chains, set temporary stake; 241.20 chains, fall 90 links W. of N; meridional excess f-N = 1.20 chains = 40 links per 80.00 chains.

Beginning at b, West, 40.00 chains, set temporary stake; 80.46 chains, fall 20 links N. of temporary stake previously set; record of original survey shows length of line 80.22 chains; continue west, etc., to F; latitudinal deficiency b-F = 84 links = 14 links per 80.00 chains.

Beginning at 2 (temporary stake), East, 40.00 chains, set temporary stake; 80.82 chains, fall 44 links S. of c; record of original survey shows length of line 79.90 chains; run west from temporary stake at 2 on similar plan; latitudinal excess c-S = 66 links = 22 links per 80.00 chains.

CALCULATIONS.

The adjustments of the temporary stakes to true line position, and the determination of the bearings and lengths of the reestablished true lines, are calculated as follows:

BETWEEN SECTIONS 35 AND 36.

Memo.	Course.	Dis- tance.	N.	S.	E.	W.
Retracement f-1.....	North.	80.00	80.00			
Adjustment at 1 for meridional excess.			.40			
Adjustment at 1 for latitudinal deficiency, 80.46—(80.22—0.14).					0.38	
True line f-1.....	N. 0° 16' E.	80.40	80.40		.38	
Adjustment at f.....			.00		.00	
Adjustment at 1.....			.40		.38	
Adjustment at $\frac{1}{4}$ sec. cor. (mean).			.20		.19	

BETWEEN SECTIONS 25 AND 26.

Adjustment at 1 from true to temporary.				0.40		0.38
Retracement 1-2.....	North.	80.00	80.00			
Adjustment at 2 for meridional excess.			.80			
Adjustment at 2 for latitudinal excess, 80.82—(79.90 +0.22).					0.70	
			80.80	.40	.70	.38
			.40		.38	
True line 1-2.....	N. 0° 14' E.	80.40	80.40		.32	
Adjustment at 1.....			.40		.38	
Adjustment at 2.....			.80		.70	
Adjustment at $\frac{1}{4}$ sec. cor. (mean).			1.20		1.08	
			.60		.54	

BETWEEN SECTIONS 23 AND 24.

Adjustment at 2 from true to temporary.				0.80		0.70
Retracement 2-N.....	North,	81.20	81.20			
Random line to N.....	East	.90			0.90	
			81.20	.80	.90	.70
			.80		.70	
True line 2-N.....	N. 0° 9' E.	80.40	80.40		.20	
Adjustment at 2.....			.80		.70	
Adjustment from 80.00 ch. point on random to N.			1.20		.90	
Adjustment at $\frac{1}{4}$ sec. cor. (mean).			2.00		1.60	
			1.00		.80	

BETWEEN SECTIONS 25 AND 36.

Memo.	Course.	Dis- tance.	N.	S.	E.	W.
Retracement b-1.....	West.	80.46				80.46
Random line to temporary stake at 1.				0.20		
Adjustment at 1 temporary to true.			0.40		0.38	
			.40	.20	.38	80.46
			.20			.38
True line b-1.....	N. 89° 51' W.	80.08	.20			80.08
Adjustment at b.....				.00		.00
Adjustment from 80.00 ch. point on random to temporary stake at 1.				.20		.46
Adjustment at 1 temporary to true.			.40		.38	
			.40	.20	.38	.46
			.20			.38
			.20			.08
Adjustment at $\frac{1}{4}$ sec. cor. (mean).			.10			.04

BETWEEN SECTIONS 24 AND 25.

to random line.....	West.			0.44		
Retracement c-2 (reversed).....		80.82				80.82
Adjustment at 2 temporary to true.			0.80		0.70	
			.80	.44	.70	80.82
			.44			.70
True line c-2.....	N. 89° 45' W.	80.12	.36			80.12
Adjustment from 80.00 ch. point on random to c.			.44		.82	
Adjustment at 2 temporary to true.			.80		.70	
			1.24		1.52	
Adjustment at $\frac{1}{4}$ sec. cor. (mean).			.62		.76	

THE INDEPENDENT RESURVEY.

428. An independent resurvey is an official re-subdivision of the public lands distinct from the original survey which it is designed to supersede. The independent resurvey is accomplished by three distinct steps:

(a) The reestablishment of the outboundaries of the lands subject to resurvey, following the method of a dependent resurvey;

(b) The segregation of lands embraced in any valid claim where the initial steps have been taken looking to the disposal of the title of the United States based upon the former approved plat; and,

(c) New exterior, subdivisional and meander lines as necessary, established upon a new regular plan, which, for every purpose of identification and description of the public lands involved, becomes the prevailing survey.

REESTABLISHMENT OF OUTBOUNDARIES.

429. The limiting boundaries of the lands subject to independent resurvey must agree with the previously established and identified exterior or subdivisional lines of the approved original surveys. In order to qualify as a suitable limiting boundary as aforementioned, a line of the accepted established surveys will be selected which can be conclusively identified (by existing original or properly restored corners) in one position to the exclusion of all others and which by its known position adequately protects all rights (located in good faith as hereinbefore defined) based upon any township plat showing subdivisions of the public lands adjacent to said boundary. Such outboundaries of the lands to be resurveyed by the independent process must necessarily be retraced and reestablished in their true original position. The lands upon one side of such outboundary are to be re-subdivided upon a new plan, while upon the opposite side of such line the original subdivisions are to be strictly maintained and none of the original conditions are to be disturbed.

430. The outboundaries are generally selected along the locus of the previously established township exteriors where the existing evidence gives positive proof of the location of the original survey, and where conditions on the ground are harmoniously related to the record of said original survey. In special cases certain section lines may fully qualify as suitable lines to mark the limit of the independent resurvey; such section lines will then be duly retraced and reestablished in their true original position. Particular attention will be given to this very important subject at the time when the field examination is made with a view to maintaining the original survey as far as consistent.

431. In those cases where a proper limiting boundary can not be secured without involving the necessity for the inclusion in the group of a greater number of townships than administratively practicable to execute in one assignment, the necessity may arise for the

extension of tract segregations (as hereinafter outlined) into a township ungrouped for resurvey. In such cases, under specific authority of the General Land Office, any tract found to extend across such group outboundary will be segregated in full, whether or not the tract was originally described as in the township to be resurveyed, and the necessary steps will thereupon be taken by the General Land Office in the matter of suspension of the lands in the adjoining township from further disposal and of additional investigations with a view to a resurvey of all or a portion of the said adjoining township. (See second rule, sec. 445.)

432. The special instructions will show specifically what lines have been selected to limit the independent resurvey, and the engineer engaged in the execution of such resurvey will proceed with the retracement and reestablishment of said outboundaries as a condition precedent to beginning the independent resurvey.

433. Where the new lines of the independent resurvey are not to be initiated or closed upon the restored original corners of the reestablished outboundaries of the independent resurvey, said restored corners will be marked only with reference to the township, range and section to which they will thenceforth relate, and new regular corners of minimum control will be established as necessary to govern the lines of the independent resurvey, all as provided in sec. 164, Chapter III. During the preliminary stages of the resurvey there will often be more or less doubt as to whether an old corner will retain its former control or will have to be altered, and until this uncertainty has been removed the marking of a corner and its accessories should be deferred. The monumentation will follow the final determination of the future significance of each point. Where an old point is to be perpetuated merely to control the former alinement, but not the corner of a subdivision, its future significance will be that of an "angle point" only and the monument and its accessories will be marked accordingly.

METES-AND-BOUNDS SURVEY OF PRIVATE CLAIMS.

434. After the reestablishment of the outboundaries of the lands subject to independent resurvey has been accomplished in accordance with the requirements of the special instructions, the engineer's attention will be directed to the segregation or marking out of all duly entered, selected, reserved (in certain cases), granted, or patented

lands whose description may be based upon the former approved plat, and which can not be conformed to the lines of the resurvey.

435. A status diagram will be furnished to the engineer showing all patented lands, valid entries, school sections, and other land grants, and all other disposals, reservations, or selections of lands whose position and description are based upon the original survey and plat, and whose boundaries can not legally be disturbed. In every case the various tracts shown upon the status diagram will be protected either by individual "metes-and-bounds" survey or by the assignment of appropriate subdivisions of the resurvey in case the latter lines (new section lines, or center lines of sections or quarter sections) are found to coincide or approximately agree with the boundaries of said tracts.

436. It is not to be understood that the metes-and-bounds survey of private claims must be completed before beginning the projection of the new lines of the independent resurvey. It has merely been deemed logical to consider the subject of the tract segregations in advance of the question of the establishment of new lines. The fact is that engineers will find it expedient to carry both branches of the survey along together in the locality of the camp or other field headquarters.

437. The jurisdiction of the General Land Office, the limit of the authority of the engineer; and the bona fide rights of claimants, where entered or patented lands are involved, remain absolutely the same whether the resurvey is to be made upon the dependent or independent plan. Thus where the independent type of resurvey has been adopted as more feasible, identified corners of the original survey in the immediate vicinity of lands to be segregated will be employed for the control of the location of such lands. The question of the good faith of the entryman will in every case be fully considered, as previously outlined in this chapter, and where the evidence of the original survey is so obliterated that a charge of a lack of good faith can not be brought against an entryman whose claim boundaries may differ from a theoretical location determined by more rigid surveying rules, the available collateral evidence is to be regarded as the best indication of the original position of the claim, and the same will be employed as far as consistent for the control of the location of the boundaries of such claim. (See sec. 395.)

438. Where there is sufficient evidence of the original survey, the identification of the areas to be segregated, resulting from the sub-

division of the original sections, will proceed in accordance with the provisions of Chapters III and V, and every corner or angle point of each tract as thus located will be marked upon the ground.

439. Where the engineer can not point out, by suitable identification of the original surveys, the definite location of an entry based upon the former approved plat, the claimant or owner of such lands will be consulted as to the position of his boundary lines. The boundaries of the private claim, so determined, will be fixed, as between the private and public lands, subject to the official acceptance of the resurvey. Where dispute is encountered in regard to the adjustment of the line between adjoining patented tracts, each acceptably located under the rules already laid down, which can not be reconciled or suitably disposed of by surveying process, the tracts will be surveyed in conflict, as hereinafter provided, and so shown on the resurvey plat; the questions arising out of such conflict will be given administrative review with the field notes of the resurvey.

440. The owner of an unidentified claim will be called upon to indicate the boundary lines thereof if possible, and in this connection, should occasion arise, the engineer will explain the manner of adjusting differences between adjoining claims and what will constitute an acceptable location of a claim. The latter condition demands a form agreeing with the original entry, approximately regular boundaries, an area not widely inconsistent with that shown upon the original plat, and a location as nearly correct as may be expected from the existing evidence of the original survey, without overlapping into an adjoining township not subject to resurvey, except as provided in section 431. In every case where the out-boundaries of the lands subject to "independent resurvey," have been reestablished by the "dependent" or "restorative" plan, the subdivisions of a tract situated and originally described as along or upon the opposite sides of such outboundary must agree with the line reestablished and harmonize in relative position.

441. In the execution of an independent resurvey, therefore, the identity of each tract to be segregated therein or indicated by conformation to the lines of the resurvey, whether patented or unpatented, must be maintained, and the engineer will not be allowed to change materially the configuration of a tract as shown by its original description in order to indemnify the owner thereof against deficiencies in area, to eliminate conflicts between entries,

or for any other purpose. If improvements have been located in good faith, the segregation survey should be so executed, or the conformation to the lines of the resurvey so indicated, as to cover as nearly as possible these improvements and at the same time maintain substantially the form of the entry as originally described. No departure from this rule will be allowed.

442. The question of amendment of entries for the purpose of permitting adjustments in terms of the resurvey involving lands not included within the original tract is a matter for the adjudication of the General Land Office after the resurvey has been accepted and the plats thereof filed in the district land office.

443. In case of absentee owners an attempt should be made to establish communication, if necessary, in order that the claimant may point out the lands subject to a metes-and-bounds survey. If the owner can not be found and there is no visible indication, such as a boundary fence, of the location of the limits of a claim, the engineer will exercise the alternative of locating the claim from the nearest original point of control or from a point of a neighboring claim, or of assigning to the entered or patented lands the appropriate subdivisions of the resurvey, all subject to the principles hereinbefore set forth. The controlling factors in such locations will be based upon the individual and neighborhood improvements (such as buildings, wells, springs of water, cultivated lands, public roads, fences, corners of recognized private surveys, etc.) which may indicate the evident intention of the entryman or patentee as to the position of his land.

444. Each non-conformable valid claim in a township will be given a serial tract number, commencing with No. 37 in the smallest numbered and entered section of the original plat, progressing through the township in the order in which lots and sections are numbered. A tract number will be used but once in a township, and if any tract lies partly in two or more townships subject to resurvey the number applied to the tract in the first township resurveyed will not be used for other tracts in the adjoining township.

445. The following rules will be observed in the execution of the metes-and-bounds survey of all specially designated tracts:

1st. Each claim, acceptably located, but at variance with the lines of the resurvey, will be surveyed and monumented at each angle point.

2d. Where a portion of a claim is originally described as in a township not subject to resurvey, such portion of the claim will not be surveyed by metes and bounds, provided the limiting boundary is found to qualify as set forth in sec. 429. The portion of the claim originally described as in the township to be resurveyed should ordinarily be defined in a position (either by segregation or conformation to the lines of the resurvey) which is properly related to the identified or restored corners on the limiting boundary. (See sec. 431.)

3d. Where the boundaries of a claim are unacceptably located as pointed out by the claimant, the engineer will proceed with a proper survey of the tract in accordance with rules already stated which will result in a suitable relation to the original survey, and the corners of the tract as thus located will be monumented. If the claimant protests against such location, the engineer will request that the protest be made in writing (to be submitted with the returns of the resurvey), and will thereupon make an accurate connection with the corners of the claim as unacceptably located, to be made the subject of a complete report by the engineer in his field notes, reviewing the facts with reference to the question of location. As a further protection to an entryman thus unacceptably located see sec. 455.

4th. Where, through a compliance by the engineer with the general rules above laid down, the metes-and-bounds segregation of a claim (or the conformation thereof to the lines of the resurvey) within the field of an independent resurvey (or the related subdivisions within the field of a dependent resurvey) fails to cover any or all of the lands, occupied, improved, or claimed by the entryman, patentee, or present owner, and the latter indicates a desire to amend his entry, that fact will be stated in the field notes, and a separate full report will be submitted describing the subdivisions actually occupied and sought to be acquired under the amended entry, but which are not covered by the tract as surveyed, all looking to the protection of the title to the lands actually earned.¹

5th. Where it so happens that the regular quarter-quarter sections embraced within a claim fall in approximately the same position as the regular quarter-quarter sections of the resurvey, and the entryman or patentee indicates a desire to conform his claim to the resurvey, and no apparent objection is found by the engineer, the facts will be stated in the field notes, and the claim will be so indi-

¹ See current circular relating to amendment of entries.

cated upon the resurvey plat. Under this circumstance the metes-and-bounds survey of the tract will be omitted. However, where any tract whose original description includes *any fractional lot*, or where any part of a tract falls upon *any fractional lot* of the resurvey, the tracts will be segregated as a whole by metes-and-bounds survey, even though some or all of the lines of the tract may coincide with certain subdivisional lines of the resurvey.

6th. Conflicting tracts, each acceptably located, will be surveyed and monumented, and conflict shown upon the resurvey plat. Each intersection of conflicting boundaries will be determined upon the ground and recorded in the field notes, and the latter will show the number of acres in conflict with each other tract.

7th. The angle points of a tract will be designated by serial numbers beginning with No. 1 at the northeast corner, and proceeding around the claim, running westerly from the initial corner. An angle point may be common to one, two, three, or four tracts, and will be monumented and marked as provided in Chapter IV; as for example:

AP 4	AP 3	T 26 N R 17 E	T 26 N R 17 E
TR 38	TR 37	S 14	S 14
AP 1	AP 2	AP 1	AP 2
TR 45	TR 46	TR 38	TR 37
1919		1919	1919

8th. No accessories will be required with the monuments at the angle points of the metes-and-bounds survey.

446. The proper supervising officer will furnish the engineer with an abstract of the valid entries, selections, reservations, patents, and grants, based upon the original plat of any township (or portion thereof) subject to resurvey, and the said resurvey can not be regarded as complete until each and every claim described in said abstract of entries (and shown on the status diagram) as in the township to be resurveyed has received full protection in the matter of location. Aside from those disposals described as in the township to be resurveyed, there will also be furnished to the engineer, as a matter of information, the status of all claims in the adjacent sections of all adjoining townships ungrouped for resurvey. The abstract will be included with the other data to accompany the written special instructions providing for a resurvey.

447. The field notes of the metes-and-bounds survey of each valid claim will be preceded by a copy of the abstract of entry thereof. A brief statement will then follow in each instance (or

with suitable reference), concerning the principal factors controlling the location of the particular tract, and whether or not the claimant was consulted, or communicated with, in the matter of the identification of the boundaries of his claim. The statement should be clear as to whether the location of a claim, shown either as a tract segregation or as conforming to the lines of the resurvey, was controlled by collateral evidence, or by one or more identified corners of the original survey, nearby or remotely located, or by its relation to adjoining tracts. In case all of the tract segregations within a township can be covered by one general statement, the same should appear at the beginning of the field notes of the metes-and-bounds surveys. The field notes should be made to account for each and every tract shown upon the status diagram.

448. All claims should be accounted for on the resurvey plat, and all will be shown either as segregated tracts or as conforming to the lines of the resurvey, as the case may be, with outline indicated by heavy black lines. An exception to this rule will be made in those rare cases where all the claims within a township have been conformed to the lines of the resurvey *under their original description*, in which event a statement may be made on the margin of the plat that—

“All claims originally described as in this township are intended to conform to the lines of the resurvey under their original description.”

449. As a further safeguard that the returns of independent resurveys may be conclusive in the matter of the significance of the tract segregations, the plats thereof will show a statement that—

“All tract segregations shown hereon represent the position and form of said tracts under the original description as referred to the original survey, located as such on the ground according to the best available evidence of their true position.”

450. The above statement will be modified if one or more of all the claims shown on the status diagram are conformed to the lines of the resurvey, either under the original description or by different legal subdivisions, as follows:

“All tract segregations shown hereon and all other claims shown to conform to the lines of the resurvey, whether by the original or new legal subdivisions, represent the position and form of said tracts under the original description as referred to the original survey, located as such on the ground according to the best available evidence of their true position.”

451. The projection and measurement of the lines of the metes-and-bounds survey and the technical record in respect to the same will conform to the usual practice in regular surveys. While the mapping of important items of topography and valuable permanent improvements will be given attention with regard to this feature of the resurvey plat, yet it will be apparent that the amount of data to be shown in connection with the metes-and-bounds surveys makes it impossible, at the usual scale, to show objects of little relative importance. This class of memoranda taken during the progress of the work will *not* be required in the field notes of metes-and-bounds surveys.

452. At least one angle point of each tract survey will be definitely connected with one of the regular corners of the resurvey, and where lines of claims are intersected by lines of the resurvey a connection will be made from the point of intersection to the nearest claim corner and recorded in the field notes of the regular section line. The latter will be considered a satisfactory connection to all adjoining claims located within the interior of either section. Where an extensive system of tract segregations has been surveyed, the interior tracts of the block will not require individual reference connections. The establishment of closing corners on the regular line when entering or leaving public land will conform to the general practice in this respect as provided in sec. 191, Chapter III.

THE PROJECTION OF NEW LINES.

453. The peculiar conditions of the situation which necessitate an independent resurvey render it impossible to formulate general rules suited to all cases. Experience has demonstrated the necessity for giving deliberate attention to the unique problems of subdivision which are to be found in each definite example. The general practice is to secure an engineer's report of the actual conditions involved in a particular independent resurvey, upon consideration of which there may be devised the best plan for a re-subdivision of the vacant public lands, and the latter will be set forth in the special instructions. The possibility of placing the regular lines of the independent resurvey so as to obtain maximum agreement with the position of the boundaries of conformable claims will be fully considered with a view to eliminating or reducing the necessity for tract segregations, if possible, where this can be accomplished in harmony with the rules previously outlined. The examiner's

recommendations in these matters should be explicit and responsive to his special advantages in the opportunity of working out the technical problem while on the ground.

454. A problem involving the re-subdivision of vacant public lands, as in an independent resurvey, should be approached in the same way as practically all problems in fragmentary subdivision, though the independent resurvey may at times involve the re-subdivision of a group of many townships wherein all conditions, except perhaps with relation to the tract segregation surveys, may be comparatively regular. First attention will be given to completing the new township exteriors which are to be independently resurveyed after having reestablished the outboundaries of the group on the dependent plan. The new exteriors will be carried forward and completed in harmony with the rules set forth in Chapter III for the establishment of original surveys. The new section lines will be run out and marked as in regular or fragmentary subdivision as the situation may be and new meander lines will be run as required. The new exterior and subdivisional lines will usually be extended across small blocks of tract segregation surveys, noting connections as previously stated, and in such cases the new lines and corners will be fully monumented regardless of the fact that some points will fall within the tract segregation surveys. The latter points are required in their usual function to determine the subdivision of the public lands affected.

455. A general exception to the rule of extending the lines of the independent resurvey across the tract segregations will be made in those townships or portions thereof so densely covered by private claims that the remaining parcels of public lands may be as well or better identified and described for expediency with reference to isolated tract numbers. In such cases closing corners will be required on the regular lines when entering or leaving public land. The regular lines may or may not be extended as blank lines across the tract segregations, according to the plan of running the new section lines of the resurvey. Where this method is employed it will be necessary to assign tract numbers to the vacant parcels of public land and to mark the angle points thereof accordingly. Where a parcel of vacant public land is to be identified on this plan, such vacant tracts will be surveyed by metes and bounds in accordance with the usual rules. Rare cases may arise where it will be deemed expedient to segregate by metes-and-bounds survey certain quarter-

quarter sections of vacant lands in accordance with the system of the original survey as indicated by adjoining tract segregations for the purpose of affording a better basis of disposal or for amendment of entries. Such segregations will not be made unless it is conclusively shown by the engineer that the fractional lots and regular quarter-quarter sections of the resurvey are inadequate as a basis of disposal under existing conditions of occupancy on the part of settlers or of entrymen who may propose to amend. The special instructions will be made as explicit as possible in these details, which will be determined upon when the plan of the resurvey is under consideration by the supervising officer.

456. Where a section of the resurvey is invaded by patented tract segregations, but not by unpatented entries or selections, the lotting of the public lands will be carried out in accordance with the usual plan of lotting within fractional sections as outlined in Chapter III. The numbering of the fractional lots will begin with the number next higher than the highest number employed in the section of the original survey which bears the same township, range and section number. This plan is intended to avoid any possible confusion which might arise from a duplication in the use of the same lot numbers.

457. A departure from the usual rule for lotting is necessary in order to provide suitable descriptions within unpatented entries and selections where such tract segregations may be subject to relinquishment or cancellation, also in other cases, to facilitate a subdivision of isolated tracts of public lands surveyed by metes and bounds. Two methods have been found available, each one better suited to particular situations. Neither method involves any change in the instructions for the field procedure heretofore laid down. The discussion of the merits of the two methods and the examples of their use are better adapted to the text of Chapter IX, where the subject will be found in connection with other details to be shown upon the resurvey plats.

458. The general requirements of Chapters II, III and IV will be fully observed in every respect throughout the execution of the independent resurvey and in the technical record thereof. General titles (in addition to the regular page heading) will be inserted in the field notes to indicate clearly the character of the independent resurvey, the technical record of which follows; such titles will be

inserted in the body of the field notes, as appropriate, and will show the full significance of all lines; as for example:

(a) "Metes-and-bounds survey of private claims as originally located in accordance with the survey executed by John B. Smith, U. S. Surveyor, in 1842;" and

(b) "Independent resurvey, superseding the survey executed by John B. Smith, U. S. Surveyor, in 1842."

459. All monuments of the original survey, not otherwise reported upon, when traces thereof have been found, will be connected by course and distance with a corner of the resurvey, and such connection and a description of the traces of the original corner as identified will be recorded in the field notes of the resurvey. A useless monument will be destroyed after the point is found to be no longer needed for the survey of a claim of any kind whose location may in any way depend upon such monument. (See sec. 163, Chapter III.)

460. Further exemplification of the approved practices incident to the successive field steps and preparation of the field notes and resurvey plats will be found in the chapters that follow.

CHAPTER VII.

SPECIAL SURVEYS AND INSTRUCTIONS.

SPECIAL INSTRUCTIONS.

461. The detail of the work to be accomplished in any survey assignment is set out in written special instructions which are issued to guide the chief of field party. The special instructions are prepared subject to the approval of the Commissioner of the General Land Office, by or under the advice of the ranking supervisory officer in direct administrative charge of the work to be done. The special instructions may give emphasis to any provision of the Manual which may be more or less unusual in application, but the purpose is more especially to set out the extent of the work intended, and the method and order of procedure in the survey. The special instructions will ordinarily be written in the third person, and, coupled with the Manual, will contain all necessary specifications for the survey. At the proper time the execution of the field work will be assigned to a selected chief of field party.

462. The special instructions are an important unit of the record relating to the survey, and it is exceedingly desirable that certain information bearing upon it be set out both for immediate and future reference. The following arrangement of the subject matter will be adhered to so far as may be appropriate, in order that there may be a similarity of practice throughout the several surveying districts:

1. Title: Special Instructions; Group No. ———, ——— (State); nature of survey, and location by township, range, and meridian.

2. Preliminary statement (bearing no address): In the execution of the surveys included under Group No. ———, ——— (State), the chief of field party is authorized and directed to make the described examination, retracements, reestablishment of points of control, surveys, and resurveys hereinafter set out, and will be guided by the Manual of Surveying Instructions, the provisions of the following special instructions, and such supplemental instructions as may be issued pursuant to the

report of complications developed during the progress of the work or by reason of additional authorization.

3. Office authority to proceed with the described field work is contained in letter "E," _____ (number), dated _____, based upon the application of _____. A brief statement of the nature of and the names of the parties who subscribed to the application will be set out, together with a reference to any appropriate citation of departmental instructions or authorization, or to any special act of Congress relating to the survey.

4. Appropriation: The costs of the field and office work incurred in the execution of the surveys herein directed, within approved official regulation, are payable from the appropriation for "Surveying public lands" (if the nature of the survey is such as to come within the provisions of the general act). Where a special appropriation has been made, its exact title will be given, or if the cost is chargeable to a special deposit the exact title of the latter will be given, together with a citation of the act of Congress under which such deposit has been received.

5. Limit and character of work: Under this heading there will be described by township, range, and meridian the lines which are to be surveyed, together with designation by section numbers where parts of townships are intended. If the work involves other than original surveys, the statement here will be extended to indicate the character of the fragmentary survey, or the type of resurvey, or the nature of the field examination, according to what has been authorized and what is expected of the engineer. It will be desirable generally, except in the case of strictly original surveys, to supply whatever supporting statements there may be needed, taken from the authorization or elsewhere in the record, for an understanding of the technical or legal questions relating to the work. Where private rights may be involved, which is often the case, the facts as known should be clearly brought out, and a statement made of such rules of practice as may require consideration in the field.

6. History of earlier surveys: Every new survey and all retracements and resurveys are predicated upon what has been previously accepted, and to the end that the engineer may proceed with the new work understandingly, a review of the established surveys will be carried into the special instructions.

Full explanations will be given in the event of known or presumed complications.

7. Method and order of procedure: If the work to be done is primarily the extension of the original surveys, the statement of it will follow Manual principles and will be taken up in the following order:

(a) Standard parallels and guide meridians;

(b) Township exteriors; and,

(c) Subdivisions, including a reference to the running of meander lines if this class of work is expected, and to the subdivision of sections if required in whole or in part.

The instructions for each township should be completed separately, and so far as practicable the work should be set out in the order in which it is to be followed in the field. If there is any reason to anticipate complications, a statement of the treatment of the problem will serve both to inform the engineer as to what may be expected and to indicate the approved method that would be applied on the assumed hypothesis. Where helpful to call attention to the Manual rules, the references may be made by chapter and section numbers, but the engineer is charged with the responsibility of an understanding of all regular practice and familiarity with the Manual as a reference guide in unusual cases, and the burden of this is not to be transferred to the special instructions.

If the work involves other than original surveys, the responsibility for a statement of the situation and for the formulation of detailed specifications for the execution of whatever examinations, fragmentary surveys, resurveys, topographic surveys, or special monumentation may be required will pass to the author of the special instructions. There follows in this chapter a discussion of a number of the more usual types of special surveys, including subjects not appearing heretofore.

8. Diagrams: In the case of original surveys a blue-print diagram to accompany the special instructions will generally be desirable. Ordinarily the diagram will be constructed on a scale of at least 80 chains to an inch, and should indicate the record surveys within 2 miles of the limiting boundaries of the group. The directions and lengths of the established lines should be shown, together with the principal topographical

features. The new work will be shown distinctively, and the method of procedure should be indicated where that will be helpful. All areas returned as surveyed will be clearly represented, together with the status of any outlying areas which the previous plats may show protracted as though surveyed. The author of the special instructions will give attention to the matter of any known claims, or improvements, or monuments of other official surveys, as indicated in paragraphs 5 and 13, section 236, Chapter III, and will bring this out in the special instructions. (See sec. 435, Ch. VI, for the requirement that a status diagram be furnished with the instructions for independent resurveys.)

9. Field notes, plats, and reports: The special instructions should point out what will be expected in connection with the preparation of the returns, with a view both to the specific understanding of what will be required and to the noting of the subjects which are to be given attention in the field. If anything is required in the way of a preliminary report or diagram to be sent in during the progress of the work, or if special lotting or other unusual matters are to be given consideration at the time of the preparation of the final returns, attention will be given to the same in the special instructions. There will also be noted the necessity for returning, for official use, the original copy of the special instructions, and all other papers which belong with the office record, and the data that may be added in the field, including the field computation sheets.

10. Modification of the instructions: The special instructions will ordinarily be signed by the ranking supervising officer in direct administrative charge of the work to be done, and will close with the advice that should conditions arise appearing to demand additional instructions, or require an interpretation of the instructions as issued, or which apparently make the special instructions inapplicable as prepared, the chief of field party will be expected promptly to submit a report of the situation, with such recommendations for office consideration as may be responsive to the authorization.

SUBDIVISION OF SECTIONS.

463. If there is need for the subdivision of sections the subject will be brought out in the special instructions, and if any un-

usual methods are required the same will be noted. The most frequent examples are those of Indian allotment surveys, subdivisions within reclamation projects, and in various types of fragmentary surveys where needed in order to mark the boundaries of the public land remaining undisposed of. Subdivisions of sections are occasionally required to avoid a possibility of incorrect local survey, and sometimes in lieu of a remonumentation of disputed section or quarter-section corner positions affecting patented lands. Wherever so intended the subdivision-of-section lines will be run out in accordance with the adopted sectional lottings, and the monuments established.

464. The customary lottings are not to be found on many plats of the very old surveys, and the information about the recognized or adopted parts of the sections can be secured only by reference to the record of the disposals. The latter will more frequently show a disposal by aliquot parts, except within fractional sections, but often without the usual complement of quarter-section corners regularly established as under the practices set out in the several Manual editions. An inquiry into the assigned areas will sometimes be the only means of arriving at the intended disposals. In some very old surveys the usual quarter-section corners were not established on all true lines of survey, but the record will show instead that "half-mile" points were marked on the random line and not corrected to the true-line mid-point position. All such unusual problems should be brought out in the special instructions, as the diversity of the questions arising on the subject and the very limited applicability of many of the answers precludes Manual treatment.

465. Where special methods are unavoidable the steps should be made to conform as nearly as may be with the rules for the subdivision of sections as based upon the acts of Congress approved February 11, 1805, and April 5, 1832, already fully exemplified in Chapters I and III.

INDIAN ALLOTMENT SURVEYS.

466. The special requirements of Indian allotment surveys are few. The surveys are made in order to mark the boundaries of individual allotments. It is the practice to run out all the bounding lines, and to monument all of the corners. Generally

the awarded allotments conform to legal subdivisions, and in such cases the lines are run in accordance with the rules for the subdivision of sections.

467. All regular corners are marked in the usual manner, and ordinarily there is added the letter A (standing for allotment) and the allotment number, in each of the several quadrants, as appropriate. Allotment numbers are employed serially with the various Indian tribes or families, assigned by the Bureau of Indian Affairs, when making an award of tribal lands. In some cases, as when two or more Indian tribes have rights within the same reservation, a designating letter is used to precede the allotment number, dropping the letter A as suggested, and substituting the first letter of the name of the Indian tribe, as K 191 (for Kiowa allotment No. 191), or C 242 (for Comanche allotment No. 242), or A 367 (for Apache allotment No. 367). Status diagrams which show the allotment awards are furnished with the special instructions for the survey.

468. If a section is to be subdivided, the center quarter-section corner will always be monumented whether or not it may be the corner of an allotment, and likewise if a quarter section is to be subdivided the sixteenth-section corners on the quarter-section boundaries and at its center will always be monumented. No other monuments of lower order will be established except at the determined allotment corners. The latter will be marked only with the designating letter and proper allotment number or numbers in the several quadrants, as appropriate.

469. As complete plat designations are usually a necessity for the allotment work, the awarding of Indian lands is rarely performed at the time of making the subdivision of the township, but the marking of the allotment corners at some subsequent time will not assume the characteristics of a resurvey except as the intervening years have served to bring about an advanced state of obliteration of the monuments. In the latter case, the rules for making a limited dependent resurvey are usually applied, and a resurvey plat is required in order to show the resulting data. Figure 70 is an illustration of this type of plat. It is always essential to furnish a field-note record to support the allotment survey, and to supply the descriptions of the established monuments.

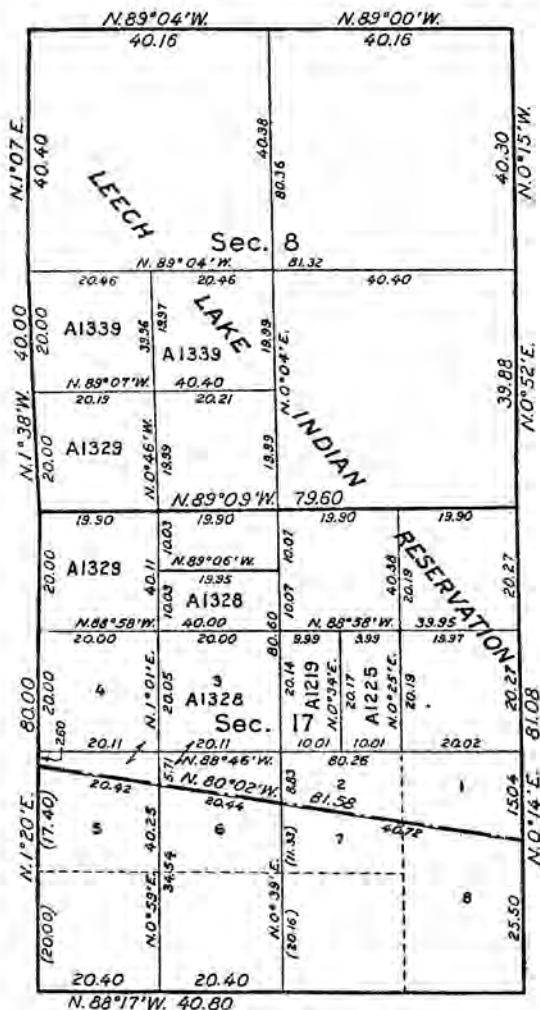


FIG. 70.—Indian allotment surveys.

This includes a limited dependent resurvey of the section-line boundaries, a subdivision of the sections as needed, and the marking of all corners of the several Indian allotments.

470. The authority for the assignment of land to individual Indians is found in both the general and special allotment acts, under which it has been the practice of making awards in some cases in units of less than the usual quarter-quarter section. One act provides that where the improvements of two or more Indians have been made on the same legal subdivision of land, unless they shall otherwise agree, a provisional line may be run dividing said lands between them, and the land to which each is entitled shall be equalized in the assignment of the remainder of the land to which they are entitled, while in another act it was provided that not less than $2\frac{1}{2}$ nor more than 10 acres of timber land be included in any one allotment. There will be no question in regard to the treatment of those cases where the allotment descriptions are in terms of aliquot parts of the section, but in some cases it is apparent that the descriptions can be stated only in terms of metes and bounds in some way definitely correlated with the section-line boundaries, to which included tract there will be assigned a lot number within the parts of the one or more sections involved, the lotting numbers thus resulting to be independent of the serial allotment number.

471. In some cases where the Indian lands border meandered bodies of water, it will be found that due to the processes of erosion or accretion, or to the construction of a dam which holds the water at a higher level, or to the recession of the water during the years intervening between the date of the subdivision of the township and the date of the allotment survey, material changes in the shore line will have taken place. In some cases it is the practice to remeander the body of water in order to amend the plat to show the true conditions at the date of the allotment survey, making new lottings within the fractional sections. A demonstration of the methods employed for the amendment of the plat in such cases is contained in sections 639 to 643, Chapter IX. If the situation is one within the class of erroneous meanders the rules to be followed will be found in sections 511 to 529, this chapter. Whatever needs to be done in this type of work should be brought out clearly in the special instructions for the survey, or in supplemental instructions where the facts were unknown in the first instance.

METES-AND-BOUNDS SURVEYS.

472. There are many irregular tracts which are nonconformable to legal subdivisions, which require survey by metes and bounds. In section 190, Chapter III, mention is made of those which are found most frequently. In all such surveys monuments are required at each angle point of the tract boundary, which are given serial numbers beginning with No. 1 at the initial point, and there will be added some appropriate designating letter, letters, or tract number. Intermediate mile corners are required between the angle points if the length of one or more courses exceeds 1 mile. Examples of the usual marks for such angle points and intermediate corners are given in sections 279, 280, 346, and 347, Chapter IV. If the tract is located upon surveyed land a connecting line will be run from the initial point to a regular corner of the subdivisional survey, as required in section 190, Chapter III, but if the location is within an unsurveyed township, specific advice regarding the running of a connecting line, or the establishment of a location monument, or the determination of the geographic position of the initial point will be supplied in the special instructions for the survey.

TOWN-SITE SURVEYS.

473. The acts of Congress approved March 3, 1863 (12 Stat. 754), and March 3, 1877 (19 Stat. 392), as carried forward into sections 2380 and 2381 Revised Statutes, and numerous special acts, make provision for the Executive withdrawal of public lands for subdivision into town-site blocks and lots, both urban and suburban, and for disposal in such units.

The normal Government town site has a rectangular plan wherever, and so far as, the site conditions so permit, but where the situation is not suitable for a simple street and block system a preliminary examination is made in order to ascertain a layout which will afford the best use of the ground available for improvement, with suitable grades for streets, give proper regard for existing locations where rights have already been acquired, and provide for railroad or other rights of way, station grounds, lake-shore frontage, natural park areas, and other important conditions which should have consideration.

474. Only the fundamental requirements of town-site surveys can well be presented here as the character of the area, the topography, its location, and whether it is a new town site or an addition to an old one, will to a large extent determine the detail of the street and block system. A preliminary field examination and topographic survey will be of the greatest value as an aid to ascertaining the layout best suited to the situation, and the special instructions will call for a preliminary report of the proposed plan where this can be done, otherwise much of the responsibility for the detail of the survey will have to be passed to the chief of the field party.

475. In the typical town site the blocks may be made 300 feet square, and usually not over 320 feet by 400 feet, with a 20-foot alley running the long dimension of the block. The principal streets are usually made 80 feet in width, though frequently as much as 100 feet where the greater width appears to be needed or desirable, and the less important intersecting streets are seldom given a width of less than 60 feet. An alley is usually placed in each block, 20 feet in width and paralleling the principal street system. The normal frontage of the lots is 50 feet, which run back in rectangular form to the alley. Where conditions are suitable the whole system is laid out on cardinal, and in all town sites the blocks are given serial numbers, usually beginning with the northeast block and proceeding with the numbers alternately to the west and to the east. The lots are given serial numbers within the block.

476. It will be noted that the foot unit is employed on all town-site surveys, and long steel tapes graduated in that unit are furnished for the purpose. In most cases the necessary accuracy can be secured only with the use of a spring balance for the maintenance of the proper tension, and with allowance for temperature corrections to the degree at which the tape is standard.

477. In making the town-site survey the greatest care will be exercised to identify the original section-line boundaries and to execute the subdivision of the section or sections in the proper legal manner for the ascertainment of the assigned town-site boundaries. Permanent monuments will be placed at each turning point of the town-site boundary lines. These may be the

3-inch iron post, or a tablet seated in a concrete block as large as 8 inches square and 36 inches long, marked with the usual subdivisional identification marks, the capital-letter initials of the town-site name, and the letters "T S," in the appropriate quadrant. The boundary streets, and the other streets, blocks, and lots are then laid out, permanent control monuments established, and connecting line measurements made, as may be necessary to afford an exact relocation of any point; and to secure all data respecting true bearings and deflection angles, both for the center lines of the streets and for the block lines, the connecting lines to the permanent monuments, and the dimensions of all streets, blocks, and lots. All of this sort of data is carried to the town-site plat, and its sufficiency may be tested by the ability to readily ascertain the position of any given point, and to calculate the area of any individual lot.

478. A number of permanent monuments will be placed at the intersections of the street center lines and connections made to the block corners so as fully to insure a complete and ready restoration of any block corner. The 2-inch iron post, or a tablet seated in a concrete block as large as 6 inches square and 24 inches long, may be employed for this purpose. These should be subsurface monuments, placed as much as 1 foot below the probable grade line of the street, and marked only for the point of intersection.

479. In ordinary cases hardwood stakes are employed for the block corners, and to mark the front corners of each lot, also to mark the intersections of the alley side lines with the block lines. The points here called for are always to be monumented, and a more durable marker, such as a galvanized-iron pipe will be employed where the site conditions are unfavorable to the preservation of a wooden stake. The block corner and alley stakes are usually made 2 inches square and 24 inches long; the lot corners 1 by 2 by 24 inches; the latter are set only on the block lines and not on the alley lines. The block corners only are marked with the appropriate numbering.

480. The field traverse of the town-site boundaries will ordinarily be made to close within an error of not to exceed $\frac{1}{3000}$, and never to exceed $\frac{1}{2000}$. The determined lengths of lines and their bearings will be balanced, so as to secure a perfect closure

for the data which are to be carried to the plat. The required accuracy can always be secured by the method of repetitions for the turning of angles, and by the method of measurement herein authorized, due regard being given to the reduction of lengths of lines to the true horizontal distances. This class of data, as well as that hereinafter mentioned, should be such as to leave no discrepancy whatever in any calculated position, whether working from one permanent monument to another, or between any two points.

481. Lengths of lines and all angles or bearings will be determined in the field for all irregular blocks and lots; and the side lines of the lots, and their back lines, will always be measured in the field, and the dimensions carried to the plat, wherever needed, as when said lines can not readily be located by the method of intersections.

482. The field notes of the town-site survey will show the retracement of the old section-line boundaries, the restoration of any needed corners, and the subdivision of the sections, all complete as may be needed for the ascertainment of the town-site boundaries, and for the description of the controlling monuments. All important connecting lines and measurements between the boundary monuments and the corners of the block lines, or to the permanent monuments marking the street center lines adjacent to the boundaries, will be given in the field notes. The plan followed in the town-site survey will be explained, and a general statement made as to the monumentation; beyond this it will be noted that the further detail of all directions and lengths of lines has been carried to the plat, but is omitted in the field-note record. If there are any improvements unavoidably left in conflict with the town-site layout the information will be brought out in the field notes, but omitted from the plat.

483. The town-site plats are usually published at a scale of 200 feet to an inch, but they are frequently drawn at a somewhat larger scale, subject to reduction when published. A marginal diagram is usually supplied in order to show the relation of the town-site boundaries to the local section-line control, with directions and lengths of lines here given in the chain unit; tenths of links will be supplied where appropriate for making

a precise reduction to the lengths of lines shown on the main drawing.

484. On the main drawing all lengths of lines will be shown in the foot unit, with tenths where needed. All directions and lengths of lines, intersection angles, and connecting lines to monuments will be given on the plat with a view to the ready location of any point by calculation from the points of permanent control, and for the ascertainment direct from the plat of the area of any individual lot.

485. The block and lot numbers will be shown, areas of all lots to the nearest square foot, and the streets will be given designating letters, or numbers, or names. In the drafting of the data for the regular blocks some of the figures which would be applied in each lot of the block may be omitted if it is left clear within the block that the lottings are regular for dimension and area.

486. All permanent monuments will be shown on the main drawing and connecting data supplied. The widths of the streets and alleys will be plainly shown, but not repeated needlessly. Where all of the lots in any block are of the same dimensions, it will be sufficient to show the measurements only along the block lines, as the depth of each lot will be indicated by the length shown from the block corner to the alley corner. A memorandum will be supplied to note the general plan of monumentation, with an outline description of the monuments.

487. If there are reservations for public-school grounds, or of ground for other public buildings or parks, the provision therefor will be stated in the special instructions. The designated blocks will be shown upon the plat, numbered regularly and titled, but not subdivided.

488. References will be made to Chapter IX for the usual requirements regarding the title and the certificates which are to appear on the town-site drawing.

SURVEY OF PARTS OF SECTIONS.

489. In section 252, Chapter IV, there is a statement of conditions where portions of the section boundaries are inaccessible, impassable, or so insecure that acceptable monumentation is impracticable, which if found to prevail will necessitate the

elimination of parts of sections. The situations thus assumed are so rare, if allowance is made for increase of cost of survey where warranted, that general rules can not well be announced. The questions to be considered are more particularly administrative, and ordinarily will be given attention in the special instructions. The subject matter here set out pertains only to the technical processes which are new to the survey of rectangular boundaries of parts of sections. Figures 71, 72, 73, and 74 show examples.

490. The west boundary of section 27 (fig. 71) is shown discontinued at the regular place for the south sixteenth-section corner, which is monumented, and the north boundary at 40.00 chains, established parallel to the south boundary. The subdivision-of-section lines are run random on theoretical courses and distances, and closing error distributed, with final results (assumed) as shown on the drawing. The several interior sixteenth-section corners on the lines run are all to be monumented, including the one on the east and west center line of the section.

491. The south boundary of section 9 (fig. 72) is shown discontinued at the east sixteenth-section corner, and the north boundary at the west sixteenth-section corner, both of which are monumented, both lines having been established parallel to the nearest completed latitudinal line southward in that range of sections. The subdivision-of-section lines are run random on theoretical courses and distances, and closing error distributed, with final results (assumed) as shown on the drawing. Here the center quarter-section corner and the two sixteenth-section corners on the east and west center line are all to be monumented.

492. In the illustration showing section 3 (fig. 73) the process is similar, excepting that the closing error in latitude is all placed in the west line of lot 2. All of the turning points are monumented, also the south sixteenth-section corner on the north and south center line, and the west sixteenth-section corner on the east and west center line.

493. In section 18 (fig. 74) the closing error in departure is all placed in the south line of lot 3, it having been assumed that (a) the corner of sections 7, 8, 17 and 18 was fixed by survey

FIG. 71.

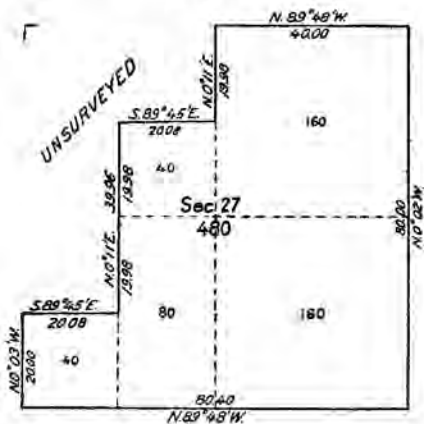


FIG. 72.—Rectangular boundaries of parts of sections.

A random subdivision-of-section line is run closing the area to be surveyed, each course parallel to the governing section boundary, with lengths in multiples of 20-chains; the closing error is then distributed, and monuments established.

Fig. 73.

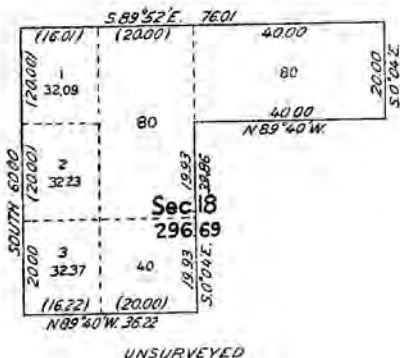
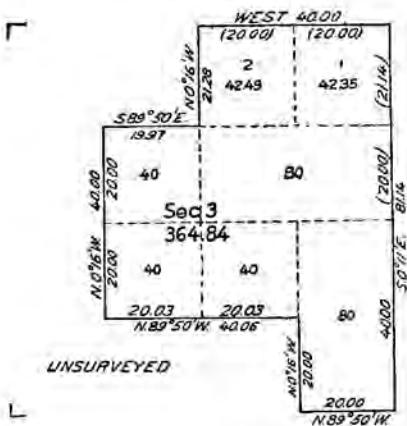


Fig. 74.—Rectangular boundaries of parts of sections.

Fractional lottings are shown. In Figure 73 the whole closing error in latitude is placed as normally in the north tier of lots, and in Figure 74 the whole closing error in departure is placed as normally in the west range of lots.

from the east or north, or (b) if from the west, that the fractional length of the north line of lot 1 had been determined by appropriate calculation.

494. The several processes are summarized in the following rules:

1. Complete the survey of all regular exterior boundaries and subdivisional lines normally, as far as accessible under the Manual rules and special instructions.

2. Where an exterior boundary is to be discontinued the line will be established on a cardinal course and on the last mile monumented regularly to the nearest 20.00, 40.00, or 60.00 ch. point.

3. Where a subdivisional line is to be discontinued, it will be established (for alinement) parallel to the governing exterior or section boundary (and for length) 20.00, 40.00, or 60.00 chs., as the situation may be.

4. The terminal sixteenth or quarter-section corner will be monumented; the quarter-section corner will be monumented in every case where the point has been attained.

5. Assign theoretical bearings to the subdivision-of-section lines closing the area to be surveyed within a section, each line parallel to the governing section boundary, with the lengths ordinarily employed for the calculation of areas, as 20.00, 40.00, 60.00, or 80.00 chs., *disregarding* the ordinary allowable excess or deficiency in the length of the latitudinal boundary of the section.

6. Run a random line closing the area to be surveyed, on the courses and distances derived in rule No. 5, and set a temporary interior sixteenth or quarter-section corner at each turning point and at the intersections of the center lines of the section.

7. Except as noted in rule No. 10, the closing error will be distributed as provided in section 380, Chapter V, and the interior sixteenth and quarter-section corners called for in rule No. 6 will be monumented.

8. The interior sixteenth and quarter-section corners thus established, together with the usual points on the regular section boundaries, will be employed to control the position of the center lines of the section and of the several quarter sections.

9. If the length of a boundary of any resulting quarter-quarter section differs from 20.00 chs. in excess of $12\frac{1}{2}$ lks., or if its direction deviates from cardinal in excess of 21' (by reason of disregarding the ordinary allowable excess or deficiency in the length of the latitudinal boundary of the section), a lot number will be assigned to such quarter-quarter section; the lot area will be derived under the usual rule applicable to the calculation of areas of fractional quarter-quarter sections.

10. In the north tier of sections the closing error in *latitude* will be placed as normally in the north tier of lots, and in the west range of sections the closing error in *departure* will be placed as normally in the west range of lots, unless the subdivisional survey may be made from north to south or from west to east under the rules which permit that procedure.

495. The field notes will show the complete random and true line courses and distances, the usual topography on the true lines, the description of all monuments, and a description of the difficulties which warranted an elimination of parts of the section or sections.

496. Reading the act of Congress approved February 11, 1805, wherein it is stated that "all the corners marked in the public surveys shall be established as the proper corners of sections, or subdivisions of sections, which they were intended to designate, and that corners of half and quarter sections not marked shall be placed as nearly as possible equidistant from those two corners which stand on the same line," and "the boundary lines which shall not have been actually run and marked as aforesaid shall be ascertained by running straight lines from the established corners to the opposite corresponding corners," it is apparent that to complete the subdivision-of-section lines in any section where the above-described practice has been invoked, leaving the section-line boundaries more or less uncompleted, the position of the said remaining subdivision-of-section lines within the surveyed area will be determined first by running straight lines between the nearest established control for the sectional center lines, with the position for the center quarter-section corner at the intersection of the latter lines, unless previously marked, placing the remaining interior sixteenth-section corners on the sectional center lines at mid-points between the exterior quarter-section corners and the center quar-

ter-section corner, except within the sections normally fractional; and, second, the center lines of the several quarter sections will then be completed separately on a similar plan based upon the control as developed. In all sections normally fractional the usual regard will be given for the placing of the fractional unit in proper relation to the regular or proportional 20-chain units.

497. The running of a traverse line as a boundary along the margin of omitted mountainous areas, and sometimes in the omission of other areas classed as impassable, was frequently practiced at one time, but was later discontinued owing to the large number of fractional lots thus unnecessarily created, as sooner or later, in a large majority of cases, the advance of settlement demanded the completion of the subdivisions across the omitted lands. However, an occasional survey of this type is desirable in order to meet a peculiar situation where the rectangular boundaries can not be completed within the section, but the examples are decidedly infrequent, and the method should be authorized in the special instructions only when supported by ample justification. In such surveys the angle points of the traverse line are given serial numbers in each fractional section, and the points are monumented. The subdivision-of-section lines are protracted only, unless a definition upon the ground should be required for some good reason.

ELONGATED SECTIONS.

498. The rule (sec. 200, Ch. III) for numbering the lots within elongated sections is illustrated by Figure 75. The example shows 12 instead of the 4 normal lots. Cases of this type, though infrequent, are sometimes even more exaggerated. The condition may occur when closing along either the northern or western township boundary, or anywhere within a township on completing fragmentary subdivisions.

499. Additional monuments are required on such section boundaries where the length of the closing line exceeds 85 chains (secs. 161, 177, 178, and 198, Ch. III); these will be placed at intervals of 40 chains counting from the regular quarter-section corner. The plan for the special marking is derived from the resulting lot numbers. It is illustrated in Figure 76. The same

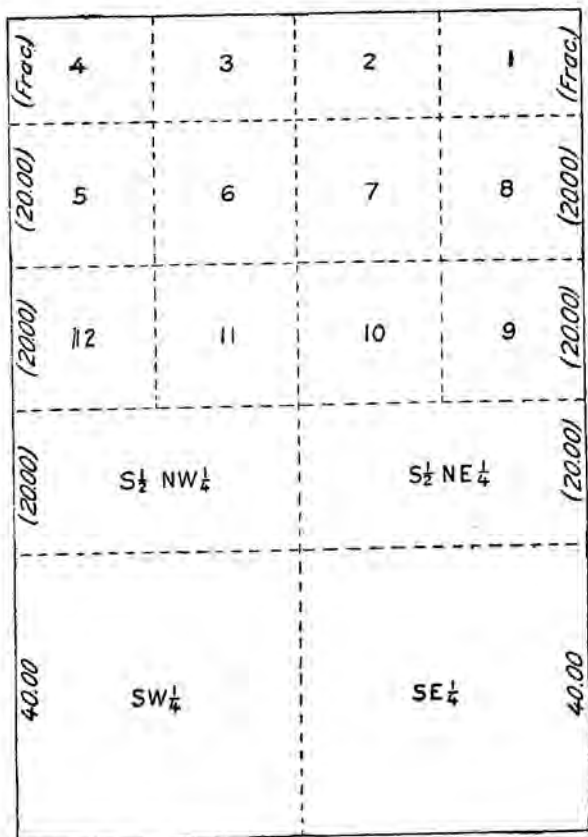


FIG. 75.—Elongated section.

The rule for numbering the lots is given in section 200 Chapter III.

figure shows an example for marking monuments set at intervals of 20 chains, and within the section, where special circumstances call for them.

500. In the very unusual situations where the distance between the regular position for the township boundaries is so

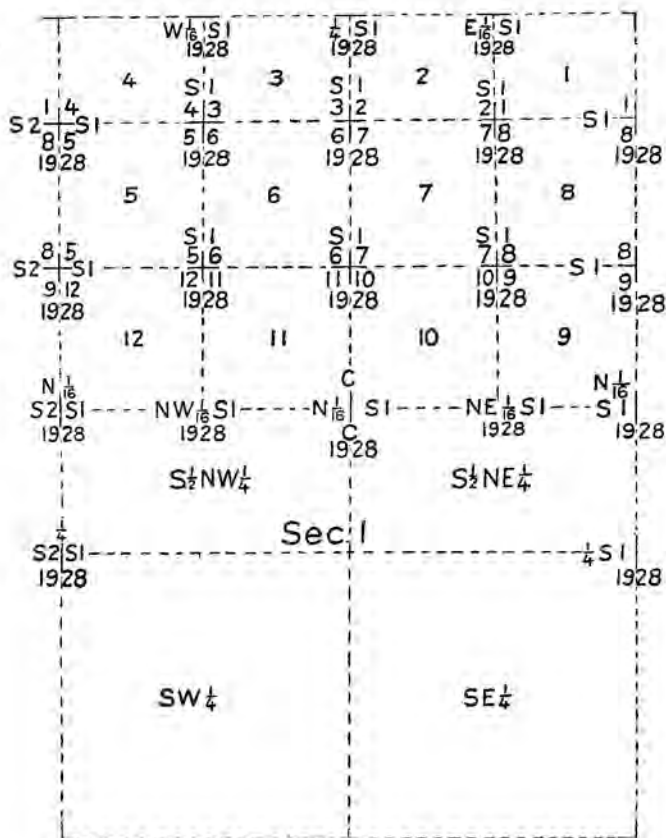


FIG. 76.—Elongated section.

The plan for marking all special monuments here illustrated is derived from the assigned lot numbers.

great that elongated sections in excess of 120 chains would result from the application of the above rules, it is better that new half-township (or half-range) numbers be created in order to cover the area located between a new normal exterior at 480 chains and the next regular township boundary.

501. The numbering of the sections within a half township (or half range) will depend upon the selection of the governing boundaries to be employed. Preference will be given to normal procedure, where conditions warrant. The survey and monumentation will follow the usual rules for fragmentary subdivision of townships.

502. It is obvious that where elongated sections occur within the interior parts of a township, growing out of partially completed but grossly irregular subdivisions, new half townships can not be created. In such cases the rules stated in sections 498 and 499 will be applied.

503. If the situation is unknown at the time when the special instructions are being prepared, and therefore not fully treated therein, the chief of field party will report the facts and await the receipt of definite instructions as to the procedure.

MINERAL SEGREGATION SURVEYS.

504. The type of work here described is one which involves a metes-and-bounds survey of a body of land classified as mineral bearing, but an area which has not been covered by a mineral-patent survey. The field work in these cases will include a retracement and remonumentation of the section boundaries, with attendant restorations of obliterated corner positions where required. The authority for this class of work will issue, as needed in conformity with office regulations, as stated in section 631, Chapter IX.

505. The segregation survey is not a mineral survey in the usual accepted sense as defined in Chapter X, as it confers no permanent rights upon the mineral claimant. Though the purpose is to ascertain the boundaries and position of one or more mining claims, it is not made primarily to define the mining claims, but rather in order to determine the limits and appropriate description of the adjoining agricultural land, where the latter is covered by pending entry. No survey of this kind is required except as needed to supply data for the accomplishment of the necessary fractional lotting, or where a showing has been made of obliteration of monuments, or distortion of lines belonging to the subdivisional survey, or both. The condition of the section-line boundaries will always be verified in this type of survey.

506. Where regular conditions are found the mineral segregation survey will consist only in running not less than two connecting lines from identified corners of the subdivisional survey to a corner or corners of the mineral location as segregated, followed by a survey of the outboundaries of the mining claim or group of claims, thus supplying the data equivalent to those ordinarily furnished by a mineral-patent survey.

507. Monuments, usually 1-inch iron posts, will be placed at the angle points along the boundary of the mining claim, or out-boundaries of a group of claims, and within the section or sections which include the pending agricultural entry, as may be needed in order to complete the marking of the limits of the latter. The monuments so established will be marked with the initials of the name of the mining claim or claims to which it belongs, and with the corner number or numbers counted as an angle point of the mining claim or claims, all in a manner similar to the practice directed for making mineral-patent surveys. See sections 706, 710, 711, 712, 722, 723 and 724, Chapter X. If the monument at the corner of the mineral location is in proper position, constructed of durable material, and suitably marked, the monument may be adopted without any alterations, and a description thereof will be entered in the field notes.

508. In townships where there appears to be an extensive obliteration of monuments, or where the condition of the lines does not conform to the original plat and field notes, the survey needed will consist of such retracements and restorations of the corners of the section-line boundaries as may be necessary to define the pending agricultural entries. If the distortion of the section lines is so great as to warrant the subdivision of one or more sections, the work authorized will be described in the special instructions.

509. The retracement of the lines of the mineral location should be made with the same degree of accuracy which is demanded in a mineral-patent survey. See sections 690, 691 and 704, Chapter X. All measurements are to be returned in the chain unit. It is essential that the requirements regarding the legal length and width of the mineral claims be observed, including parallelism of end lines, that is, to confine the claim to the legal length along the mineral lode, placing the side lines within the legal width as determined from the center of the

vein at the surface, and that the end lines of each claim shall be parallel. The segregated claim is to be made identical with, or be embraced within, the boundaries of its location, as provided in the mining regulations. If not identical, a bearing and distance will be given from each established corner of the survey to the corresponding corner of the location. See sections 696, 698, 699, 701, 702, 703 and 704, Chapter X.

510. All rules for the plat construction will be found in Chapter IX.

ERRONEOUSLY OMITTED AREAS.

511. This title is employed to denominate lands that are not shown upon the original township plat, which are so situated as to have been excluded from the survey by some gross discrepancy in the location of a meander line as given by the field-note record. In the typical cases the unsurveyed land is found to be situated between the actual bank of a lake, stream, or tide water, and the meander line as given by the field-note record, though a considerable number of cases of erroneous meanders have been found in the older surveys of the south where temporarily overflowed lands, or swamp and overflowed lands (strictly classified as such), were mistakenly traversed as if they were permanent meanderable bodies of water; and a few cases have developed where no bodies of water ever existed in fact. All are treated in the same manner as those where the discrepancy is traceable directly to a grossly erroneous position for the record meander line. The converse is found in those cases of areas of water surface that were erroneously included, where the record meander line is found to depart from the actual bank line in the opposite direction so as to extend into the body of water, thus representing an included area to be land instead of water. The term is not applicable where the differences can be traced to changes in the water level, or to erosion or accretion subsequent to survey.

512. The question of the ownership of the marginal areas and of the legal boundaries of the fractional subdivisions that have been disposed of by the United States can be determined only through a consideration of the rights of the proprietors who have acquired title based upon the representations of the original township plat. The marginal discrepancies fall at once into

two classes, those that may be regarded merely as technical differences, and those that constitute *erroneous omission*, as where in the latter class the plat and field notes of the original survey are so grossly in error as to bear no reasonable conformity with the bank line. These principles are laid down in the leading court and departmental decisions on the subject, and have been referred to previously in sections 223, 226, and 229, Chapter III.

The right of the owner of a fractional lot to the possession of the land which fronts upon the actual bank line, in all ordinary cases, is derived from the principle that a meander line is not a boundary in the usual sense, it being the intention of the Government to convey title to the water's edge. If there should be changes in the position of the bank line, as by accretion, or by recession of the water, the ownership may, in many States, include the new land, but this is a claim of an entirely different character, being one that has its origin in the State or common law, and is called a riparian right. The law, in many States, grants additional exercise of authority within the bed of the body of water, with which the text here is not concerned.

The Government conveyance of title to a fractional subdivision fronting upon a nonnavigable stream, unless specific reservations are indicated, either in the patent from the Federal Government or in the laws of the State in which the land is located, carries ownership to the middle of the stream.

The above principles are set out in the syllabus in 50 L. D. 678, as follows:

Public lands—Courts—Vested rights—Statutes: Whenever the question arises in any court, State or Federal, as to whether the title to land, which had once been the property of the United States, has passed, that question must be resolved by the laws of the United States; but when, according to those laws, the title shall have passed, then that property, like other property in the State, is subject to the laws of the State, so far as those laws are consistent with the admission that the title passed and vested according to the laws of the United States.

Navigable waters—Riparian rights: Upon the admission of a State into the Union the title to all lands under the navigable waters within the State inures to the State as an incident of sovereignty, and the laws of the State govern with respect to the extent of the riparian rights of the shore owners.

Public lands—Patent—Riparian rights: With respect to public lands bordering on nonnavigable bodies of water, the Government assumes the position of a private owner, and when

it parts with its title to those lands, without reservation or restriction, the extent of the title of the patentee to the lands under water is governed by the laws of the State within which the lands are situated.

Survey—Fraud—Lake—Boundary—Public lands—Riparian rights: Where a survey was fraudulent or grossly inaccurate in that it purported to bound tracts of public lands upon a body of water, when in fact no such body of water existed at or near the meander line, the false meander line and not an imaginary line to fill out the fraction of the normal subdivision marks the limits of the grant of a lot abutting thereon, and, upon discovery of the mistake, the Government may survey and dispose of the omitted area as a part of the public domain.

513. The first thing to be established, where the principle of erroneous omission is to be set up, is to show affirmatively that the area was *land in place* at the date of the original subdivision of the township and at the date of the admission of the State into the Union, so that if found similar to the surveyed lands the usual inference that the official survey was correct may be set aside, and the conclusion substituted that the land should have been covered by that survey; but, before looking upon a discrepancy as one constituting erroneous omission, or an omission in the contemplation of the controlling decisions on the subject, a convincing showing is needed on the fact that the representations of the original plat and field notes are grossly in error.

514. The applications for the extension of the subdivisional lines so as to include the areas erroneously omitted from the original survey are in most cases initiated either by settlers upon the omitted land or by the owners of the adjoining land. The owner of the surveyed land, or a claimant who has purchased from said owner, may apply for the survey of the omitted area as a preliminary to proceeding with steps to quiet the title. In the latter event the possibility of an adverse claim may or may not be present, but the immediate question is the merit of the application under the acts of Congress which grant relief in these cases. In nearly all cases the points to be determined require a field examination to verify the showing made in the application, and to safeguard the action of the department upon it. It should be understood that it is objectionable in principle to amend a plat in any of these cases except upon the showing of large and unwarranted

discrepancies, or by demonstration of equitable title in the Government, as otherwise the making of the corrective survey is frequently at the hazard of interference with private rights; and it should be understood that no proof is required to show the whys and wherefores of an erroneous meander line, but rather that the line as run and as represented on the plat and in the field notes is in effect grossly in error. The rule is concisely stated in 29 L. D. 521:

It is not necessary to search for the source of the error. The result is the same whether such error arose from mistake, inadvertence, incompetence, or fraud on the part of the men who made the former survey.

515. The general procedure in the survey of lands erroneously omitted is outlined in section 223, Chapter III, and section 380, Chapter V. The angle points of the original record-meander courses are given serial numbers, avoiding duplication of the numbers where there are two or more of such record-meander lines within a section. The adjusted positions for the angle points are monumented, and marked as shown in sections 279 and 346, Chapter IV.

516. The requirements for making the plats to represent this type of survey are outlined in sections 639 to 644, Chapter IX.

517. It is important that the plat should carry a memorandum precisely stating the situation with reference to the survey represented thereon, as:

The position of the original record-meander courses of the so-called Moon Lake is shown by an irregular line with numbered angle points. This line as thus originally reported was grossly in error, and has therefore been marked as a fixed boundary, with the directions and lengths of the several courses adjusted to the record of the original survey.

The position of the original record-meander courses of Ferry Lake fronting along lot 4, section 9, and lots 2, 3, and 4, section 10, is shown by an irregular line with numbered angle points. This line as thus originally reported was grossly in error, and has therefore been marked as a fixed boundary, with the directions and lengths of the several courses adjusted to the record of the original survey.

The position of the original record-meander courses of a lake reported as having been located in section 36 is shown by an irregular line with numbered angle points. This line as thus originally reported was grossly in error, and, with the exception of certain courses fronting along lots 1, 2, and 9, has there-

fore been marked as a fixed boundary, with the directions and lengths of the several courses adjusted to the record of the original survey.

518. A memorandum will also be supplied with reference to the dependent resurvey of the several section-line boundaries, as required in section 425, Chapter VI.

519. If there should be substantial areas of accretion to be dealt with that fact will be brought out in the special instructions, with an outline of the governing procedure, and the surveying work in reference to all accretion areas will be distinctly mentioned in the field notes and so shown upon the plat.

520. Accretion is a term in general use to denote the lands formed by the deposit of material along the bank of a body of water, or to denote land uncovered by the recession of the water as by the lowering of its level, and the right to such newly made land, unless reserved to the State, attaches to the ownership of the ground along which the accretion is formed. Where the title to the original subdivisions along nonnavigable bodies of water is still in the Government, and where there is similar title along navigable waters in those States where there is no legal reservation to the State, such title carries the right of the Government to subdivide the lands formed by accretion, or by the recession of the water, and to dispose of the same under the general land laws. If the original subdivisions were disposed of prior to the formation of the accretion, or if the accretions that are formed along navigable waters are reserved by State law, the Government has no jurisdiction.

521. A few examples of the survey of erroneously omitted areas, with a review of the facts, will serve to illustrate the practice:

522. *Moon Lake case*: The plat of T. 12 N., R. 9 E., fifth principal meridian, Arkansas, approved October 27, 1845, shows a meandered lake occupying the greater part of sections 22 and 27, and extending a short distance into section 26. The field notes of the line between sections 26 and 27 call for an intersection with the southeast side of "Sunk Lake," here classed as impassable and navigable. The surrounding fractional subdivisions as surveyed were all patented to the State under the provisions of the swamp land grant.

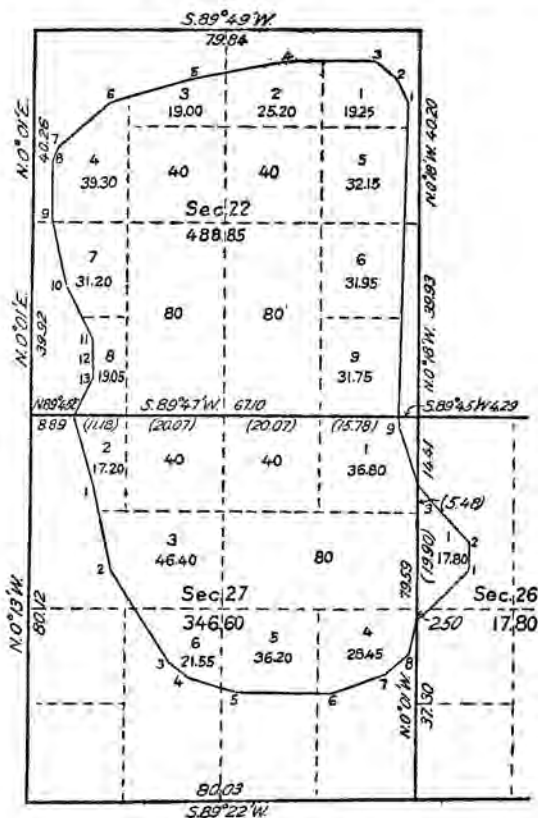


FIG. 77.—The Moon Lake case.

As no such body of water was ever present, riparian rights do not attach (sec. 523).

The case originated on the report of the removal of timber from portions of the area, under the color of title arising through the ownership of the adjoining land, but it was indicated clearly in the report that practically all of the area was high, dry land, covered with a growth of large timber, with no

difference in the character of the land from that which had been included in the original subdivision, and that the topography, elevation, and timber all revealed little if any change since the date of the subdivision of the township.

The greater part of the tract was found to be covered with various species of oak, maple, cottonwood, hickory, sycamore, hackberry, cypress, and willow, many of the trees being of great age, 300 years or more, and many of them indicating strictly upland site conditions. Altogether the area was found to be level land, at about the same elevation and in some places higher than the surrounding lands, though there was evidence of what had been a slough along parts of the edge of the so-called lake.

523. By decision dated November 30, 1909, bearing departmental approval, the Commissioner of the General Land Office held that the area, 853.25 acres, was not a navigable lake on June 15, 1836, the date when Arkansas was admitted into the Union, nor in 1841 at the date of the subdivision of the township, but as the land was in place at that period and not having been permanently covered by water, it was part of the public domain, and that title had not passed from the Government.

On November 5, 1917, the Supreme Court of the United States announced an opinion (245 U. S. 24) denying the merits of the riparian claimants to the area within the meander line of the so-called lake, restating two legal propositions held indisputable because settled by previous decisions:

First. Where, in a survey of the public domain a body of water or lake is found to exist and is meandered, the result of such meander is to exclude the area from the survey and to cause it as thus separated to become subject to the riparian rights of the respective owners abutting on the meander line in accordance with the laws of the several States. *Hardin v. Jordan*, 140 U. S. 371; *Kean v. Calumet Canal Co.*, 190 U. S. 452, 459; *Hardin v. Shedd*, 190 U. S. 508, 519.

Second. But where upon the assumption of the existence of a body of water or lake a meander line is through fraud or error mistakenly run because there is no such body of water, riparian rights do not attach because in the nature of things the condition upon which they depend does not exist and upon the discovery of the mistake it is within the power of the Land Department of the United States to deal with the area which was excluded from the survey, to cause it to be surveyed and to law-

fully dispose of it. *Niles v. Cedar Point Club*, 175 U. S. 300; *French-Glenn Live Stock Co. v. Springer*, 185 U. S. 47; *Security Land & Exploration Co. v. Burns*, 193 U. S. 167; *Chapman & Dewey Lumber Co. v. St. Francis Levee District*, 232 U. S. 186.

Other important points in this and similar cases are found summarized in the syllabus:

If, in the making of a survey of public lands, an area is through fraud or mistake meandered as a body of water or lake where no such body of water exists, riparian rights do not accrue to the surrounding lands, and the Land Department, upon discovering the error, has power to deal with the meandered area, to cause it to be surveyed, and lawfully to dispose of it.

The fact that its administrative officers, before discovery of the error, have treated such a meandered tract as subjected to the riparian rights of abutting owners, under the State laws, and consequently as not subject to disposal under the laws of the United States, can not estop the United States from asserting its title in a controversy with an abutting owner; and even as against such an owner, who acquired his property before the mistake was discovered and in reliance upon actions and representations of Federal officers carrying assurance that such riparian rights existed, the United States may equitably correct the mistake and protect its title to the meandered land. The equities of the abutting owner, if any, in such circumstances are not cognizable judicially, but should be addressed to the legislative department of the Government.

The swamp land act of September 28, 1850 (ch. 84, 9 Stat. 519), did not convey land of its own force, without survey, selection, or patent.

524. The surveying work to be done in the Moon Lake case consisted of a retracement of the boundaries of the several sections, a restoration of the obliterated corners, a remonumentation of all of the corners, a retracement of the record meander line with monumentation of the angle points, and a completion of the fractional section lines. (See sec. 515.)

525. *Ferry Lake case*: The plat of T. 20 N., R. 16 W., La. Mer., Louisiana, approved August 31, 1839, shows the north boundary of the township discontinued on the bank of Ferry Lake. The line between sections 10 and 11, in harmony with the remaining subdivisions, was discontinued on the lake bank, but the line between sections 3 and 10, instead of being extended to the main lake front was stopped on an arm or bay of the lake. The meander line through section 3 could be, and was run with



FIG. 78.—The Ferry Lake case.

The contour representing the mean high-water elevation of the lake in the year 1812, when Louisiana was admitted into the Union, and in 1830, when the township was subdivided, is shown thus: The circumstances, as well as the extent and character of the lands, necessitate the conclusion that the omission was of deliberate purpose or the result of such gross and palpable error as to constitute in effect a fraud upon the Government (sec. 526).

reasonable conformity, but in section 10, owing to the failure to extend the northern section boundary to the main lake front, there was no possibility of running a true meander line; and, excepting the end courses, the record line, as developed, bears no proper relation to the actual bank.

The plat of fractional sections 4, 9, and 10 of the same township, approved August 18, 1871, represents an extension of the lines between sections 3 and 10, and between sections 4 and 9, to the main lake front. The corner of sections 3, 4, 9, and 10 was established in this survey, also a meander corner on the west side of a narrow bayou which drains out of the north part of section 9; but again, for no apparent reason, in running south on the line between sections 9 and 10 the survey was terminated at a point more than 3,400 feet north of the bank of Ferry Lake. A part of the meander courses in sections 4 and 9 were accurately run, but the remaining courses, particularly those which connected with the terminal point on the line between sections 9 and 10, were merely a traverse line through the woods, though represented in the field notes and shown on the plat to be the bank of the lake.

Such was the situation in this township until oil and gas were discovered in large quantities, when in the years 1909 and 1910 applications were filed with the department to make mineral locations, not only on the areas that had been erroneously omitted from the official surveys, but within the bed of the lake, it being alleged that large errors had been made in the running of the meander lines, that the lake itself was merely a temporary body of water, and that it had not been in existence as a navigable lake, such as would belong to the State by right of sovereignty, and reserved to the State on admission into the Union on April 30, 1812. In 1910 all of the fractional lots adjoining the omitted area had been disposed of by the United States.

The report of the field investigation included a review of considerable historical data, expert studies of the geology of the lake basin, expert examination of the forest trees, and the surveying situation, all leading to corroborative conclusions that Ferry Lake was in fact present in 1812 as a navigable body of water, though there had been a marked recession of the lake by 1910, and that in neither of the surveys made in 1839 and

1871 had the lake been correctly meandered in sections 9 and 10, either as it was at the dates of the surveys or as it was in 1812.

The soil, topography, and timber on the omitted area were identically the same as found on the surveyed land, and for the greater part of the length of the record meander line there was not the slightest indication of there ever having been a lake bank or water-washed escarpment of any kind. The forest growth on the omitted land, which in the one body in sections 9, 10, 15, and 16 amounted to 229.67 acres, included overcup oak, sweet gum, and red gum on the lower levels, and on the remainder post oak, black-jack oak, Spanish oak, hickory, pine, and other varieties, many of them of great age, and clearly the descendants of a mixed forest that had occupied the situation for many centuries. The overcup oak was found to occupy a belt immediately above a belt of cypress timber principally, but with some other varieties, which were found occupying the plain terraces above and below an escarpment, easily traceable, which had been made by the waters of Ferry Lake, and which continued, without interruption, around the entire basin. A contour survey showed the elevations in the omitted area in sections 9 and 10 to range up to 17 feet above the former lake level.

526. Upon a review of the record, the Attorney General of the United States, in a letter to the Secretary of the Interior, dated September 11, 1916, concluded—

That no action should be taken to enforce or assert any claim by the Government to that portion of the area involved which is covered by the waters of the lake because if the State's title by virtue of its sovereignty should fail for any reason, I see no way of successfully resisting her claim under the swamp land grant.

However, in so far as concerns the land lying between the old meander line and the waters of the lake, I entirely agree with you that it constitutes unsurveyed public land of the United States, and * * *.

On January 2, 1923, the Supreme Court of the United States announced an opinion (260 U. S. 561, 563), denying the claims to the land in sections 9, 10, 15, and 16, adverse to those of the Government, and commented:

The inaccuracy of the plat is plainly apparent upon a like inspection. Why—— made the survey and returned the plat

as he did is a matter of speculation, but the facts demonstrate that no survey of the large, compact body of land, which includes the tract in controversy, was ever made. The circumstances, as well as the extent and character of the lands, necessitate the conclusion that the omission was of deliberate purpose or the result of such gross and palpable error as to constitute in effect a fraud upon the Government.

527. The surveying work to be done in the Ferry Lake case consisted of the steps already noted in the Moon Lake case (see secs. 515 and 524); also a monumentation of the contour which agreed with the evident mean high-water elevation of the lake as it was in the year 1812. The contour line, owing to the recession of the waters, was needed to mark the boundary of the public land; thus recognizing, in principle, not only the sovereignty of the State over the bed of the lake, but as well the reservation to the State, under her law, of the land uncovered by the recession of the water.

528. *Crooked Lake and Bear Lake case:* The plat of T. 43 N., R. 6 E., 4th Prin. Mer., Wisconsin, approved April 6, 1863, shows a meandered lake in section 36. Meander corners were established regularly on the south and east boundaries of the section. The field notes show the running of meander courses through the section on opposite sides of the lake, and call for high banks, along timbered land. No mention is made of an arm of a lake extending northwesterly into section 25. The fractional lottings were disposed of according to the representations of the plat.

By letter dated April 16, 1923, the Commissioner of the General Land Office advised the Secretary of the Interior of an application to make a forest-land selection for the NE $\frac{1}{4}$ SW $\frac{1}{4}$ section 36 (lot 15, fig. 79), which according to the representations of the township plat would be located entirely within the bed of the meandered lake as above described. This letter contains a review of the facts as developed by a field examination, and concludes with a recommendation that the land theretofore shown as a meandered lake be surveyed and a proper plat constructed. The proposed action bears departmental approval.

The report of the field examination showed the following facts:

The south and east boundaries of the section cross two lakes instead of one, the lakes being separated by a body of land amounting to 236.90 acres contained within the lines represented on the original plat as the banks of the one meandered lake. This area is rolling upland ranging up to 50

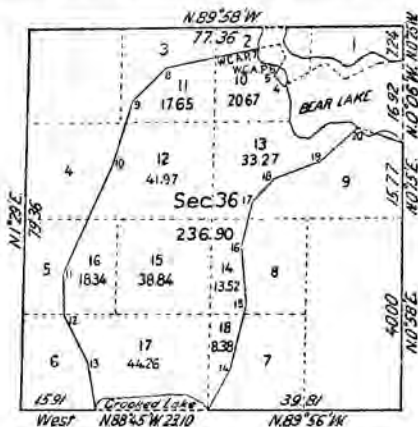


FIG. 79.—The Crooked Lake and Bear Lake case.

The south and east boundaries of the section cross two lakes instead of one, the lakes being separated by a large body of land, ranging up to 50 feet above the level of either lake, and heavily forested, while the shores of the lakes are well defined.

Witness angle points Nos. 6 and 7 are established on the bank in order to show the directions of the lines running from angle points Nos. 5 and 8.

feet above the level of either lake, and forested with pine, hemlock, birch, maple and spruce timber. There was no evidence of any changes in the water level of the lakes, nor of any escarpment along the fictitious meander courses connecting them, these lines having been found to traverse rolling land instead of following a contour, with not the slightest difference between the character of the land, soil or timber on the area

theretofore surveyed and that which had been omitted. The shores of the two lakes were well defined, with banks from three to eight feet high, bordered by a strip of level land from 10 to 30 feet in width, surrounded by rolling hills. The geologic formation, as well as the forest trees, indicated great age.

529. The surveying work to be done consisted of the steps previously outlined in the Moon Lake case. (See secs. 515 and 524.)

SWAMP AND OVERFLOWED LANDS.

TIDE LANDS.

530. References are made in section 3 to the coastal limits of the public domain as defined by mean high tide, and in section 4, Chapter I, to the several acts of Congress which granted to certain States the swamp lands within their respective boundaries. The references are continued in sections 226 to 233, and in paragraph 10, section 236, Chapter III, under the general subjects of the meandering of bodies of water and classification of land.

Tide lands include all coastal areas that are situated above mean low tide and below mean high tide, particularly as such areas are alternately uncovered and covered by the ebb and flow of the ordinary daily tides. Overflowed lands include essentially the lower levels within a stream flood plain as distinguished from the higher levels, according to the characteristic effect of submergence where long continued. Swamp lands include all other marshes and intermittent ponds which do not have effective natural drainage, particularly where such conditions are long continued.

531. The Supreme Court of the United States in *Baer v. Moran Bros. Co.* (153 U. S. 287), states that tide lands are those which are uncovered at low tide and are covered at ordinary high tide. In *Pollard's Lessee v. Hagan* (15 Curtis, 391, 403) the Supreme Court held:

The shores of navigable waters and the soil under them were not granted by the Constitution of the United States, but were reserved to the States, respectively—

and in *Mumford v. Wardell* (6 Wall. 423, 436) the court said:

The settled rule of law in this court is that the shores of navigable waters and the soil under the same in the original States, were not granted by the Constitution to the United States, but were reserved to the several States, and that the new States, since admitted, have the same rights, sovereignty, and jurisdiction in that behalf as the original States possess within their respective borders.

In *San Francisco v. LeRoy* (138 U. S. 656, 671), the court stated:

The lands which passed to the State upon her admission to the Union were not those which were affected occasionally by the tide, but only those over which tide-water flowed, so continuously as to prevent their use and occupation. To render lands tidelands, which the State by virtue of her sovereignty could claim, there must have been such continuity of the flow of tidewater over them, or such regularity of the flow within every twenty-four hours, as to render them unfit for cultivation, the growth of grasses or other uses to which upland is applied.

532. In the light of the decisions it is clearly indicated that coastal "salt marshes" that are covered by the daily tide belong to the States by right of sovereignty, and such areas are not subject to survey. Coastal marshes that are not covered by the daily tide are subject to survey, but being low in elevation and usually saturated will be classified as swamp and overflowed within the meaning of the several grants.

533. Riparian rights, as defined by the laws of the several States, which are applicable within the beds of lakes, streams, and tidal waters, are not enforceable over the swamp and overflowed lands granted to the States.

534. Where surveys or field examinations are to be made covering or relating to swamp and overflowed lands, the special instructions should point out the particular questions which are presented, and in general, in aid of the adjustments which are required by the swamp land granting acts, the following rules will be observed:

1. According to section 3 of the swamp land grant of 1850, any legal subdivision the greater part of which is "wet and unfit for cultivation," shall be included in the list, but when the greater part of a subdivision is not of that character the whole of it shall be excluded. The "legal subdivision" mentioned herein is the usual quarter-quarter section or lot as shown by the plat of survey.

2. In order to bring land within the definition of the several swamp land granting acts, the greater part of any quarter-section or any lot must have been so swampy or subject to overflow during the planting, growing, or harvesting season, in the majority of years at or near the date of the grant, as to be unfit for cultivation in any staple crop of the region in which it is located, without the use of some artificial means of reclamation, such as levee protection or drainage ditches.

3. A subdivision which becomes swampy or overflowed at a season of the year when this condition does not interfere with the planting, cultivating, or harvesting of a crop at the proper time and by the ordinary methods, and so not being "made unfit thereby for cultivation," does not pass to the State under the swamp-land grant.

4. Tame grass or hay, when produced by the ordinary methods of preparing the ground, will be considered a staple crop, as well as the cereals, or cotton, or tobacco.

5. In the administration of the several acts granting the swamp lands, the States have been allowed optional methods of preparing the lists of the subdivisions that are to be identified as swamp and overflowed within the meaning of said acts, but in every survey, the duty devolves upon the engineer to determine with accuracy the position and extent of the swamp and overflowed land within the area under survey, regardless of the methods employed by the States in asserting claims.

6. The States of Alabama, Arkansas, Indiana, Louisiana, Michigan, Minnesota (excepting as to lands within the Indian reservations), Mississippi, Ohio, and Wisconsin have elected to base their swamp-land lists on the field-note record, and in these States it is imperative that the field notes of the survey include a specific list of the subdivisions each of which is more than 50 per cent wet and unfit for cultivation, regarding such character as at the date of the passage of the granting act.

7. In California, under the act of July 23, 1866 (14 Stat. 218), the swamp-land lists are based upon the representations of the plat of the survey, and in this State it is imperative that the plats correctly show the conditions in this respect.

8. The selection of the swamp lands within the States of Florida, Illinois, Iowa, Missouri, and Oregon, and within the Indian reservations in the State of Minnesota, is based upon investigations and reports by representatives of the State and of the General Land Office, but this does not set aside the Manual requirements for the usual complete showing of the character of the land.

595. It is always of importance to note any marked changes in the water level and drainage conditions of the region, and to ascertain the situation which obtained at the date of the grant-

ing act, and in all such inquiries it is proper to secure the testimony of persons who have known the lands for the longest periods. The most convincing evidence relative to the character of the land at the date of the granting act will be afforded by the older native forest trees, if any are present, or where their stumps remain, as these will reflect their site conditions with great certainty.

This line of investigation will require an inquiry into the habitat of the forest species which are found, particularly as to whether the usual range of the tree is within low wet ground, as for example the cypress, tupelo, sweet gum, water ash, water locust, and red bay of the southern latitudes, and the tamarack, white cedar, black spruce, swamp spruce, and black ash of the northern latitudes of the United States. The presence of any of the species named indicates the possibility of swamp land, and while conclusive with some of them, others of the species named have a wider range and may be found associated with upland varieties. If upland varieties are present the plain inference will be that the site conditions are that of upland, even though a forest species may favor moist rich soil.

SOIL CLASSIFICATION.

536. The subject of soil classification is referred to in paragraphs 8 and 20, section 236, Chapter III. It is one of considerable importance when related to the development of the public domain, not only to the prospective settler but for the value to be found in this field-note information for use in all general soil surveys and in the administration of forest lands. While it is beyond the purpose of the Manual to go into a subject which belongs properly to another scientific branch, yet it is apparent (R. S. 2395; Manual, sec. 8, subsec. 99, Ch. I) that the general laws require the engineer to note and to report upon the soil types.

537. The objective to be stressed in this line of observation is to report upon the characteristic soil types, which when considered in relation to the normal moisture conditions, including precipitation and drainage, the possibility of irrigation at reasonable cost, the climatic conditions, elevation above sea level, and latitude, will bring out the adaptability of the soil

for farming purposes, grazing or forestry, or whether it is desert or waste rocky land.

538. A layman's outline only is here presented, to the end that it may serve as a guide to the engineer, both in the field and for his inquiry into technical books on the subject as may be needed for an intelligent understanding of the various soil types, their make-up, and their use:

1. Soil types, based on texture: Gravel, coarse and fine; sand, coarse and fine; sandy loam; silt loam; loam; clay, heavy and light; and muck.

2. Structure: Single grained, pulverulent, and lumpy.

3. Color: Surface soil and subsoil, both when dry and when wet.

4. Depth: Surface soil and subsoil.

5. Location: River bottom or flood plain, bench, slope, plateau, prairie, and mountain.

6. Topography: Level, rolling, broken, hilly, and mountainous; and elevation above sea level.

7. Drainage: Direction, depth to water table, and quality, as poor, good, or erosive.

8. Mode of formation: Water laid, glacier laid, wind laid, and residual.

9. Chemical properties: Acidity, alkalinity, and humus content.

10. Geological derivation:

(a) Sedimentary rocks: (1) Formed of fragments of other rock transported from their sources and deposited as conglomerate, sandstone, and shale; and (2) formed by simple precipitation from solution, as limestone, or of secretions of organisms, as some coastal rocks.

(b) Metamorphic rocks: Formed through change in constitution, especially those due to great pressure, heat, and water, and resulting in a more compact or more highly crystalline condition, including, for example, quartzite, marble, slate, and schist.

(c) Igneous rocks: Formed through the action of intense heat, including, for example (first, eruptive rocks), basalt, lava, and volcanic ash; (second, trap rock) felsite and quartz-porphry; and (third, granular rock) granite, diorite, and porphyry.

539. The soil has its origin in the material which comes from the disintegration of the rocks. Roots and other vegetable matter in the soil are by decay gradually converted into humus, which is found only in the surface soil, and in quantities which

vary with the activity and profusion of plant life. Plant food comes from the chemical elements contained within the rock and the humus, one is the product of the inorganic, the other a product of the decomposition of the organic matter. There are four elements that the plants mainly need in soils—phosphorus, potassium, nitrogen, and calcium—the others usually being present in plentiful supply and so of less importance in considering the fertility. The physical properties of the humus are of the greatest importance to the relation of the fertility of the soil, and the humus confers upon the soil the power of absorbing and retaining the moisture.

The soil bacteria thrive best in one which is rich in decaying vegetation, with favorable proportions of lime, air, light, warmth, and moisture, and through their presence much nitrogen is taken from the air for storage in the ground. The relation of these things leads to the notable observation that soils seem to select their plants, or vice versa. There is found in a certain soil type one class of grasses or forest cover, in another soil very different plant life. These are the keys to a study of the soils, and when all are considered in connection with the moisture, climatic, and other conditions of the environment will very largely determine its value for agriculture, stock grazing, or forestry.

540. The following is an illustration of a general description of the land and soil types found within a selected township, designed to bring out rather minute references to the soil structure:

Land, level, and gently rolling plateau, with elevation from 500 to 700 feet above sea level. Soil, fine sandy loam; surface soil dark gray to black, rich in humus, from 10 to 15 inches deep; subsoil, light brown loam, 36 inches deep, resting on gravel bed; sedimentary origin, lake laid. Drainage good, the stream system being the ——— river and its tributaries. The normal precipitation of the region is ordinarily deficient for general farming, but the soil is well adapted to any of the cereals usually grown in this latitude by dry-farming methods, and it produces excellent grasses, both native and tame.

CHAPTER VIII.

FIELD NOTES.

THE GENERAL PLAN.

541. The field notes are the written record of the survey. It is essential that this record show an appropriate identification of the lines previously established from which the survey has been extended, with suitable "calls" referring to the alignment and measurements, description of topography along the lines surveyed, and monumentation of the work. All new subdivisions to be platted and the quantity of land in each unit are derived from the field notes, and this record will be, in turn, the basis for the identification of the boundaries. The early laws on public-land surveys comprehended the importance of the field notes, and this chapter of the Manual is devoted to outlining the requirements, with examples of the various forms of record.

542. The initial notes are kept in pocket field tablets. The final field notes for filing are transcribed from the field tablets, and are typewritten upon regulation field note paper. It is desirable that the final field notes be made to conform to the general arrangement and phraseology set out in the Manual. It is obvious, for practical reasons, that a large part of the final field notes must be extended from an abbreviated field record, and equally apparent that much of the minute detail of the initial notes may be appropriately summarized into a form of record which will refer directly to the completed survey. This distinction in the two stages of the record is carried through the text. The subject in hand is that of the final field notes, the record that is extended from the field tablets; this record is termed the "*field notes*."

543. There will be entered in the *field tablets* all appropriate notes of the method and the order of the procedure; the dates will be shown when engaged upon each part of the work; and the division will be noted if the work is divided between two or more parties. These notes will also show the minute detail

of all observations for time, latitude, and azimuth; the resulting directions of the lines run; the measurements; and all necessary descriptions. The preceding chapters contain explicit instructions on these subjects which do not need to be repeated. It suffices to state that the record made in the field tablets should supply, along the plan already laid down in the preceding chapters, all information which may be needed for a complete verification of the final transcript record.

544. The need for choice of methods in handling the great variety of survey types makes it desirable that judgment be exercised as to whether part of the work of entering the initial record in the *field tablets* shall be allotted to one or more assistants, and how the notes are to be arranged. The chief of field party is necessarily charged with responsibility for the accuracy and sufficiency of this record, all subject to the approval of the proper supervising officer. The work of transcribing the record usually receives the personal attention of the engineer, but as that is not always the case, it is important that the arrangement of the notes in the tablets and the use of abbreviations be such as to be readily understood by others who are familiar with the technical processes. It follows that due regard should be given to the Manual requirements and form, though it is intended that set forms of expression be used flexibly and modified when necessary to conform to the survey procedure. The work of the reviewing officers will be directed to the fundamental requirements of the Manual and the written special instructions, and the comments, if any, *as to the form* of the final field notes, will be based upon broad grounds.

545. The *field notes* will be compiled in "books" as directed by the proper supervising officer. A separate book will be employed for the subdivisinal notes of each township. Exteriors may be combined in the same book with the subdivisinal lines in the survey of a single township, but in extensive surveys the standard parallels and guide meridians will be separated from the township exteriors, and the latter will be separated from the subdivisinal and meander lines in such a way as the proper supervising officer may deem appropriate for the permanent filing of the record. The several books of the same series will be given designating letters, as A, B, C, etc.

TITLES.

546. Each book of field notes will be included in a regulation cover, with appropriate title setting out general information as follows:

1. The description of the lines recorded in that book;
2. The principal meridian to which the survey refers;
3. The State in which the survey is located;
4. The name or names of the engineers by whom the work was executed;
5. The date of the special instructions, with serial group number, and date of approval;
6. The date of the assignment instructions; and,
7. The dates of the beginning and completion of the work included in that book.

EXAMPLES OF TITLES.

Field Notes
Of the Survey of the
Tenth Standard Parallel North,
Along the South Boundary of Township 41 North,
Through Ranges 13, 14, 15, and 16 West;
and the
Fourth Guide Meridian West,
Through Townships 41, 42, 43, and 44 North,
Between Ranges 16 and 17 West.

(Or)

East and North Boundaries of
Townships 41 and 42 North,
Ranges 15 and 16 West.

(Or)

Subdivisional and Meander Lines of
Township 41 North, Range 15 West.

(Or)

West and North Boundaries
and
Subdivisional and Meander Lines of
Township 41 North, Range 13 West.

(All)

Of the Sixth Principal Meridian
In the State of Wyoming,
Executed by
Wm. C. Jones, U. S. Cadastral Engineer.

(Or)

John B. Smith and Fred A. Brown,
U. S. Cadastral Engineers.
(All)

Under special instructions dated June 30, 1927, which provided for the surveys included under Group No. 156, bearing

the approval of the Commissioner of the General Land Office under date of July 10, 1927; and assignment instructions dated July 15, 1927, addressed to the above-named engineer (or engineers).

Survey commenced July 25, 1927.

Survey completed October 10, 1927.

547. The descriptive portion of the title will be appropriately modified if there is a fractional portion of a township included in a survey, and for all resurveys and fragmentary surveys, as for example:

Field Notes
Of the Survey of
A portion of the Subdivisional Lines
Completing (or continuing) the
Subdivision of
Township 39 South, Range 18 East.

(Or)

Field Notes
Of the Survey of
Four Islands in Burntside Lake,
In Sections 13, 20, and 29.
Township 63 North, Range 13 West.

(Or)

Field Notes
Of the Survey of
Fiddlers Island in Venice Bay,
In Section 1.
Township 39 South, Range 18 East.

(Or)

Field Notes
Of the Dependent Resurvey of the
Exterior and Subdivisional Lines of
Township 18 South, Range 59 West.

(Or)

Field Notes
Of the Dependent Resurvey of the
Eleventh Standard Parallel North,
Along the South Boundary of Township 45 North,
Through Range 79 West;
The East Boundary of
Township 45 North, Range 80 West;
and the
South Boundary of
Township 46 North, Range 79 West.

(Or)

Field Notes
Of the Independent Resurvey of the
East Boundary and Subdivisional Lines of
Township 45 North, Range 79 West,
and
Metes-and-Bounds Survey of Private Claims.

(Or)

Field Notes
Of the Dependent Resurvey of the Boundaries of the
Anastasia Island Lighthouse and Military Reservations,
In Sections 21, 22, 27, and 28,
Township 7 South, Range 30 East.

(Or)

Field Notes
Of the Dependent Resurvey and Extension of Lines
Subdividing the so-called Moon Lake,
In Sections 22, 26, and 27,
Township 12 North, Range 9 East.

(Or)

Field Notes
Of the Dependent Resurvey and Extension of Lines
Subdividing Land Bordering Perry Lake and James Bayou,
In Sections 9, 10, 15, and 16,
Township 20 North, Range 16 West.

(Or)

Field Notes
Of the Retracement and Extension of Lines
Subdividing Accretion Area Bordering Red River,
Including Riverbed Tracts,
In Sections 4, 5, and 8,
Township 5 South, Range 14 West.

(Or)

Field Notes
Of the Dependent Resurvey of the Section Boundaries,
The Subdivision of the Sections,
and
The Establishment of Corners of Indian Allotments,
Sections 9, 10, and 15,
Township 143 North, Range 30 West.

(Or)

Field Notes
Of the Dependent Resurvey of the Section Boundaries,
The Subdivision of the Sections,
and
The Establishment of the Boundary, Block and Lot Corners,
And Street Center-Lines of the
Town site of Lac du Flambeau, in
Sections 5 and 8,
Township 40 North, Range 5 East.

(Or)

Field Notes
Of the Dependent Resurvey of the Section Boundaries,
And the Metes-and-Bounds Survey of a body of land classi-
fied as mineral bearing, included within the Whitmore
Quartz and the Monday Quartz Mining Claims, in
Section 22,
Township 7 North, Range 12 East.

INDEX.

548. Upon the completion of the field notes of each book there will be prepared a small-scale index diagram of the lines included in that book. A form diagram will be employed ordi-

narily, but it is frequently necessary to construct a special diagram to suit the work; in the latter case a sheet of regulation field-note paper, or a sheet of the same size, will be employed, and a scale adopted that is suited to the available space. It is usually preferable to orient the diagram with north to the top of the page, though sometimes the outline of the work is such that it is better to orient the diagram with north to the left-hand (or binding) edge. The index diagram should show all of the lines the record of which is included within the book, with page numbers referring to such record to be shown upon the lines of the diagram. Meanders and other irregular lines will be drawn and indexed. The index sheet will be inserted in the book on the inside of the front cover, to appear on the right-hand side, without page number; no field notes will be written on the index sheet.

PAGE HEADINGS.

549. Each page of the field notes will be given a heading. Such heading will be a 1-line summary of the title of the field notes to be found on that page. New headings will be employed within the body of the field notes where changes are made to a new division of the survey; this will become the heading of the pages that follow. Examples will be found in the specimen field notes.

ABBREVIATIONS.

550. The following abbreviations, especially suited to field notes of surveys and designed for brevity, are permitted in the final transcript record, and are employed generally in the field notes where repetitions in the form of the record and the expressions used are such as to make the abbreviations readily understood. These abbreviations are employed in the field-note record in addition to those shown in Chapter II for analytical notation of observations, and those shown in Chapter IV for marks upon monuments. Some of these abbreviations, as appropriate, are employed upon the township plat. An extended explanation of the use of the trigonometric formulas frequently employed is contained in Tables 24 and 25, Standard Field Tables. All abbreviations will be given capital or lower-case letters the same as would be proper if the spelling were to be completed.

TABLE OF ABBREVIATIONS.

A.	for acres.	mer.	for meridian.
alt.	for altitude.	mkd.	for marked.
a. m.	for forenoon.	M. S.	for mineral survey.
ang.	for angle.	nat.	for natural function.
app. noon.	for apparent noon.	N.	for north.
app. t.	for apparent time.	NE.	for northeast
asc.	for ascend.	NW.	for northwest.
astron.	for astronomical.	No.	for number.
B. M.	for bench mark.	obs.	for observe.
bet.	for between.	obsn.	for observation.
bdy., bdrs.	for boundary, boundaries	p. m.	for afternoon.
ch., chs.	for chain, chains.	pt.	for point.
cor., cors.	for corner, corners.	Prin. Mer.	for principal meridian.
corr.	for correction.	$\frac{1}{4}$ sec.	for quarter section.
decl.	for declination.	R., Rs.	for range, ranges.
dep.	for departure.	red.	for reduction.
desc.	for descend.	rev.	for reverse.
diam.	for diameter.	s.	for second, seconds.
diff.	for difference.	sec., secs.	for section, sections.
dir.	for direct.	S.	for south.
dist.	for distance.	SE.	for southeast.
E.	for east.	SW.	for southwest.
e. e.	for eastern elongation.	sq.	for square.
elev.	for elevation.	Stan. Par.	for standard parallel.
elong.	for elongation.	sta.	for station.
ft.	for foot, feet.	tele.	for telescope.
frac.	for fractional.	temp.	for temporary.
Gr.	for Greenwich.	t.	for time (and hour angle).
G. M.	for guide meridian.	T., Tp., Tps.	for township, townships.
hor.	for horizontal.	tri.	for triangulation.
h.	for hour, hours.	u. c.	for upper culmination.
h. a.	for hour angle.	U. S. L. M.	for United States location monument.
in., ins.	for inch, inches.	U. S. M. M.	for United States mineral monument.
lat.	for latitude.	vert.	for vertical.
lk., lks.	for link, links.	w. corr.	for watch correction.
l. m. noon.	for local mean noon.	w. t.	for watch time.
l. m. t.	for local mean time.	W.	for west.
log.	for logarithmic function.	w. e.	for western elongation.
long.	for longitude.	x.	for separating dimension values.
l. c.	for lower culmination.		
m.	for minute, minutes.		
meas.	for measurement.		

THE DETAILED FIELD-NOTE RECORD.

551. Coming now to the body of the field notes, attention is again directed to those sections of the preceding chapters which deal with the preliminaries of the field work and to the Manual requirements in regard to the field-note record.

552. The purpose of the record, in reference to the introductory statements, is to qualify the survey structure; the data to be supplied are as follows:

1. A description of the instruments employed, and the adjustments and tests (a reference to where the record will be found may be supplied if it is contained in another book of field notes of the same series);
2. A description of the measuring tapes, and their test for accuracy;
3. A description of any special methods employed;
4. A description of the point of beginning and its geographic position; and,
5. The observed magnetic variation.

553. The following *list* will assist in locating many *specific requirements* in regard to the field-note record, with examples of forms of record:

Measurements: Descriptions required, sections 16, 23, 35, 141, 142, 575; examples, sections 18, 20, 27, 29, 32, 33, 38.

Instruments, and requirements as to their adjustment: Descriptions required, sections 41, 42, 43, 44, 45, 46.

Observations for time: Descriptions required, section 91; examples, sections 51, 55, 70, 71, 75.

Observations for latitude: Descriptions required, section 73; examples, sections 74, 75, 76, 82, 133-A.

Observations for azimuth: Descriptions required, sections 40, 81; examples, sections 81, 87, 88, 97, 98, 108, 112, 120.

Standard lines: Sections 141, 142, 143, 146.

Township exteriors: Sections 151, 154, 160, 163, 167.

Subdivisional lines: Sections 180, 187, 190, 192, 215, 228, 230, 232, 233, 235, 236.

Monuments: Sections 238, 241, 254, 324, 325.

Resurveys: Sections 420, 422, 423, 424, 445, 447, 452, 458, 459.

Indian allotment surveys: Section 469.

Town-site surveys: Section 482.

Rectangular boundaries of parts of sections: Section 495.

Mineral segregation surveys: Section 507.

Erroneously omitted areas: Section 519.

554. A full description of all monuments belonging to the established surveys, upon which the new lines are to be initiated or closed, will always be furnished with the written

special instructions. Upon the identification of such monuments, if in good condition, the new field-note record may take the form, "which is a ———, firmly set, marked and witnessed as described in the official record"; but if a monument does not conform to the record, or if it is found to be in poor condition, a complete description will be supplied; a description of the monument as reconstructed will always be entered if any changes are made.

555. The complete description of a monument will be entered once only. In subsequent notes the expression "heretofore described" may be employed when referring to a point of a previous survey already occupied in the new survey; all new corners recorded will be referred to by name only, without repeating the description of the monument, as for example: "the cor. of secs. 2, 3, 10, and 11"; or "the standard cor. of secs. 33 and 34"; or "the cor. of secs. 5, 6, 31, and 32, on the S. Bdy. of the Tp."

556. The character of the land, soil, and forest cover upon the lines surveyed will be summarized at the conclusion of the field notes of each mile. The record of the mile will be closed by a line drawn across the page. A general description of a township as a whole, with regard to topography, soil, forest cover, merchantable timber, native grasses, water supply and drainage, minerals, settlement, and improvements, will be supplied at the conclusion of the subdivisional notes.

557. The record of the names of the assistants and the certificates of the engineer and supervising officer will take the forms given in the specimen field notes.

SPECIMEN FIELD NOTES.

558. In the specimen field notes (appendix) there are shown the several forms of description of the approved types of corner monuments. The types that are employed ordinarily are given prominence, but those that are used in exceptional circumstances are included in order to supply a form of description. The indicated departures from the usual type of monumentation (iron post corners) are not to be construed as an authorization to disregard the standard practice which is outlined in

Chapter IV, as such authorization, if any, will be found in the special instructions, or will be contained in a formal letter from the proper supervising officer.

In the specimen field notes some page headings are shown in italics in order to conform with printing style, and in the paragraph entries which give the descriptive calls along the lines surveyed the second and following lines are indented one space to conform with printing style; the italics as mentioned will not be indicated in the typewritten field notes, nor will the indentation referred to be made. Descriptions of bearing trees and other accessories will be indented as indicated. In the ordinary descriptive style as printed the proper names of the principal meridians are not capitalized unless abbreviated. In tabulations no period is shown after an abbreviation if the latter is followed by a leader. A comma is inserted preceding the conjunction "and," as in "the corner of sections 3, 4, 9, and 10." Such differences in printing from the approved typewritten style employed in writing field notes are noted here as unavoidable.

559. Other specimen field notes as needed to show the miscellaneous forms of record which relate to the general and specialized class of surveys and resurveys to be found in the usual work of a surveying district will be supplied by the proper supervising officer. A liberal assortment of such specimen field notes, with their accompanying plats, all carefully considered, should be at hand for reference purposes.

560. The specimen field notes are carried in the Manual appendix, beginning on page 463. Below the title is an index of the *forms of record* that are to be found in the specimen field notes; the appropriate graphic indexes are supplied on pages 467 and 491.

CHAPTER IX.

PLATS.

THE IMPORTANCE OF THE PLAT.

561. The term "*plat*," as employed technically, refers to the drawing which represents the lines surveyed, established, re-traced, or resurveyed, showing the direction and length of each of such lines; the relation to the adjoining official surveys; the boundaries, description, and area of each parcel of the land subdivided; and, as nearly as may be practicable, a delineation of the topography of the region, including a representation of the culture and improvements within the limits of the survey. The purpose of the plat and its relation to the survey have been pointed out in sections 193, 194, and 210, Chapter III. Upon the approval of the field notes and plat by the proper supervising officer, and the acceptance of the same by the Commissioner of the General Land Office, the survey may be termed officially established or completed, and it follows that the survey does not attain official or legal status until thus completed.

562. It is a well-settled principle of law that a plat becomes a part of every Government land patent that refers to any subdivisions whose descriptions are to be found upon such plat, and that the legal significance of the plat in this respect is fully as important as though a copy of such plat had been incorporated into such patent. The same applies to any subsequent deeds of transfer. The public land is not to be regarded as "surveyed" until it has been duly shown upon an approved plat, and no subdivisions are to be "disposed of" until so identified.

563. As ordinarily conceived, an original survey of public lands does not *ascertain* boundaries; it *creates* them. Hence, the running of lines in the field and the laying out and platting of townships, sections, and legal subdivisions are not alone sufficient to constitute a survey. Until all conditions as to approval have been complied with, the public lands are to be regarded as unsurveyed and not subject to disposal. It follows that although a survey may have been physically made, if it be disapproved by the duly authorized administrative officers, the public lands which were the subject of the survey are still to

be classed as unsurveyed. In other words, to justify the application of the term "surveyed" to a body of public land something is required beyond the completion of the field work and the consequent laying out of the boundaries, and the thing that is required is the approval of the work of the engineer. If, pending such approval, and still more, if after disapproval of the survey, the public lands in contemplation of law are unsurveyed, it may follow that when the survey originally approved and platted is subsequently annulled, as to the unappropriated public lands, because the lines and marks established have become obliterated, such public lands may revert to an unsurveyed status for all purposes of settlement and sale. A purpose thus to annul such survey may be disclosed by an act of Congress or by departmental order directing a resurvey to supersede the original, plainly based upon the fact of such obliteration. With the disappearance of the physical evidences a survey survives only as an historical event. As a tangible, present fact it ceases to exist, and a new survey may become necessary to reestablish the status of the area over which it had extended as surveyed lands of the United States.

564. Entries and disposals are based upon and are defined by the monuments or other evidences of the controlling official survey, and so long as these evidences are in existence the plat of the survey is an official exhibit from which certain information and record data are obtainable. It is presumed that such plat correctly represents the actual field conditions, but if there are discrepancies the indications of the plat must give way to the evidence of the corners in place, as it is with reference to the monuments on the ground that the lands are identified, and the affidavit of the entryman is made that he is well acquainted with each and every legal subdivision thereof.

565. The foregoing reference to the superiority of the controlling monuments must not be confused with those cases wherein resurvey procedure is involved, as in the absence of visible evidences of the original survey, the field notes and plat are the best means of identification of the areas disposed of, and being the sole subsisting record, the field notes and plat will retain this purpose until the entries have been redefined, whereupon the plat of the resurvey becomes in turn the exhibit of the true conditions on the ground.

566. The requirements of the plat and the process of its production, the ascertainment of areas, amounts, or quantities shown, and the use of conventional symbols employed to delineate the topography will be set forth in this chapter.

SPECIMEN TOWNSHIP PLAT.

567. This is a revision of the specimen township plat which accompanied the Manual of 1902. (See Insert No. 1.) An effort has been made to secure maximum clarity of the essential features of the subdivisional survey with a standardization of the lettering which refers to section numbers, lot numbers, areas, and lengths and directions of lines, in suitable styles and gages, all in conformity with relative importance. The style of lettering which has been selected is intended to combine the greatest possible simplicity of execution with minimum liability of loss of definition on reproduction.

568. There has been added the detail of lengths of lines appertaining to fractional subdivisions in order to reveal the basis of the computation of all areas in harmony with the plan of subdivision of each section as shown. The distances noted in parentheses are those regular and fractional portions of lines between established monuments which constitute the boundaries of the quarter-quarter sections and fractional subdivisions bounded thereby; the parentheses are employed where the record is not supplied by the field notes; the lengths indicate what was used in the calculation of areas. The same lengths are to be adopted proportionately whenever there is a need for an establishment of sixteenth-section corners on the section boundaries, and for control points for the subdivision of sections.

569. The base drawing and all important improvements, works, or structures, and all names, where required, are in black. (See Insert No. 2.) The term "base drawing" as here employed refers to the lines showing all section boundaries, subdivisions of sections, and any other lines of segregation, such as mineral or private claim boundaries, meander lines (unless to be shown in blue), together with all lettering referring to title, names, memorandum, certificates, section numbers, lot numbers, areas, and lengths and directions of lines. The base drawing is one stripped of every detail nonessential to the identification of the subdivisions shown upon the plat. It is this

definition, with the descriptions suitable for the disposal of title to the land, that characterizes a plat as distinguished from a map. It is intended that the arrangement of data on all base drawings be made as nearly uniform as possible in harmony with the specimen plat, subject only to the unavoidable need for modification where irregular lottings must be made.

570. The specimen township plat shows a number of improvements over former methods of representing map features. These changes have been harmonized with modern practice in so far as adaptable to the plat. A noticeable improvement has been introduced by the use of transparent overprints for representing map data, to be employed on certain types of plats where former methods have proven to be ineffective. In this connection it should be observed that a substantial part of current work is made up of two classes of surveys which present the most important and increasingly difficult questions of mapping: (1) where the remaining original subdivisions are located in rough mountain regions; and (2) where in the execution of re-surveys there is a demand that the reliable topographic data exercise a more important influence in ascertaining the control to be adopted. A growing disappointment in dealing with plats of these types has come about through the inadequate results obtainable by the use of all black map symbols without confusion with or the obscuring of the essential data of the base drawing. This has been overcome by the use of transparent overprints where needed. Colors are not proposed for the general run of simple plats.

DRAFTING THE BASE DRAWING.

571. Township plats are generally drawn on the scale of 40 chains to 1 inch, on sheets 19 by 24 inches when trimmed. The scale is often enlarged to 20 chains to 1 inch, for showing irregular portions of parts of townships; the scale of 10 chains to 1 inch or larger is employed where necessary. The size of the sheets will always be made 19 by 24 inches, regardless of the scale or area to be shown; this is important on account of the need for uniformity in the dimensions of filing devices. A border-line rectangle $18\frac{1}{2}$ by 20 inches is right for the normal township plat; the length may be regulated between 18 and $21\frac{1}{2}$ inches if the subject is correspondingly smaller or larger.

572. The plat subject should be compiled or laid out with a good grade, medium hard drawing pencil, one which will make a clean mark, but not so hard that it will engrave the lines.

573. The township will be drafted as a plane, without allowance for reduction from the spheroid, as is required in the making of small-scale topographic maps showing large areas. All *regular* townships may be laid out as a rectangular grid, with allowance for fractional measurements along the north tier and west range of sections.

574. In the case of *irregular* townships, or those containing meanderable bodies of water, and lines of segregation such as mineral or private claim boundaries, the drawing should be laid out from the field closing sheets, duly balanced. The exteriors should be closed and balanced, then each section, and last the subdivisions within each section. The point of origin is then selected on the drawing, from which point the exteriors are carefully laid out, each salient being accurately located by scaling, from the point of origin, the balanced values of the total latitude and departure of that salient. The section boundaries are then laid out similarly from suitable points of origin on the exteriors. Finally the subdivisions of each section, including the necessary lines of segregation and meander lines, are accurately scaled by the method of total latitudes and departures from an origin on the section boundary. On this plan the work may be laid out without introducing accumulative errors of scaling.

575. Elements of triangulation figures and offset lines will not be shown on the plat when the field procedure results in duly ascertaining, indirectly, the course and length of the line sought to be established. Such diagrams should be shown in the field notes if needed for a clear understanding of the procedure, but are not required on the plat.

576. Township plats will show the complete condition of all their exteriors, including all closing and standard township and section corners, and connecting courses and distances. A line common to two townships will be drawn with equal completeness for both, as far as approved surveys will permit. The relative position of and data for near-by corners of one or two townships and closing township corners, if established, will be shown. Corners common to four townships will be shown only

T21S. R12E.



Fig. 80.—Two sets of corners on an irregular township boundary.

The directions and distances along a line common to two townships will be shown with equal completeness for both, as far as approved surveys will permit.

as referring to the subdivisional survey on that plat. Separate diagrams of township exteriors are not required.

577. A township made fractional by an adjacent reservation or private land grant, will have the intervening boundary properly lettered, and the mile posts and connecting distances shown. The proper designation of the area omitted will be shown.

578. Where a fractional portion of a township is surveyed, the condition of adjacent areas will be shown clearly by words lettered thereon, such as: "Unsurveyed," "U. S. National Forest," "Rancho San Luis," "Surveyed by John Smith, 1877," "Waste Lava Bed," or other explanation.

579. On plats of fragmentary surveys areas previously surveyed will have the sections and lots drawn in blank, to show the relation of old and new work.

580. The line of demarcation between areas previously counted in the total acreage surveyed and the new surveys will be distinctly shown. A light diagonal shading with black ink on the side previously surveyed is recommended to distinguish such a line.

581. Each regular section will show the center lines only and the area as 640 acres. In all other sections where lottings are required each subdivision must be distinctly shown. Where a section contains one or more fractional lots, its regular parts will show the usual areas as 40, 80, or 160 acres; the fractional lots will each show the assigned lot number and quantity computed to the nearest $\frac{1}{100}$ of an acre. The total area of public land within each irregular section will be shown as equal to the sum of the several parts, as identified by the plat, and disregarding parts omitted.

582. The complete technique of laying out the regular and fractional subdivisions of sections and the designations of the same by reference to aliquot parts and serial lot numbers is covered by sections 193 to 233, inclusive, Chapter III.

583. With reference to plats which are to show the completion of remaining parts of sections not previously surveyed, particularly in regard to sections where parts have been shown as outlying areas protracted as surveyed (see secs. 214 to 222, inclusive, Chapter III), it is the practice, where irregular conditions are found on the ground and no entries have been made,

to effect an annulment of the showing on the former plat, in order thus to simplify the execution and platting of the new surveys. Occasionally it may be desirable to resurvey a limited area, including entire sections previously returned as surveyed, where no rights to the land have been acquired, if in so doing a more satisfactory result may be obtained. An order suspending part or all of the previous survey is required in such cases.

COMPUTATION OF AREAS.

584. The deficiency in area which results from the convergency of meridians is placed normally in the fractional lots adjoining the west boundary of the township. Here sections 7, 18, 19, 30, and 31, each usually contains lots 1 to 4, inclusive, whose meridional dimensions are all an even 20.00 chains; the dimensions of the latitudinal boundaries of these lots are computed proportionately from the fractional measurements ascertained on the section lines. The area, in acres, of each lot is then found simply by adding the lengths, in chains, of its north and south boundaries.

585. For example, taking section 30, shown on the specimen plat, the dimensions of the latitudinal boundaries, and the areas are found as follows:

	(1)	(2)	(3)	(4)
N-----	18.21	18.245	18.28	18.315 chs.
S-----	18.245	18.28	18.315	18.35 "
	<hr/>	<hr/>	<hr/>	<hr/>
	36.455	36.525	36.595	36.665 acres
	36.45(+)	36.53(-)	36.59(+)	36.67(-) "

586. The areas of lots 5, 6, and 7, section 6, are ascertained similarly, making due allowance, when calculating the length of the north boundary of lot 5, for any material variation from 20.00 chains in the meridional dimension of lot 4.

587. The surplus or deficiency in area which results from the discrepancy in the meridional measurements between the exterior boundaries and the subdivisinal lines is placed normally in the fractional lots adjoining the north boundary of the township. Here sections 1 to 5, inclusive, each usually contains lots 1 to 4, inclusive, whose dimensions on their latitudinal boundaries are all treated as an even 20.00 chains; the meridional dimensions of these lots and their areas are computed on the

plan heretofore described for the fractional lots adjoining the west boundary of the township.

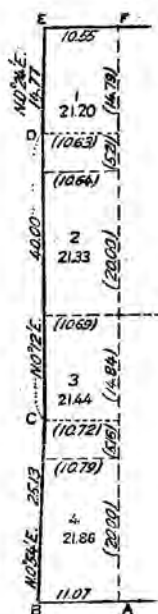
588. The areas of lots 1, 2, and 3, section 6, are ascertained similarly, making due allowance when calculating the length of the west boundary of lot 3, for the departure across lot 4, where more or less than 20.00 chains. The area of lot 4, section 6, in acres, may be ascertained by taking the product of its mean dimensions in chains, divided by 10.

589. The following is an example of ascertaining the areas of the fractional lots in section 6, shown on the specimen township plat:

	(1)	(2)	(3)	(4)	
E-----	20. 05	20. 037	20. 024	20. 011	chs.
W-----	20. 037	20. 024	20. 011	20. 000	"
	<u>40. 087</u>	<u>40. 061</u>	<u>40. 035</u>		acres
	40. 09	40. 06	40. 03 (+)		"
				<u>20. 005</u>	mean
	(5)	(6)	(7)		
N-----	17. 78	17. 81	17. 84	17. 75	chs.
S-----	17. 81	17. 84	17. 87	17. 78	"
	<u>35. 59</u>	<u>35. 65</u>	<u>35. 71</u>		acres
				<u>17. 765</u>	mean
				<u>35. 539</u>	acres
				35. 54	"

$$2.0005 \times 17.765 =$$

590. For purpose of computation of areas, where three sides of a section are regular and only one side irregular, the irregular boundary may be treated as a straight line if there is no break in allinement in that boundary in excess of 21' of arc; in such sections, if the field notes show that the cardinal length of the irregular boundary is within the usual limit of 50 links in 80.00 chains, the regular dimensions will be treated as having values in multiples of 20.00 chains. In the event that portions of the irregular boundary differ in course by more than 21' of arc, the break in allinement will be recognized and such adjustment of the lengths of lines which form the basis for the computation of the areas will be made as to bring all dimensions to a proper closing with the field measurements, taking into consideration the direction of the opposite governing boundary with respect to the areas of the regular portions of the section. The elements which enter into the computation of the areas will be derived from the balanced closure.



591. Example, Figure A-B-E-F. As the section is otherwise regular, the areas of the $E\frac{1}{2}$ and $E\frac{1}{2}W\frac{1}{2}$ are based on the assumption that the line A-F is 80.00 chains in length and parallel to the governing east boundary, disregarding the allowable error in closure. The lengths of the lines A-B and E-F are given by the field measurements: the intervening dimensions are obtained by the following calculations:

	N.	E.	W.
Westing A-B			11.07
N.0° 54' E	25.13	25.16	.39
N.0° 12' E	40.00	40.05	.14
N.0° 24' E	14.77	14.79	.10
Easting E-F		10.55	
		79.90	
Add to B-E		.10	
		80.00	11.18
			11.07
Line A-F	80.00	.11	

	N.	E.	W.		
Line A-B	20.00	.31	11.07	11.07	S. bdy. lot 4.
Line B-C	5.16	.08		- .31	
				+ .03	.03 For line A-F.
Line C-D	20.00	.07		10.79	S. bdy. lot 3.
				- .08	
				+ .01	.01 For line A-F.
Line D-E	40.05	.14		10.72	Lot 3 at C.
				- .05	
				+ .02	.02 For line A-F.
Line E-F	14.79	.10		10.69	S. bdy. lot 2.
				- .07	
				+ .02	.02 For line A-F.
Line A-F	80.00	11.18	11.07	10.64	S. bdy. lot 1.
				- .02	
				+ .01	.01 For line A-F.
Line B-E	25.53	.39		10.63	Lot 1 at D.
				- .10	
				+ .02	.02 For line A-F.
Line E-F	10.55			10.55	N. bdy. lot 1.
					.11

The areas are then computed as follows:

$$\text{Lot 1: } \begin{array}{r} 10.55 \\ 10.63 \\ \hline \end{array}$$

$$\underline{\underline{21.18}} \times 14.79 = 313.25$$

$$\begin{array}{r} 10.63 \\ 10.64 \\ \hline \end{array}$$

$$\underline{\underline{21.27}} \times 5.21 = 110.82$$

$$\begin{array}{r} 424.07 \text{ to be divided by } 20. \\ \hline = 21.20 \text{ acres.} \\ \hline \end{array}$$

$$\text{Lot 2: } \begin{array}{r} 10.64 \\ 10.69 \\ \hline \end{array}$$

$$= \underline{\underline{21.33}} \text{ acres.}$$

$$\text{Lot 3: } \begin{array}{r} 10.69 \\ 10.72 \\ \hline \end{array}$$

$$\underline{\underline{21.41}} \times 14.84 = 317.72$$

$$\begin{array}{r} 10.72 \\ 10.79 \\ \hline \end{array}$$

$$\underline{\underline{21.51}} \times 5.16 = 110.99$$

$$\begin{array}{r} 428.71 \text{ to be divided by } 20. \\ \hline = 21.44 \text{ acres.} \\ \hline \end{array}$$

$$\text{Lot 4: } \begin{array}{r} 10.79 \\ 11.07 \\ \hline \end{array}$$

$$= \underline{\underline{21.86}} \text{ acres.}$$

592. In all irregular sections and in sections that are invaded by meanderable bodies of water, or by lines of segregation, the center lines of the section and the center lines of each quarter section in turn are given calculated values based upon the balanced field closing sheets. Points of intersection of the center lines with the meander lines or other lines of segregation are then computed in order to complete the boundaries of each fractional lot. With the results of these computations at hand

the area of each fractional lot may be most readily computed by the method of "double meridian distances."

593. In order to proceed with a computation by double meridian distances, the closing error of the figure is first to be eliminated, or the traverse of its boundary to be balanced, by the most applicable rule. The general rule is that the correction to be applied to the $\left\{ \begin{array}{l} \text{latitude} \\ \text{departure} \end{array} \right\}$ of any course is to the total error in $\left\{ \begin{array}{l} \text{latitude} \\ \text{departure} \end{array} \right\}$ as the length of the course is to the perimeter of the figure. Another method of balancing the closing error will be applicable if the purpose is to apply a uniform correction to the directions and lengths of lines.

The double meridian distances of the several courses, or D.M.D.'s, are then computed by the following rules:

(1) The D.M.D. of the first course equals the departure, or the increment in easting or westing, of the course itself;

(2) The D.M.D. of the second course, and each of the succeeding courses in turn, is ascertained by taking the D.M.D. of the preceding course, plus the departure of the preceding course, plus the departure of the course itself; and,

(3) The D.M.D. of the last course is numerically equal to its departure, but with opposite sign, thus verifying the value of each preceding D.M.D.

For convenience in making the computations, the differences in $\left\{ \begin{array}{l} \text{latitude} \\ \text{departure} \end{array} \right\}$ to the $\left\{ \begin{array}{l} \text{north} \\ \text{east} \end{array} \right\}$ are treated as of positive sign, to the $\left\{ \begin{array}{l} \text{south} \\ \text{west} \end{array} \right\}$ as of negative sign. The point of beginning is taken at the westernmost salient of the figure, and the direction of the traverse is run counterclockwise. On this plan each D.M.D. and the algebraic sign of the final result are of positive sign.

The next step in the process is to multiply the latitude of each course by the double meridian distance of the course; the positive products are arranged in a column for "north areas," and the negative products in a column for "south areas." The sum of the negative products is to be subtracted from the sum of the positive products. The area, corresponding to the unit of measurement that is employed, is ascertained by taking one-half of the last result. Where the unit of measurement is the chain, the area in square chains is to be divided by 10 to give the area in acres.

The field closing sheets may be readily adapted to the calculation of areas by the method of double meridian distances; two examples follow:

594. Tabling and calculations of T. 15 N., R. 20 E., Diamond Rock, in Lins Lake, in section 18:

No.	Course,	Distance.	Latitudes.		Departures.		D.M.D.'s,	N. areas.	S. areas.	Totals.	
			North.	South.	East.	West.				Lat. N.	Dep. E.
Tie	N. 71° 30' E.	21.44	6.80	-----	20.33	-----	-----	-----	-----	6.80	20.33
5	S. 86° 46' E.	3.19	-----	0.18	3.18½	-----	4.73	-----	.85	6.62	23.52
4	N. 33° 00' E.	2.20	1.84½	-----	1.20	-----	9.12	16.83	-----	8.46½	24.72
3	N. 48° 30' W.	3.50	2.32	-----	-----	-----	2.62	7.70	17.86	10.78½	22.10
2	S. 61° 15' W.	2.90	-----	1.39½	-----	2.54	2.54	-----	3.54	9.39	19.56
1	S. 16° 30' E.	2.70	-----	2.59	-----	.77	.77	-----	1.99	6.80	20.33
			4.16½	4.16½	5.15½	5.16	-----	34.69	6.38	-----	-----
					-----	-----	-----	6.38	-----	-----	-----
		14.49	4.16½	4.16½	5.16	5.16	-----	28.31	Double area.	-----	-----

Begin total lats. and deps. at M. C. on W. bdy. sec. 19, for purposes of platting.	(1)	D.M.D's	0.77	9.12	(4)	14.15 Square chains.
			+ .77	+ 1.20		1.41 Acres.
			+ 3.19	- 2.62		
Numbering of courses as taken from field notes, order reversed to counterclockwise.	(5)		4.73	7.70	(3)	Begin D.M.D's at angle point of meanders farthest west, end of course No. 2 running SW., or end of course No. 1 running NW.
			+ 3.19	- 2.62		
			+ 1.20	- 2.54		
	(4)		9.12	2.54	(2)	

595. Tabling and calculations of T. 15 N., R. 20 E., right bank of Yellowstone River, in section 25:

No.	Course.	Distance.	Latitudes.		Departures.		D. M. D.'s.	N. areas.	S. areas.	Totals.	
			North.	South.	East.	West.				Lat. N.	Dep. E.
	S. 0° 01' E. . .	5.36		5.36	0.00		0.00			0.00	0.00
	S. 59° 56' E. . .	79.96		.09	+ .04		80.00	7.20		-.09	80.00
	North	23.20	23.20		79.96		160.00	3,712.00		23.11	80.00
				-.01							
1	S. 85° 00' W. . .	13.00		1.13		12.95	147.04		164.68	21.99	67.04
2	S. 72° 00' W. . .	7.10		2.19		6.75	127.33		278.85	19.80	60.29
				-.01							
3	S. 64° 30' W. . .	13.00		5.60		11.73	108.84		608.42	14.21	48.55
4	S. 40° 30' W. . .	5.40		4.11		3.51	93.59		384.65	10.10	45.04
				-.01							
5	S. 77° 45' W. . .	7.00		1.49		6.84	83.24		123.20	8.62	38.20
				+ .01							
6	N. 76° 00' W. . .	7.40		1.79		7.18	69.22	124.60		10.42	31.02
				-.01							
7	S. 80° 00' W. . .	12.00		2.08		11.82	50.22		103.96	8.35	19.20
				-.01							
8	S. 81° 08' W. . .	19.43		3.00		19.19	19.20		57.41	5.38	0.00
			24.99	25.05	79.96	79.97		3,836.60	1,728.37		
			+ .01	-.05	+ .04	+ .03		1,728.37			
		84.33	25.00	25.00	80.00	80.00		2,108.23	Double area.		

Begin traverse and D.M.D.'s at M. C. on W. bdy. of sec. 25.

Begin total lats. and deps. at point for S. 1/4 sec. cor. on W. bdy. of sec. 25, for purposes of platting.

Numbering of courses as taken from field notes.

1,054.11 Square chains.

105.41 Acres, sum of lots 5 to 8, incl.

Tabling and calculations of T. 15 N., R. 20 E., section 25,
lots 5 and 6:

No.	Course.	Dis- tance.	Latitudes.		Departures.		D.M.D's.	N.areas.	S.areas
			North.	South.	East.	West.			
	South.....	19.73		19.73					
	S. 89° 56' E.....	20.00		.02	20.00		20.00		0.40
	North.....	23.20	23.20				40.00	928.00	
1	S. 85° 00' W.....	13.00		1.12		12.96	27.04		30.28
2	S. 72° 00' W.....	7.10		2.19		6.75	7.33		16.05
3	S. 64° 30' W.....	.33		.14		.29	.29		.04
			23.20	23.20	20.00	20.00		928.00	46.77
								46.77	
								881.23	
								44.06	Lot 5.
	South.....	9.06		9.06					
	S. 89° 56' E.....	20.00		.02	20.00		20.00		0.40
	North.....	19.73	19.73				40.00	789.20	
3	S. 64° 30' W.....	12.67		6.45		11.45	28.55		155.60
4	S. 40° 30' W.....	5.40		4.11		3.51	13.59		55.85
5	S. 77° 45' W.....	5.16		1.09		5.04	5.04		5.49
			19.73	19.73	20.00	20.00		789.20	217.34
								217.34	
								571.86	
								28.59	Lot 6.

Tabling and calculations of T. 15 N., R. 20 E., section 25, lots 7 and 8:

No.	Course.	Dis- tance.	Latitudes.		Departures.		D.M.D.'s.	N.areas.	S.areas
			North.	South.	East.	West.			
5 6 7	S. 0° 01' E.....	8.51		8.51					
	S. 89° 56' E.....	20.00		.03	20.00		20.00		0.60
	North.....	9.06	9.06				40.00	362.40	
	S. 77° 45' W.....	1.84		.39		1.80	38.20		14.90
	N. 76° 00' W.....	7.40	1.80			7.18	29.22	52.60	
7	S. 80° 00' W.....	11.19		1.93		11.02	11.02		21.27
			10.86	10.86	20.00	20.00		415.00	36.77
								378.23	
								18.91	Lot 7.
7 8	S. 0° 01' E.....	5.36		5.36					
	S. 89° 56' E.....	20.00		.02	20.00		20.00		.40
	N. 0° 01' W.....	8.51	8.51				40.00	340.40	
	S. 80° 00' W.....	.81		.14		.80	39.20		5.49
	S. 81° 08' W.....	19.43		2.99		19.20	19.20		57.41
			8.51	8.51	20.00	20.00		340.40	63.30
								63.30	
								277.10	
								13.85	Lot 8.

INKING THE DRAWING.

596. The best *black* drawing ink should always be employed, and the ink should never be diluted. The drafting work should be sharp and clear, uniform in density of color, and the lettering standardized as to gage and style. It is important to bear in mind that if the drafting is done with a diluted ink or otherwise left gray in appearance, it will be lost in varying degrees during the process of reproduction.

597. The drafting work should be *open*, making reasonable allowance for needed separation of detail. This will help to avoid a tendency for work to close across narrow spaces during reproduction. Where necessary, the detail of improvements, works, or structures should be discontinued in order to avoid overlapping or obscuring the more essential features of the plat. The arrangement of some of the more minute data on the specimen township plat illustrates the minimum to which the work may be condensed safely. Attention is directed to the space allowed between the lettering and the adjacent lines;

this is never less than the space between the upper two points of the gage for the lettering; this is the rule where the drawing is to be reproduced at the same scale; proportionately more space should be allowed on special drawings where a reduction of scale is to be made on reproduction. The same safeguards should be applied in spacing the adjoining letters, and it will be noted that the spacing between letters bears a definite relation to the gage employed.

598. An experienced draftsman will endeavor to keep the drawing as clean as possible, so as to avoid needless erasing. A cover sheet, with an opening, is recommended. The sharp, black lines must be preserved in their original clear-cut effect, or else, unless carefully retouched, there will follow a certain loss in the process of reproduction.

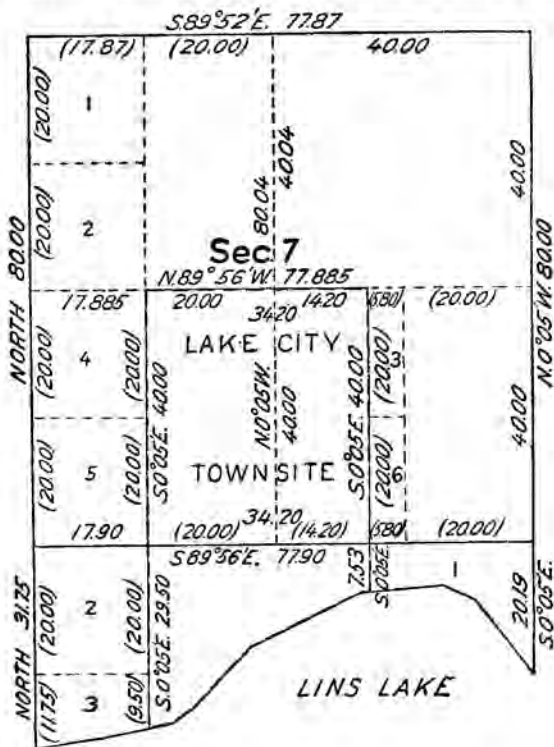
LETTERING.

599. All letters and figures are drafted in the pure Gothic, or simple block style. Sample alphabets and numbers, both vertical and slanting, capitals and lower case, are shown on Insert No. 3. In the smaller gages the letters and figures are drawn as single lines; it is ordinarily called single-stroke lettering. In the larger gages double parallel lines are required, usually made by single stroke, after which the form is filled in. The same gages and similar styles will be selected if lettering devices are employed.

600. The following outline shows the usual styles and gages; the gage refers to a drafting tool which bears the corresponding number:

Class.	Gage.	Style.
Title.....	60	Vertical, caps.
Sections.....	20	Vertical, cap. and l. c.
Total areas.....	15	Vertical.
Lot numbers and areas, usually.....	12	Do.
Proper names of land objects, towns, vil- lages, works, and structures, and tab- ular data.	20-10	Vertical, caps., or cap. and l. c.
Proper names of water areas and streams..	20-10	Slanting, caps., or cap. and l. c.
Directions and lengths of lines and other technical data.	15-10	Slanting, caps.
Explanatory notes, kinds of timber, des- tination of roads, and similar data.	15-10	Slanting, cap. and l. c.
Certificates.....	15	Do.

601. At this stage of the drafting work attention should be given to the showing of the directions and lengths of all necessary connecting lines, in addition to the data which ordinarily



Sec. 18

FIG. 81.—Boundaries of Lake City town site.

Additional sheets, drawn to a larger scale, are employed in order to show the detail of complicated situations.

appears on the section boundaries. The requirements are set out in sections 163, 190, 232, 233, and 254, Chapters III and IV. Additional sheets, drawn to a larger scale, are employed in order to show the detail of complicated situations.

TOPOGRAPHY.

602. Coming now to a consideration of the *map features* of the plat, it is thought best to point out first that generally only the most essential topographic data need be shown upon the plat. All classes of topography are encountered in practice. Some plats may not require the showing of any topography, others may require the showing of many different features, where the drawing in addition to being a plat may be a complete topographic map. Whatever may be the requirements of the situation, it is intended that the important map features be delineated by the standard symbols adopted by the Board of Surveys and Maps of the Federal Government. A summary of what is required is contained in section 236, Chapter III.

603. In the preparation of the drawing the first question to be considered, after the completion of the base and before adding the topography, is how the important map features are to be shown without obscuring the base data. In simple cases all work may be done readily in black ink on the base drawing. In the difficult cases several overprints in transparent colors will be required. Good judgment should be exercised regarding what is essential, and how the essential things may be shown without unwarranted cost.

604. If the situation requires a transparent overprint of a certain conventional color all of the group of map features which are usually shown in that color will be included. The specimen plat is intended as an example where all map features, with the exception of certain improvements, works, or structures are shown in conventional transparent overprints.

605. Where colors are not required, as in the more simple cases, all map features or groups of features will be delineated upon the base drawing in black ink, following the conventional symbols, and with the exercise of the greatest care that the map features do not interfere with or overlap, or too closely approach the base data. In all such simple cases the topography will be shown as in the following outline:

SIMPLE DRAWINGS, ALL BLACK.

Low relief	Black hachure.
Wagon roads and highways	Black lines, parallel.
Pack trail	Black line, broken.
Culture	Black pattern.
Alkali flats	Black depression-contour and pattern.
Sand dunes	Black pattern.
Water surface, large rivers and lakes	Black meander line, without water lines.
Minor drainage	Black line, or broken line and dots.
Ponds	Black pattern.
Marsh	Do.
Timber on level and gentle slopes	Do.

606. Where groups of important map features are extensive or complicated, or are of such a character that it is impracticable to execute the drawing in black without detriment to the base, transparent overprints will be employed as shown in the following outlines:

BROWN OVERPRINT.

Low relief where important, and all heavy relief	Brown hachure.
Wagon roads and highways	Brown lines, parallel.
Pack trail	Brown line, broken.
Culture	Brown pattern.
Alkali flats	Brown depression-con- tour and pattern.
Sand dunes	Brown pattern.

BLUE OVERPRINT.

Water surface, large rivers and lakes	Blue meander line and blue water lines.
Minor drainage	Blue line, or broken line and dots.
Ponds	Blue pattern.
Marsh	Do.

GREEN OVERPRINT.

Timber on level and gentle slopes.....	Green pattern.
Timber on steep slopes.....	Kind, lettered in black, or green pattern (to be transferred from a special overlay.) (See secs. 608, 609, 612, and 616.)

607. In making the drawing, where overprints are required, a separate sheet is employed, known as the overlay, upon which will be drawn in *black ink* all natural features which are to be shown by overprint. (See Insert No. 3.) It is important that this sheet be of the same quality, well-seasoned drawing paper as that used for the base, using the same exact scale and making provision for exact "register" when combined with the base drawing.

Before cutting large sheets of drawing paper the draftsman should mark parallel pencil lines on each unit to be cut, on the proper face, and thereafter execute all work on the face of the paper, and see that companion sheets are not turned at right angles. This will avoid much trouble in registration of companion sheets through unequal expansion or contraction due to moisture conditions or changes of temperature.

608. Usually it will be best to transfer the section boundaries accurately from the base drawing to the overlay, by carefully pricking through, then showing the lines in pencil only, excepting that for purposes of assembling the positions of a few section corners should be indicated by very short intersecting fine black lines. The township corners and the center point of the township will generally serve best for purposes of registration. Additional points may be employed if the work is complicated. The several groups of map features as may suit the situation will then be drawn on the overlay, all to be in black ink. Only a single overlay is required ordinarily as the several colors are separated in the process of reproduction.

609. On the specimen plat there has been no overlapping of natural features, and therefore no occasion for difficult separation of colors. It is recommended that this practice be observed generally. Ordinarily the important map features do not over-

lap, excepting timber and relief. Where both occur and both should be shown, the presence of the timber may be indicated by appropriate lettering, but this practice will not give the margin of the forested areas, so that if it is a matter of importance the color plan may be secured by the drafting on a second overlay, in black ink, of the appropriate timber pattern, with its true outline, this special sheet to furnish the green overprint.

610. Ordinarily, the hachure is utilized to show abrupt changes in elevation within level and gently rolling regions, such differences as the eye would quickly note on the ground and readily follow. The hachure is also employed to show all important mesas, peaks, ridges, spurs, and heavy slopes, in such a manner as to portray the bold relief without attempting to show unimportant and minor detail. Only the most important slopes will be shown in a gently rolling country, and care will be needed in drafting to avoid giving a rolling mountainous region the appearance of abrupt or high mountainous slopes.

611. The blue overprint is intended only where there are streams and lakes of major importance, or where the drainage features, if shown in black, would tend to obscure the base, as where there are numerous lakes and streams, or extensive ponds or marshes to be shown in areas of swamp and overflowed lands.

612. The green overprint is likewise intended for use only where numerous distinctions must be shown between forested and nonforested areas and where the cost of the overprint is justified, as in the case of important forest areas.

FIELD SKETCH.

613. Preference should be given to the use of form lines on the field sketch plat to show heavy relief. The form lines are intended to be approximate contours, but are largely sketched without an exact interval or precise elevation above sea level. The form lines carry a much better portrayal of heavy relief than can possibly be shown by the hachure alone, and readily indicate to the engineer and draftsman the position and outline of abrupt changes in slope and the extent of ascents and descents. The hachure is fundamentally dependent upon the approximate contour line for relative slopes and forms. All available data for elevation above sea level and extent of ascents

and descents along the surveyed lines may be incorporated in the form-line sketch. To most engineers after practice, the form lines are more readily, uniformly, and accurately secured than to draw the hachure initially on the field sketch without that guide. Where this is done the draftsman will transfer the form lines to the overlay, in pencil only, then supply the artistic hachuring to bring out the true forms.

614. A well-executed and reasonably accurate field sketch plat is a necessity, if the draftsman is to obtain a representative result, and the engineer is expected to exercise good judgment in doing what is required in the field. A choice of methods is available for ascertaining the map data within the interior of sections, to be accomplished always with regard for the practical value of the work for the purpose of the plat and the economic manner of obtaining the data. The crest or divide forms, slope forms, stream or drainage lines, and meander lines of the larger bodies of water, together constitute the natural skeleton of the map, and when carefully drawn may be readily and correctly interpreted.

615. The proper supervising officer will outline, in the special instructions for each survey, any exceptional methods which are to be employed in the field in the ascertainment of the topographic data, and how the data are to be shown upon the field sketch or map, particularly where the situation requires special consideration, and where it can be foreseen that one or more groups of map features so predominate the situation that overprints will be required on the completed plat, as heretofore described. The field sketch becomes the draftsman's guide, and together with the field notes, the record to be followed. It suffices to state that such record should be truly representative of the situation on the ground, with an accuracy in its various details which will reflect the practical relative importance.

616. Occasionally, in connection with resurveys, for example, the development of the map data of the region may even precede other parts of the survey work, for its great value in making restorations of lost or obliterated monuments, and for ascertaining the location of roads, improvements, and cultivated tracts upon patented and entered lands. Additional examples of the enlarged importance of the map features of the plat will be

found in certain classes of surveys within Indian and forest reservations, coal fields, mineral areas, water-power sites, reservoir sites, irrigation projects, and other regions of relatively large prospective value. In these cases, which frequently embrace regions of extremely bold relief, coordinated cadastral and topographic surveys are made if and when deemed to be advisable for administrative purposes. The relief is shown by brown contour lines, and the timber by green pattern, as conventional for topographic maps.

617. The names of natural features will be correctly given according to accepted usage. Engineers are not authorized to report names of their own selection, but in case of doubt will submit the question through official channels for reference to the United States Geographic Board.

TITLE.

618. Every plat will be given a title similar to that on the specimen plat. This shows the position, the principal meridian, and the State in which the township is located. Fractional portions of townships showing original subdivisional surveys may usually be given the same title without confusion, and it is usually desirable to do so in order to identify the plat in the simplest possible manner. Where supplemental plats and fragmentary subdivisional surveys are necessary, and for all resurvey plats, some appropriate subheading, to qualify the nature of the survey, is usually desirable. The subject is again referred to in section 668. The title and date of approval usually suffice to identify a plat; the subheading, if employed, will explain the special purpose of the plat.

TABULAR DATA.

619. The purpose of the tabular data shown on the specimen township plat is to consolidate the record of the subsisting surveys. The form may be modified to suit special requirements.

CERTIFICATES.

620. The administrative act of surveying the public lands is confided to the Commissioner of the General Land Office under the direction of the Secretary of the Interior. (R. S. 453; Manual, sec. 8, subsec. 32, Ch. I.) It is competent for the

commissioner, acting within this authority, to direct how surveys shall be made and plats constructed, and to require that both field notes and plats be subject to examination, approval, and acceptance.

621. All surveying returns are now prepared for the approval of the Supervisor of Surveys, and when so approved will be forwarded to the Commissioner of the General Land Office, for consideration and acceptance, when satisfactory. The administrative details of the technical examination of the work prior to the approval and acceptance of surveys are prescribed by departmental regulations. The forms of approval and acceptance are shown on the specimen township plat.

DISPOSITION OF THE ORIGINAL, DUPLICATE, AND TRIPLICATE PLATS, AND ADDITIONAL COPIES.

622. The usual practice, where no overprints are required, is to secure a photolithographic edition of the original plat, one copy of which is filed in the General Land Office as the official duplicate, and one transmitted to the proper United States district land office as the official triplicate. A small supply, printed on map paper, is held in the General Land Office for other official use and for sale to the public. Certified copies are secured from this source. The original plat is returned to the proper public survey office to be permanently filed with the field notes of the survey.

623. The original returns of current surveys within those States where the public survey offices have been discontinued are filed in the General Land Office. The duplicates of the plat and field notes of such surveys are furnished to the proper State office, noted in section 1, Chapter I.

624. In the types of plats where overprints are required, the certificates will be completed as usual on the base drawing. One photolithographic copy, with all map features supplied, will be taken from the press without the signatures. New autograph signatures will be made on this plat, which then becomes the official original. The base drawing and overlay, and a copy of each color overprint will be returned to the proper public survey office to be filed for such subsequent use as may be required.

SUPPLEMENTAL PLATS.

625. A supplemental plat is one designed to show a revised subdivision of one or more sections without change in the section boundaries, and usually without other modification of the original survey excepting where necessary for the segregation of lands to be eliminated.

626. A distinction is needed between plats designed to show a revised subdivision of certain sections and those required to show additional fragmentary areas that were omitted from the previously approved plats of the same fractional sections. Excluding now the plats which involve parts of sections that were not completed in the first instance, supplemental plats are most frequently required in order to show the segregation of mineral lands from adjoining agricultural lands, where the former are included in mineral claim surveys made subsequent to the original subdivision of the township, or where the mineral claims were overlooked at the time of the approval of the original township plat.

627. Similar supplemental plats are required for the lotting of public lands surrounding private claims of every description where the latter were not segregated at the time of the original subdivision of the public lands. Supplemental plats are frequently required for the segregation of forest homestead surveys, and also to facilitate allotments of Indian lands in small fractional units. Occasionally a supplemental plat is required for the entry of public lands where the original plat failed to provide units suitable for disposal, and in other cases where special laws or regulations permit the entry of public lands in fractional units not provided by the original plat.

628. All supplemental plats should show a proper reference to the original approved plat, the purpose of and the authority for its preparation, and all additional technical data, without unnecessary duplication of that carried by the original plat. It is usually desirable to furnish the directions and lengths of the section boundaries, and to show data derived by retracements. The scale of the supplemental plat may be enlarged to 20 or 10 chains to an inch as appropriate. The new fractional lots will

be numbered as required in sections 199 and 224, Chapter III, and proper quantities shown. No revision of the total area within the section is required, and there is generally no occasion for showing topography.

629. The computation of the areas of the several fractional lots will be based upon the subsisting record, including the data derived by retracements where field work is required. The results of the computations will ordinarily require some proportionate adjustment to secure a sum of the several parts within each original quarter-quarter section or fractional lot, equal to the area returned on the original plat. If the retracements show an excessive discrepancy in the record, as defined by section 661, the areas derived by exact calculation will be employed.

630. A few additional considerations will be applied to supplemental plats which are to show a segregation of mineral land. The revised lotting will be designed to accommodate only the pending entry, as there is generally no way of foreseeing the type of entry that may be made subsequently on the vacant areas. The lengths of lines given by the record of a mineral patent survey are in the foot unit; a conversion to the chain unit is required to the extent that the data are needed in the computation of areas to be shown on the supplemental plat. The equivalent distances will be shown to the nearest tenth of a link. The scale of the mineral segregation plat will be expressed in both units, but the values on the face of the drawing will be given in the chain unit only.

631. The authority for the preparation of supplemental plats issues only from the General Land Office and as may be necessary to accommodate pending entries. In every case the status of the surrounding subdivisions must be examined in the General Land Office and care exercised that no changes are contemplated which will affect any adjoining entry or patent. If additional field work is required, the public survey office will request authority to issue the usual special instructions.

632. The certificates of approval and acceptance will take the forms shown in the illustrations, modified as may be appropriate.

633. Illustration on opposite page.

A modified form of lotting to accommodate an unusual entry, based entirely upon the public land survey record on file in the public survey office, and without additional field work.

Title: Township No. 8 North, Range No. 20 West, of the San Bernardino Meridian, California. Supplemental Plat of Section 19.

Scale: 20 chains to an inch.

Certificates:

PUBLIC SURVEY OFFICE,

San Francisco, Calif., April 30, 1926.

The above supplemental plat of section 19, Township No. 8 North, Range No. 20 West, of the San Bernardino Meridian, California, based upon the plat approved October 8, 1880, showing a subdivision of original lots 3 and 4, to accommodate homestead entry Los Angeles 035503, prepared in accordance with instructions contained in the Commissioner's letter "E" dated April 20, 1926, is hereby approved.

(Signed)

Office Cadastral Engineer.

DEPARTMENT OF THE INTERIOR,

GENERAL LAND OFFICE,

Washington, D. C., May 14, 1926.

The amended lottings represented by this supplemental plat having been correctly made in accordance with the regulations of this office, the plat is hereby accepted.

(Signed)

Assistant Commissioner.

634. Illustration on opposite page.

A fractional lotting made subsequent to two forest homestead entry surveys, based entirely upon the public land and forest homestead entry survey records on file in the Washington office, and without additional field work.

Title: Township No. 5 South, Range No. 5 East, of the Black Hills Meridian, South Dakota. Supplemental Plat of Section 15.

Scale: 10 chains to an inch.

Certificate:

DEPARTMENT OF THE INTERIOR,

GENERAL LAND OFFICE,

Washington, D. C., November 23, 1926.

The above supplemental plat of section 15, Township No. 5 South, Range No. 5 East, of the Black Hills Meridian, South Dakota, based upon the plat approved May 23, 1899, showing lottings of fractional areas created by the segregation of forest homestead entry surveys Nos. 263 and 477, to accommodate additional homestead entry Pierre 024993, having been correctly prepared in accordance with the regulations of this office, is hereby approved.

(Signed)

Assistant Commissioner.

FIG. 82.—Explanation on opposite page.

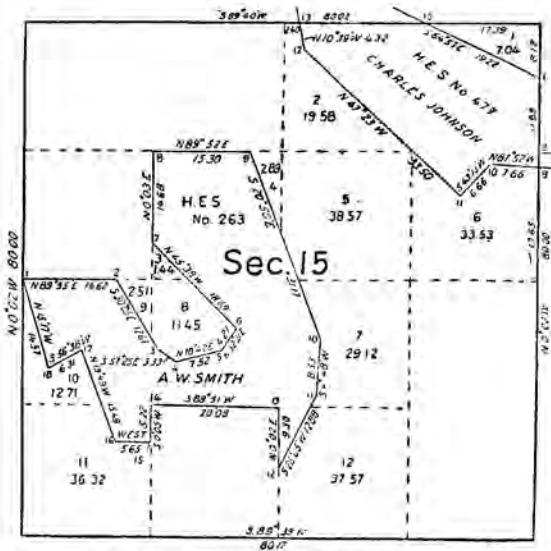
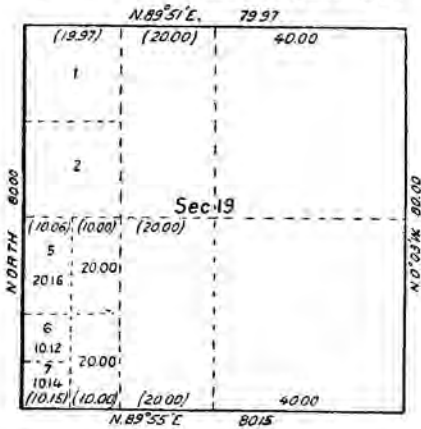


FIG. 83.—Explanation on opposite page.

635. Illustration on opposite page.

Segregation of patented mineral claims, based entirely upon the public land and mineral survey records on file in the public survey office, and without additional field work. The data shown along the boundaries of lots 2 and 3 are derived by calculation.

Showing one-half of original drawing.

Title: Township No. 13 South, Range No. 41 East, of the Willamette Meridian, Oregon. Supplemental Plat of Section 29.

Scale: 10 chains (or 660 feet) to an inch.

Certificates:

PUBLIC SURVEY OFFICE,
Portland, Oreg., December 6, 1926.

The above supplemental plat of section 29, Township No. 13 South, Range No. 41 East, of the Willamette Meridian, Oregon, based upon the plat approved December 13, 1871, showing lottings of fractional areas created by the segregation of the Red, White, and Blue; Red, White, and Blue No. 4; Belfast; and Champion lodes of mineral survey No. 759, to accommodate homestead entry Vale 08873, prepared in accordance with instructions contained in the Commissioner's letter "N" dated April 12, 1926, is hereby approved.

(Signed)

Office Cadastral Engineer.

DEPARTMENT OF THE INTERIOR,
GENERAL LAND OFFICE,
Washington, D. C., February 24, 1927.

The amended lottings represented by this supplemental plat having been correctly made in accordance with the regulations of this office, the plat is hereby accepted.

(Signed)

Assistant Commissioner.

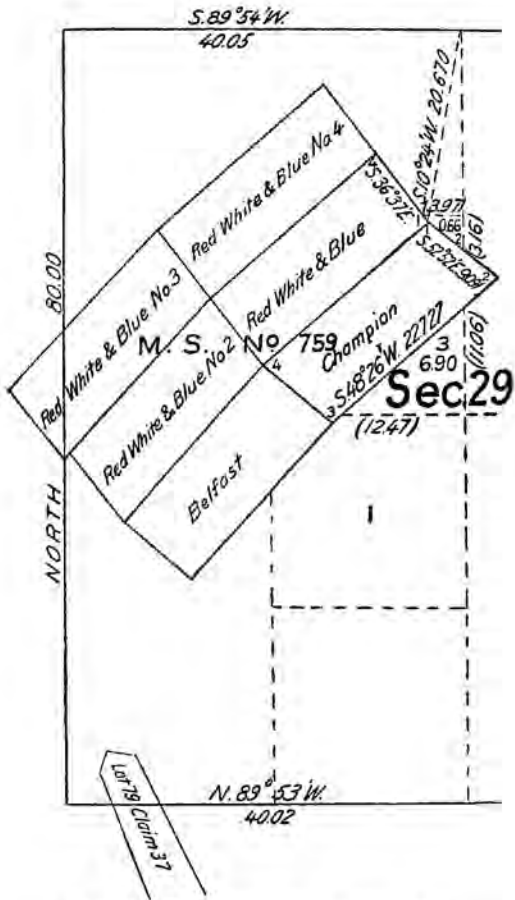


FIG. 84.—Explanation on opposite page.

636. Illustration on opposite page.

Elimination of unperfected mineral claims, based entirely upon the public land and mineral survey records on file in the public survey office, and without additional field work. This is an amendment of a prior supplemental plat. The claims shown invade original lots 1, 2, 3, and 4; the same numbers were employed on the supplemental plat approved February 6, 1904. Lots 5 to 11, inclusive, excepting lot 10, shown on the latter plat, *all vacant*, are consolidated in the amended lottings.

Showing one-half of original drawing.

Title: Township No. 14 South, Range No. 81 West, of the Sixth Principal Meridian, Colorado. Supplemental Plat of Section 31.

Scale: 10 chains (or 660 feet) to an inch.

Certificates:

OFFICE OF U. S. SUPERVISOR OF SURVEYS,
Denver, Colo., January 18, 1927.

The above supplemental plat of section 31, Township No. 14 South, Range No. 81 West, of the Sixth Principal Meridian, Colorado, based upon the plats approved August 22, 1882, and February 6, 1904, showing regular and fractional lottings restored to status of vacant public land, caused by the elimination of the unperfected Hillerton and Vanadium placer claims covered by mineral surveys Nos. 439 and 440, to accommodate forest homestead entry Glenwood Springs 026705, prepared in accordance with instructions contained in the Commissioner's letter "N" dated January 8, 1927, is hereby approved.

(Signed)

Administrative Cadastral Engineer.

DEPARTMENT OF THE INTERIOR,
GENERAL LAND OFFICE,
Washington, D. C., March 28, 1927.

The amended lottings represented by this supplemental plat having been correctly made in accordance with the regulations of this office, the plat is hereby accepted.

(Signed)

Assistant Commissioner.

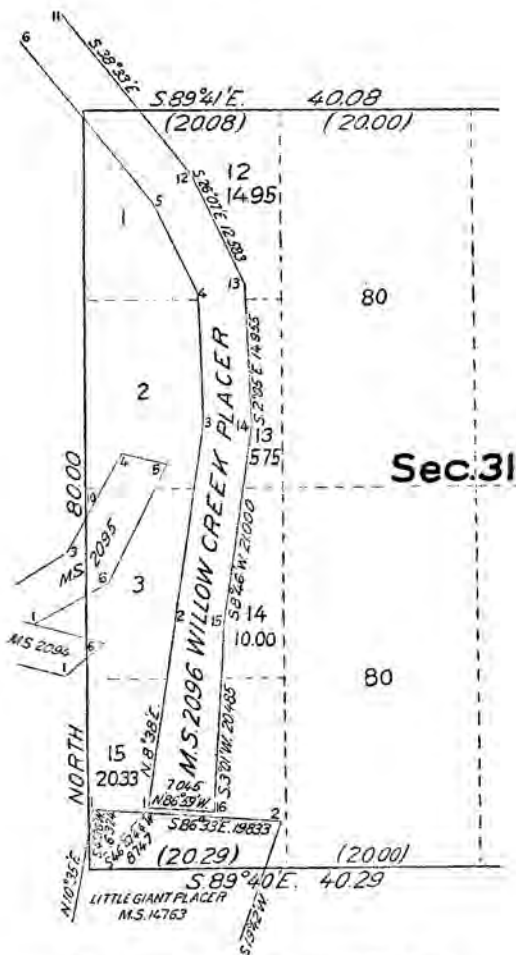


FIG. 85.—Explanation on opposite page.

637. Illustration on opposite page.

Segregation of patented mineral claim, including a retracement and remonumentation of the section boundaries. Field work required to secure connecting line from public land to mineral survey monument.

Showing one-half of original drawing.

Title: Township No. 20 South, Range No. 10 East, of the Gila and Salt River Meridian, Arizona. Supplemental Plat of Section 24.

Scale: 10 chains (or 660 feet) to an inch.

Record of subsisting surveys:

Dependent resurvey of the boundaries of section 24, and survey of connecting line to U. S. M. M., deriving lottings of fractional areas created by the segregation of the Lillie lode of mineral survey No. 562, to accommodate indemnity school selection Phoenix 039024, executed by Roger F. Wilson, United States Transitman, December 20 and 21, 1924, under special instructions dated June 19, 1924, for Group No. 133, authorized by the Commissioner's letter "E" dated March 8, 1924.

E. bdy. surveyed by Lewis Wolfley, D. S., in 1885, and subdivisional lines by G. J. Roskruge, D. S., in 1886, as shown upon the plat approved March 27, 1888.

Certificates:

OFFICE OF U. S. SUPERVISOR OF SURVEYS,
Denver, Colo., July 18, 1927.

The above supplemental plat of section 24, Township No. 20 South, Range No. 10 East, of the Gila and Salt River Meridian, Arizona, is strictly conformable to the field notes of the survey thereof which have been examined and approved.

(Signed)

U. S. Supervisor of Surveys.

DEPARTMENT OF THE INTERIOR,
GENERAL LAND OFFICE,
Washington, D. C., October 12, 1927.

The survey represented by this plat having been correctly executed in accordance with the requirements of law and the regulations of this office, is hereby accepted.

(Signed)

Assistant Commissioner.

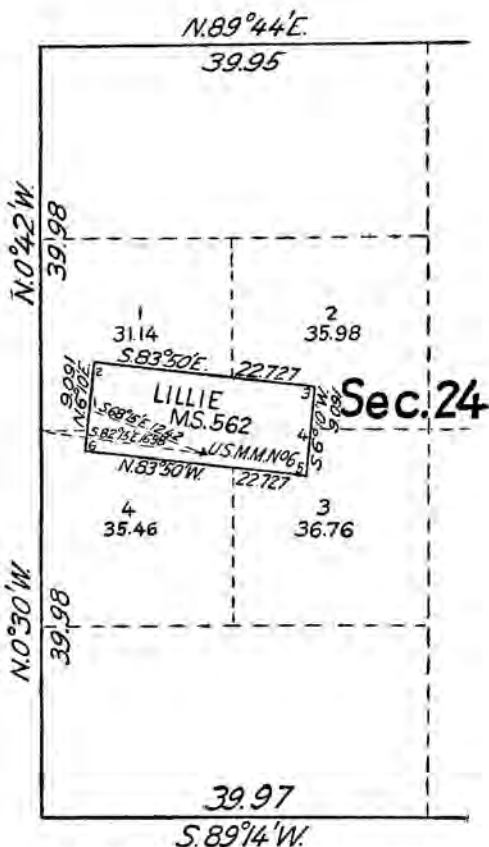


FIG. 86.—Explanation on opposite page.

638. Illustration on opposite page.

Metes-and-bounds survey of a body of land classified as mineral bearing, but not covered by a mineral patent survey, including a retracement and remonumentation of the section boundaries. As the retracement shows an excessive discrepancy in the record, the areas of lots 1 and 2, which are vacant, have been computed under the provisions of section 661.

Showing one-half of original drawing.

Title: Township No. 21 South, Range No. 70 West, of the Sixth Principal Meridian, Colorado. Supplemental Plat of Section 20.

Scale: 10 chains (or 660 feet) to an inch.

Record of subsisting surveys:

Dependent resurvey of the boundaries of section 20, with metes-and-bounds survey of land classified as mineral bearing, and connecting lines, deriving lottings of fractional areas of adjoining nonmineral land, to accommodate homestead entry Pueblo 044617, executed by Roy E. Chase, United States Cadastral Engineer, October 7 to 12, 1927, inclusive, under special instructions dated September 14, 1927, for Group No. 203, authorized by the Commissioner's letter "E" dated June 24, 1927.

Boundaries of section 20 surveyed by Albert W. Brewster, D. S., in 1879, as shown upon the plat approved October 23, 1879.

Certificates:

OFFICE OF UNITED STATES SUPERVISOR OF SURVEYS,
Denver, Colo., November 22, 1927.

The above supplemental plat of section 20, Township No. 21 South, Range No. 70 West, of the Sixth Principal Meridian, Colorado, is strictly conformable to the field notes of the survey thereof which have been examined and approved.

(Signed)

U. S. Supervisor of Surveys.

DEPARTMENT OF THE INTERIOR,
GENERAL LAND OFFICE,
Washington, D. C., December 7, 1927.

The survey represented by this plat having been correctly executed in accordance with the requirements of law and the regulations of this office, is hereby accepted.

(Signed)

Assistant Commissioner.

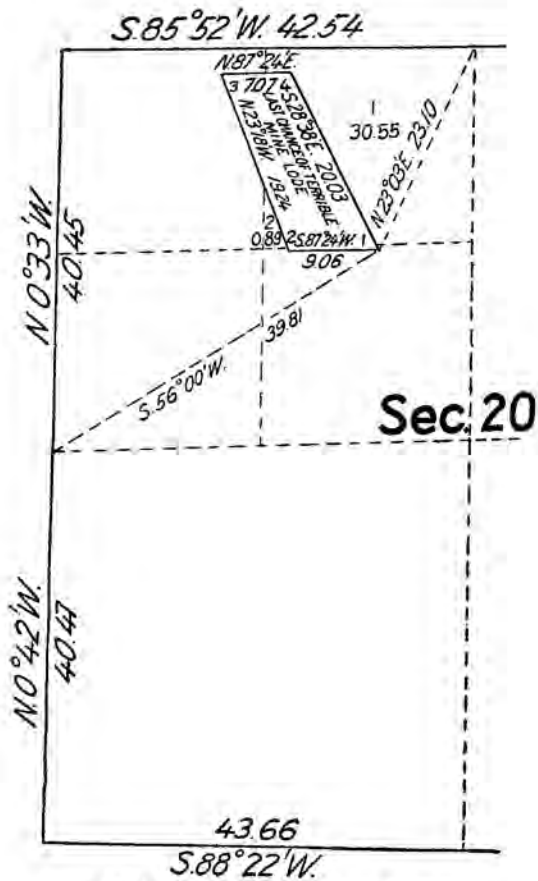


FIG. 87.—Explanation on opposite page.

PLATS OF FRAGMENTARY SURVEYS.

639. The term "fragmentary survey" may be appropriately applied to all surveys that are required to identify parts of sections that were not completed in the first instance. In this

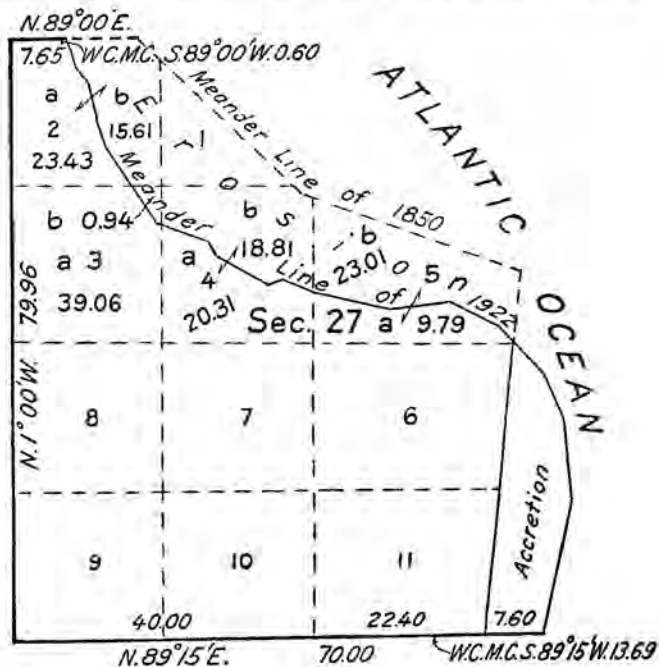


FIG. 88.

Representing fractional subdivisions as affected by erosion and accretion after survey, without introducing questions of riparian rights. The subdivisions affected are shown in two parts: "a" denoting land area and "b" water area; a proportional adjustment is made in the computation of the quantities, if necessary, in order to make the sum of "a" and "b" equal to the original total.

class may be included partially surveyed sections; omitted islands, if title is in the United States; such areas as lands in place at date of original subdivision situated between a grossly erroneous or fictitious meander line and the actual bank of a

stream or lake, where riparian rights do not obtain as under the usual doctrine; and other lands of substantial value and extent, which for various reasons were not included in the original surveys.

640. These types of surveys require departmental consideration on the questions of title involved and invariably require more or less of an extension of the former surveys. The unusual features of this class of field work, and the things to be considered in the preparation of the special instructions therefor, are properly the subject of Chapter VII.

641. In all such fragmentary surveys the new lottings are essentially in addition to but without changing the former subdivisions. The sum of the areas of the new lots in each section will be shown. The scale of the plats may be enlarged as appropriate.

642. A notable exception to the principle that no changes should be made in the former lottings is found in those cases which involve retracements or resurveys where *erosion* has occurred along the bank of a stream or lake or other body of water which substantially changes the configuration of the former lots, and where it may be desirable to show the quantity of land remaining and that destroyed. Similar problems in platting are found in those cases of erroneous meandering where the record position of the original meander line is found to fall within the body of water. In these cases the former lot boundaries where situated within the water area are indicated in light broken lines, and the quantities of each subdivision affected are shown in two parts: part "a" denoting land area and part "b" denoting water area; these areas are computed proportionately according to the amount shown for the original subdivision, the sum of "a" and "b" being made equal to the original total. A memorandum to this effect should appear upon the plat.

643. All technical data in reference to the retracement, reestablishment and extension of the section boundaries and connecting lines, and the complete topographical representation over the additional areas, will be shown upon the plats of fragmentary surveys. If the retracements and remonumentation assume the character of a dependent resurvey of the boundaries

of one or more sections, that fact will be indicated on the plat together with a proper showing of the important map data throughout the entire area surveyed and resurveyed. There will also be shown an appropriate reference to the former approved plats, and a citation of the departmental decision which authorized the extension survey.

644. The certificates of approval and acceptance on plats of fragmentary surveys will take the usual form; the necessary memorandum will be modeled after the examples given for the special cases already explained in Chapter VII.

RESURVEY PLATS.

645. A somewhat different type of plat is required for representing resurveys as defined in Chapter VI. In all cases where valid rights have been acquired based upon a prior subdivision, it is important that the plat of the resurvey clearly identify the lands so involved, and that the plat of the resurvey indicate the descriptions of such lands with reference to the former plat. The subdivision of the remaining public lands may or may not be modified, according to the type of resurvey.

646. A resurvey by the United States after the issuance of a patent does not affect the rights of the patentee under the former survey and plat. The United States, so long as it has not conveyed the title, may resurvey or reestablish boundaries. This is done as may appear necessary, but the resurvey can not affect the rights of owners situated outside of the boundaries of the public lands. The authority to make resurveys is subject to the necessary limitation that the courts may protect the private rights based upon the former survey and plat against interference by the corrective survey. The courts may properly take jurisdiction over matters of interference and hear disputes relating to the position of the former lines.

647. The peculiar requirements of the resurvey plat with respect to indicating the position of the alienated lands are set out in the memorandum forms which appear in sections 425, 448, 449, and 450, Chapter VI. It remains to be shown how the identification is to be accomplished in the case of tract segregations, as required in section 448, Chapter VI, but no new principles are involved.

648. The tract segregations will be laid out on the plats of resurveys as any private land claim would be shown upon an original plat, but in order to show the detail of complicated situations one or more additional sheets are frequently necessary. If a claim is found to be conformable as defined in section 445, fifth paragraph, Chapter VI, its boundaries may be shown by giving greater weight to such parts of the regular subdivision-of-section lines of the resurvey. In every case the outline of all tract segregations is to be shown on the first or principal sheet on the normal plan usually employed to show other types of private land claims.

649. On any of the several sheets as appropriate an index will be supplied to tabulate the description of each tract in terms of the original plat. The following index form is acceptable:

Index to segregated tracts.

Tract.		Original survey.			
No.	Entry and status.	Tp.	Rg.	Sec.	Subdvn.
39	Buffalo 2979. H. E. W. J. Williams. Patented.	58	75	29	NW $\frac{1}{4}$ NW $\frac{1}{4}$.
		58	75	29	S $\frac{1}{2}$ NW $\frac{1}{4}$.
		58	75	29	NW $\frac{1}{4}$ SW $\frac{1}{4}$.
41	Buffalo 1567. D. E. W. J. Williams. Pending.	58	75	20	SE $\frac{1}{4}$ SW $\frac{1}{4}$.
		58	75	20	W $\frac{1}{2}$ SE $\frac{1}{4}$.
		58	75	29	NE $\frac{1}{4}$ NW $\frac{1}{4}$.
77	Designated school section.	58	75	36	All.
95	Sundance 03186. D. E. C. R. Massey. Final certificate.	58	74	30	Lot 1.
		58	74	30	Lot 2.
101	Vacant.	58	75	24	Lot 4.
102	Vacant.	58	75	23	NE $\frac{1}{4}$ SE $\frac{1}{4}$.

650. In some cases there is a demand for the description of a tract in terms of its component parts as determined by the original survey; in these exceptional cases, and only as deemed to be appropriate, the several parts may be indicated by letters A, B, C, etc., with the index modified as follows:

Index to segregated tracts.

Tract.		Original survey.				Component parts.	
No.	Entry and status.	Tp.	Rg.	Sec.	Subdvn.	Sub-tract.	Area.
42	Buffalo 0833.	58	75	20	NE $\frac{1}{4}$ SE $\frac{1}{4}$.	B	40.00
	H. E.	58	75	21	Lot 4.	A	32.00
	Thomas R. Williams.	58	75	21	NW $\frac{1}{4}$ SW $\frac{1}{4}$.	C	40.00
	Pending.	58	75	21	SW $\frac{1}{4}$ SW $\frac{1}{4}$.	D	40.00
46	Buffalo 08642.	58	75	24	Lot 3.	A	28.12
	H. E.	58	75	24	NW $\frac{1}{4}$ SW $\frac{1}{4}$.	B	40.00
	Emmet Cain.	58	75	24	NE $\frac{1}{4}$ SW $\frac{1}{4}$.	C	40.00
	Pending.	58	75	24	SE $\frac{1}{4}$ SW $\frac{1}{4}$.	D	40.00

651. The above method is well adapted to the identification and subdivision of isolated tracts of public lands where said tracts have been surveyed by metes and bounds. In these cases the arrangement of the data carried by the index will be the same, and the status of the tract will be shown as vacant.

652. If there are one or more conformable claims to be identified by amended description in terms of the resurvey, without segregation by metes and bounds, another form of index will be required, as follows:

Index to appropriated subdivisions.

Tract.	Original survey.				Resurvey.			
	Entry and status.	Tp.	Rg.	Sec.	Subdvn.	Tp.	Rg.	Sec.
Buffalo 984. T. & S. Fred A. Jones. Pending.	45	79	12	NE $\frac{1}{4}$ SE $\frac{1}{4}$.	45	79	12	SW $\frac{1}{4}$ SE $\frac{1}{4}$.
	45	79	12	NW $\frac{1}{4}$ SE $\frac{1}{4}$.	45	79	12	SE $\frac{1}{4}$ SW $\frac{1}{4}$.
	45	79	12	NE $\frac{1}{4}$ SW $\frac{1}{4}$.	45	79	12	SW $\frac{1}{4}$ SW $\frac{1}{4}$.
Buffalo. I. S. S. List 6. Approved.	45	79	12	SE $\frac{1}{4}$ SE $\frac{1}{4}$.	45	79	13	NW $\frac{1}{4}$ NE $\frac{1}{4}$.

653. The several forms of index may be readily combined into one tabulation, if desirable, in which case it should be given

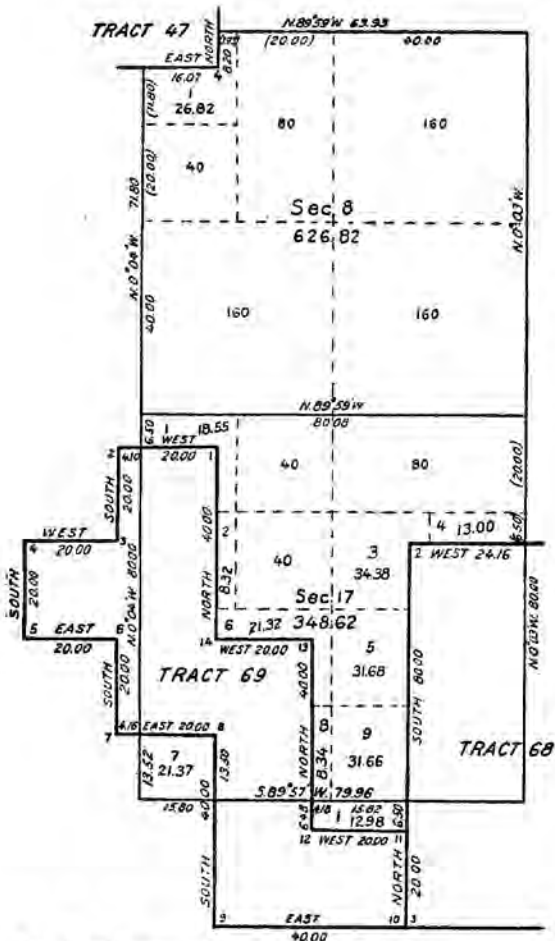


FIG. 89.—Normal tract segregations, with fractional lotting of the adjoining public land. The tract segregations will be laid out on the plats of resurveys as any private land claim would be shown upon an original plat.

a general title as *Index to Segregated Tracts and Appropriated Subdivisions*; the bracket for "component" parts may be filled in only as needed.

654. The special requirements for lotting fractional parts of sections that are invaded by tract segregations are set out in sections 456 and 457, Chapter VI, and are illustrated by the diagrams which accompany the text.

655. Occasionally there is a need for denoting the several parts of a tract in terms of quarter-quarter sections and fractional lots of the *resurvey*. This may be accomplished by protraction, showing lot numbers and areas as determined by the *resurvey*. The lottings within the tract should be made to complete the adjoining fractional quarter-quarter sections of the *resurvey*. This type of lotting requires no change in the index.

656. Where a tract is to be subdivided, preference will be given to the method best suited to the situation: (1) If it is deemed essential to perpetuate the units of the original survey then the lines of the quarter-quarter sections so established will be shown; but (2) in those cases of relinquishment or cancellation where it appears probable that any new entry will be coupled with adjoining lottings by the *resurvey* then a lotting within the segregated tract as determined by the section boundaries of the *resurvey* should be adopted. It may well be noted that in the great majority of cases the patent eventually issues in accordance with the original entry, and the necessity for the subdivision of segregated tracts is exceptional. If the circumstances indicate the necessity for the subdivision of a tract at the time of the preparation of the *resurvey* plat, the proper supervising officer will exercise judgment based upon the type of disposal and the purpose to be served, but where such necessity is not clearly apparent no subdivision of this nature will be made. A supplemental plat may be prepared at a later date to meet specific requirements.

657. If there are overlapping claims as defined in section 445, sixth paragraph, Chapter VI, the conflict will be indicated on the plat of the *resurvey*; the component parts will be protracted, but no new lot numbers will be assigned nor quantities shown within the segregated tracts that are involved in the conflict.

A memorandum will be added to the index as follows: *See field notes for the area of any part of a tract in conflict with another tract.* The uninvolved public land outside of the segregated tracts will be lotted regularly as heretofore provided.

658. No memorandum or other declaration will be inserted or shown upon a plat of a resurvey that can be construed as an adjudication of a settlement right, entry, or State selection or right under any grant *as to status* nor as an adjudication of a conflict, excepting as appropriate action on the case may have been taken prior to the date of the approval of the resurvey plat.

659. The usual technical data in reference to the direction and lengths of lines will be shown upon the plats of resurveys arranged on the several sheets as may be appropriate. The fractional distances along the section lines, the record intersections of the lines of the resurvey with the lines of claims, and the connecting distances to the angle points of the tract surveys will be shown in such a manner as to indicate the values employed in the computation of the areas of the public-land subdivisions. The lettering will follow the styles and gages shown upon the specimen township plat. The complete topographical representation will always be carried by the first or principal sheet. The section numbers will be carried on all of the sheets. The first or principal sheet of a series will carry a memorandum of the total number of sheets in that series.

660. On plats of independent resurveys the lot numbers and areas within the sections that are invaded by nonconformable tract segregations will usually be shown on the additional sheets, where such sheets are required, otherwise the lot numbers and areas will be shown on the first or principal sheet.

661. On plats of dependent resurveys the areas of the subdivisions are shown only in those exceptional cases where the differences between the actual quantity of the vacant subdivisions as found by resurvey and the former area as returned on the original approved plat are so great as to warrant revision. In that case the question of a revision should rest upon the element of *quantity* rather than upon that of *distortion*, and for practical purposes a variation of as much as 2.00 acres to the quarter-quarter section has been found advisable before

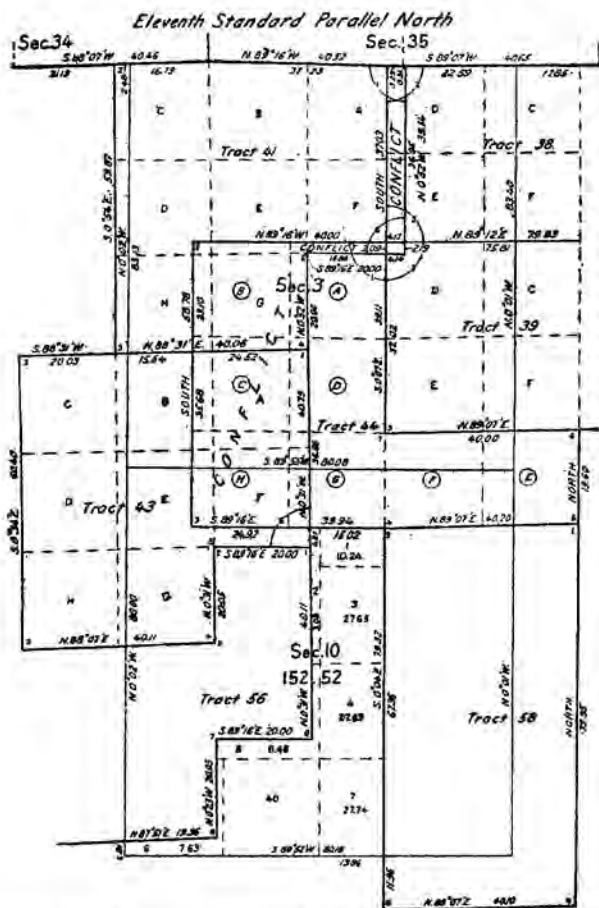


FIG. 90.—Tract segregations in conflict, but not an adequate basis for amendment of descriptions. If there are overlapping claims the conflict will be indicated on the plat of the resurvey.

making a change. If amendment is required, new lot numbers will be assigned to each vacant subdivision, and the total area within the section will be shown as the sum of the several lots as thus revised.

662. The total area shown within each independently resurveyed section, or within a dependently resurveyed section where revised lottings have been found necessary, will indicate the sum of the several parts which are to be identified for purposes of disposal by exclusive reference to the resurvey plat. In the tabular data to be supplied on the plat of a dependent resurvey, giving the area resurveyed, the number of acres will be the same as the total shown on the original plat, except as revised lottings have been required under the rule stated in section 661, in which case the total should reflect the proper amount of the increase or decrease. In the tabular data to be supplied on the plat of an independent resurvey, giving the area resurveyed, the number of acres will be shown in two parts: (1) Total area of tract segregations and conformed entries; and (2) total area subject to entry. If a tract overlaps a township boundary, only the part within the township will be counted in this total; and if there are conflicting tract segregations or conformed entries, the area in conflict will be counted once only.

663. The first or principal sheet of the plat of a resurvey will carry an appropriate memorandum of the authority upon which the resurvey was made; all of the sheets will show the usual forms of certificates of approval and acceptance.

664. Office instructions for the preparation of a supplemental plat will be issued subsequent to the adjudication of the rights involved within a conflict when required to facilitate an amendment of entry or patent. On the supplemental plat lot numbers will be assigned to the revised component parts of each adjudicated tract, serially within the sections of the resurvey, and areas shown, to afford descriptions that are conflict free. In these cases the supplemental plat will carry a revised index to the segregated tracts shown and a reference to the preceding plat. In the index the descriptions in terms of the original survey of those tract subdivisions that are found reduced by reason of the previous conflict will be omitted, and in the columns

of resurvey descriptions and areas of component parts will be substituted the appropriate section numbers, lot numbers, and areas of the reduced tract subdivisions that are conflict free.

665. The usual rules of field procedure will be observed in the protraction of the tract subdivisions—i. e., if by dependent resurvey, or where adequate control is shown in the record, the original sections will be subdivided regularly—but if by independent resurvey and limited control for the tract segregations, the points for all intermediate sixteenth-section, quarter-section, and section corners on the original tract boundaries will be determined by proportionate intervals between the established angle points, and the interior lines will be drawn to connect corresponding points on the opposite sides of the tract boundaries, fixing the corners of each component part by intersections. The areas to be computed will be based upon the data derived in the resurvey. If additional field work is required in order to supply data needed in the computations or otherwise, the public survey office will request authority to issue the usual special instructions.

666. The following table is a revised index conforming to Figure 91:

Index to segregated tracts.

No.	Tract.	Original survey.				Component parts. ¹		Resurvey.			
		Entry and status.	Tp.	Rg.	Sec.	Subdvn.	Sub-tract.	Area.	Tp.	Rg.	Sec.
38	Buffalo 010118.	44	80	1	Lot 4.	A	35.16				
	A. H. E.	44	80	1	SW $\frac{1}{4}$ NW $\frac{1}{4}$.	H	40.00				
	Ralph R. Baldwin.	44	80	2	Lot 1.	B	35.88				
	Pending.	44	80	2	Lot 2.	C	36.06				
		44	80	2	SW $\frac{1}{4}$ NE $\frac{1}{4}$.	F	40.00				
		44	80	2	SE $\frac{1}{4}$ NE $\frac{1}{4}$.	G	40.00				
							28.81	44	80	3	Lot 5.
						30.87	44	80	3	Lot 7.	
39	Buffalo 09382.	44	80	1	W $\frac{1}{2}$ SW $\frac{1}{4}$.						
	H. E.	44	80	2	SE $\frac{1}{4}$.						
	Ralph R. Baldwin.	44	80	2	E $\frac{1}{2}$ SW $\frac{1}{4}$.						
	Patented.										

¹ See sec. 650.

Index to segregated tracts—Continued

Tract.		Original survey.				Component parts.		Resurvey.			
No.	Entry and status.	Tp.	Rg.	Sec.	Subdvn.	Sub-tract.	Area.	Tp.	Rg.	Sec.	Subdvn.
41	Buffalo 09311.	44	80	3	Lot 1.	A	36.66				
	H. E.	44	80	3	Lot 2.	B	36.85				
	Henry J. Brun-	44	80	3	Lot 3.	C	37.00				
	ning.	44	80	3	SE $\frac{1}{4}$ NW $\frac{1}{4}$.	D	40.00				
	Pending.	44	80	3	SW $\frac{1}{4}$ NE $\frac{1}{4}$.	E	40.00				
		44	80	3	NW $\frac{1}{4}$ SE $\frac{1}{4}$.	G	40.00				
		44	80	3	NE $\frac{1}{4}$ SW $\frac{1}{4}$.	H	40.00				
							39.76	44	80	3	Lot 6.
43	Buffalo 011734.	44	80	3	SW $\frac{1}{4}$ SW $\frac{1}{4}$.	C	40.00				
	H. E.	44	80	10	NW $\frac{1}{4}$ NW $\frac{1}{4}$.	D	40.00				
	Perry Barnes.	44	80	10	SE $\frac{1}{4}$ NW $\frac{1}{4}$.	G	40.00				
	Pending.	44	80	10	SW $\frac{1}{4}$ NW $\frac{1}{4}$.	H	40.00				
							28.32	44	80	3	Lot 9.
							4.47	44	80	3	Lot 10.
							2.94	44	80	4	Lot 9.
							0.41	44	80	4	Lot 10.
44	Buffalo 07532.	44	80	10	NE $\frac{1}{4}$ NE $\frac{1}{4}$.	H	40.00				
	H. E.	44	80	11	NW $\frac{1}{4}$ NE $\frac{1}{4}$.	E	40.00				
	Antoine Faure.	44	80	11	NE $\frac{1}{4}$ NW $\frac{1}{4}$.	F	40.00				
	Pending.	44	80	11	NW $\frac{1}{4}$ NW $\frac{1}{4}$.	G	40.00				
							27.51	44	80	3	Lot 8.
							32.90	44	80	3	Lot 11.
							38.12	44	80	3	Lot 12.

667. A word of caution to the engineers and draftsmen who are engaged upon the platting of *resurveys* is needed in order to guard against a possible misinterpretation of the rules on that subject, to the effect that it is not expected that the different cases can all be brought into a similar treatment. The contributing factors to be dealt with appear in considerable variety, and the methods suited to those situations which may not be involved in a particular case should be promptly set aside, so as to avoid the introduction of unnecessary complications. The normal resurvey may be brought within a fairly definite, standardized drafting practice, but each unusual case

needs a special analysis with the purpose that the proper supervising officer may exercise discretion as to how the detail may be most suitably platted.

TITLE SUBHEADINGS.

668. The various types of special plats will be given the usual title by township, range, meridian, and State (gage 60), with appropriate subheading (gages 30-15) modeled after one of the following forms:

- (1) Supplemental Plat of Section 15.
- (2) Plat of Four Islands in Burntside Lake.
- (3) Plat of Fiddlers Island in Venice Bay.
- (4) Dependent Resurvey.
- (5) Independent Resurvey with Tract Segregations.
- (6) Independent Resurvey with Tract Segregations,
Sheet No. 2
- (7) Anastasia Island Lighthouse and Military Reservations,
Dependent Resurvey.
- (8) Dependent Resurvey and Extension of Lines Subdividing
Land Bordering Ferry Lake and James Bayou.
- (9) Dependent Resurvey and Extension of Lines Subdividing
the so-called Moon Lake.
- (10) Retracement and Extension of Lines Subdividing Accre-
tion Area Bordering Red River, Including Riverbed
Tracts.

CHAPTER X.

MINERAL SURVEYS.

APPOINTMENT OF MINERAL SURVEYORS.

669. There is set out in this chapter all matters relating to the duties of a United States mineral surveyor, and to the field and office procedure to be observed in the execution of mineral surveys and the filing of the returns.

670. The act of March 3, 1925, Manual, section 9, Chapter I, necessitated a detailed revision of the regulations governing the administration of mineral surveys, but the field operations are fixed by former legal requirements and long continued practice. A full statement of the administrative control of the general public land surveys, with citations of the authorities, is contained in Chapter I, and in section 1 there is a list of the several public survey offices. The citations which refer specifically to the making of mineral surveys will be found in the following sections, where closely related to the subject matter.

671. Under section 2334 of the Revised Statutes of the United States, as amended by the act of March 3, 1925, the United States Supervisor of Surveys may appoint as United States mineral surveyor, in each land district or State where mineral lands are located, as many competent surveyors as shall apply.

672. Application for appointment as United States mineral surveyor should be addressed to the public survey office in the district for which appointment is desired. An examination will be made there of the applicant's technical qualifications, and if found to be satisfactory, that office will forward the application to the chief of field division, General Land Office, for report regarding the applicant's general reputation and fitness for the position. If favorable, recommendation for appointment will be made to the supervisor of surveys, who will issue an appointment, addressing the same through the public survey office, and

calling upon the appointee to file the required bond (sec. 679). The bond will be forwarded to the supervisor of surveys for approval; the papers will then be forwarded to the Commissioner of the General Land Office for acceptance. Notice of the acceptance will be mailed to the public survey office, with copy to the supervisor of surveys, and the former will advise the mineral surveyor. In the event of adverse recommendation, the chief of field division will report direct to the General Land Office, and at the same time will notify the public survey office.

673. Mineral surveyors may, at the same time, hold appointments in more than one State or district. (20 L. D. 163.)

674. In the matter of reappointments, notice should be given the mineral surveyor 60 days prior to the expiration of his bond, with request that he signify his intentions regarding its renewal. If answered in the affirmative, the chief of field division will be called upon for the customary report. Favorable report will be followed by notice to file renewal bond, the approval and acceptance of which will follow the procedure for original bonds.

675. A biennial report will be submitted by each public survey office to the General Land Office on the sufficiency of the surety for each mineral surveyor on the roll for the district.

676. In case of failure to file renewal bond, or in the event of resignation or death, the name of the mineral surveyor will be dropped from the roll, and the General Land Office will be notified of the action through the office of the supervisor of surveys.

677. The supervisor of surveys has authority to suspend or revoke for cause the appointments of mineral surveyors, but the latter will be allowed the right of appeal. An appeal will be filed with the supervisor of surveys, who will at once transmit it, with a full report, to the General Land Office. (20 L. D. 283.)

678. The appointment of a mineral surveyor is not for any fixed period, the continuation thereof depending upon the character of the service. The supervisor of surveys will therefore not appoint mineral surveyors for a specified term. While under the act of March 2, 1895 (28 Stat. 807), mineral surveyors' bonds are examined every two years as to their suffi-

clency, and new bonds required every four years from the dates of their acceptance, the latter requirement is not because the term has then expired.

679. A mineral surveyor is not authorized to perform any work under his appointment until his official bond shall have been accepted by the Commissioner of the General Land Office. The bond shall be in the sum of \$5,000, and will become effective, and the liability of the principal and surety will begin with its acceptance by the Commissioner of the General Land Office.

680. Bonds can not be canceled, nor can the surety thereon withdraw so as to relieve the liability during the time the principal performs official duties thereunder. The most that may be done is to relieve the surety of future responsibility through formal notice from the Commissioner of the General Land Office of the acceptance of a new bond or of the resignation of the principal.

681. The claimant is required in all cases to make satisfactory arrangements with the mineral surveyor for the payment for his services; the United States will not be responsible for the settlement. Neither the supervisor of surveys nor the Commissioner of the General Land Office has jurisdiction in the settlement of differences relative to the payment of charges made by mineral surveyors. These are matters of private contract, to be enforced in the ordinary manner—i. e., in the local courts. The department has, however, authority to investigate allegations regarding the official actions of mineral surveyors, including combinations to fix prices for survey work, and on sufficient showing of cause will suspend or revoke an appointment.

682. A mineral surveyor is precluded from acting, either directly or indirectly, as attorney in mineral claims. His duty in any particular case ceases when he has executed the survey and returned the field notes and preliminary plat with report to the public survey office, but he may be called upon to verify, or correct if necessary, any part of the field work or the record thereof, pending the approval of the survey. He will not be allowed to prepare for the mineral claimant application papers for patent or otherwise perform the duties of an attorney before the district land office.

683. The mineral surveyor will be held to a strict accountability for the faithful discharge of his duties, and will be required to observe fully the requirements and regulations in force affecting mineral surveys. If found incompetent, careless in the discharge of his duties, or willfully guilty of a violation of the regulations, his appointment will be subject to revocation.

684. A mineral surveyor is within the purview of section 452, Revised Statutes, which prohibits officers, clerks, and employees of the General Land Office from directly or indirectly purchasing or becoming interested in the purchase of any of the public lands, upon penalty of forfeiture of official position. (36 L. D. 61.)

GENERAL INSTRUCTIONS.

685. No return by a mineral surveyor will be recognized as official unless it is over his signature as a United States mineral surveyor and made in pursuance of a special order from the proper public survey office. After he has received an order, he is required to make the survey and return the prescribed field notes and preliminary plat thereof without undue delay.

686. Application for the survey of a mining claim, accompanied by a certified copy of the location certificate and requisite deposit of the estimated cost of the office work (sec. 687) should be made to the public survey office for the district in which the claim is located. This office will receipt for the deposit, issue an order for the survey, if appropriate, administer all office work in connection therewith, approving plat and field notes of such survey, and otherwise perform the duties prescribed by the mining regulations, including certification as to expenditure made upon the claim.

687. The public survey office will furnish the applicant an estimate of the cost of the final platting and other office work in connection with the survey, and the applicant will forward this amount in the form of cash, money order, or certified check, for which receipt will issue. Office work will be charged at actual cost, and if the original deposit is found insufficient a further deposit will be called for, or if found excessive or the survey abandoned before approval, a refund of the unearned

amount may be obtained. The claimant will be notified of any excess amount upon the approval or abandonment of the survey, and blank application for refund will be furnished.

688. A mineral surveyor should not combine the duties of surveyor and notary public in the same case by administering oaths to the parties in interest. It is preferable that the oaths of his field assistants be taken before some officer duly authorized to administer oaths. In cases, however, where great delay, expense, or inconvenience would result from a strict compliance with this rule, the mineral surveyor is authorized to administer the necessary oaths to his assistants, but where this is done he will submit a full written report of the circumstances which required this action; otherwise he is required to have nothing to do with a case except in his official capacity as a mineral surveyor.

689. Claimants, their attorneys, or parties in interest are not to be employed as assistants in making mineral surveys.

690. All lengths of lines are to be returned as their true horizontal equivalents in the foot unit, as determined by the general methods of measurement prescribed in sections 16, 17, 35, 36, and 37, Chapter II. The high degree of accuracy required in the making of mineral surveys calls for careful steel-tape measurements; and if needed in order to secure acceptable results, a spring balance may be used and temperature corrections applied.

691. All mineral surveys are to be made with an instrument by which the meridian may be determined independently of the magnetic needle, and the directions of all lines are to be referred to the true meridian. An engineer's transit with or without a solar attachment may be employed and any method described in Chapter II may be used. The true course of at least one line of each survey is to be ascertained at the time of the survey by observation either upon the sun or Polaris by one of the methods given in sections 84 to 124, inclusive, Chapter II, with proper verification of the time and latitude; the methods so employed and the results will be recorded in the field notes of the survey.

692. The magnetic variation is to be noted at each corner of the survey; if it is the same at the several corners one state-

ment to this effect, and the value of the declination will be given in the field notes. The variation will be noted and recorded at each corner of the survey where differences are found.

REQUIREMENTS OF FIELD WORK.

693. The term "survey" as here employed includes the usual technical procedure, and also all examinations required for the preparation of the affidavits of an expenditure of \$500 for development purposes, descriptive reports on placer claims, and any other reports to be made by the mineral surveyor.

694. In every case the survey made and reported is to be an actual survey on the ground in full detail, made by the mineral surveyor in person after the receipt of the order, and without reference to any knowledge he may have previously acquired by reason of having made the location survey or otherwise, and the record will show the actual facts existing at the time. This precludes a calculation of the connections to corners of the public survey and to mineral monuments, or of any other lines of the survey, through prior surveys, unless it is satisfactorily shown in his report that he has retraced such lines and found them to be correct. (6 L. D. 718; 7 L. D. 81.)

695. The survey of a mining claim may include several contiguous locations owned in common, but in conformity with statutory requirements such survey record will distinguish the several locations and exhibit the boundaries of each. (5 L. D. 199; 6 L. D. 808; 20 L. D. 585.)

696. The survey will be made in strict conformity with, or be embraced within, the lines of the location upon which the order is based. If the survey and location are identical that fact will be clearly stated in the field notes. If not identical, a bearing and distance will be given from each established corner of the survey to the corresponding corner of the location. The lines of the location as found upon the ground will be laid down upon the preliminary plat in such manner as to contrast and show their relation to the lines of survey. (1 L. D. 581.)

697. The survey will be given but one number. A location under the mining laws can legally be made only of a tract or piece of land embraced within one set of boundary lines; and

two or more tracts merely cornering with each other can not legally be embraced in a single location. (33 L. D. 560; 35 L. D. 485.)

698. In accordance with the principle that courses and distances must give way when in conflict with fixed objects and monuments, the mineral surveyor will not under any circumstances change the corners of the location for the purpose of making them conform to the description in the record. If the difference from the location certificate is slight, it may be explained in the field notes, as indicated in the specimen field notes.

699. The act of Congress of May 10, 1872, expressly provides that "the location must be distinctly marked upon the ground so that its boundaries can be readily traced," and "that all records of mining claims hereafter made shall contain the name or names of the locators, the date of the location, and such a description of the claim or claims located, by reference to some natural object or permanent monument, as will identify the claim." (R. S. 2324.)

700. A single discovery working can not support more than one location. (16 L. D. 1.)

701. These provisions of law must be strictly complied with in each case to entitle the claimant to a survey and patent, and should a claimant under a location made subsequent to the passage of the act of May 10, 1872, who has not complied with said requirements in regard to marking the location upon the ground and recording the location certificate, apply for a survey, the mineral surveyor will decline to make it. (1 L. D. 581.) He will report the facts to the public survey office and await further instructions.

702. If after having obtained an order for survey the applicant should find that the record of location does not practically describe the location as staked upon the ground, he should file a certified copy of an amended location certificate, correctly describing the claim, and obtain an amended order for survey.

703. Should the survey be applied for under a location made prior to May 10, 1872 (R. S. 2332), the mineral surveyor will be governed by the special instructions accompanying the order for survey.

704. No mining claim located subsequent to May 10, 1872, should exceed the statutory limit in width on each side of the center of the vein, or 1,500 feet in length. All surveys must close within 0.50 feet in 1,000 feet, and the error must not be such as to make the claim exceed the statutory limit. In the absence of proof to the contrary, the discovery point is held to be the center of the vein on the surface. The course and length of the lode line or presumed course of the vein should be marked upon the plat and specifically described in the field notes.

LODE LINE AND END LINES.

705. It was held in 35 Land Decisions, 22 (syllabus), that—

There is no warrant in the mining laws for extending, arbitrarily and without any basis of fact therefor, the vein or lode line of a location in an irregular and zigzag manner for the purpose of controlling the length or situation of the exterior lines of the location to suit the convenience, real or imagined, of the locator.

The end lines of a lode location must be straight and parallel to each other and when at right angles with the side lines may not exceed 600 feet in length.

The mining laws contemplate that the end lines of a lode claim shall have substantial existence in fact, and in length shall reasonably comport with the width of the claim as located.

METHOD AND ORDER OF PROCEDURE.

706. In making the official survey, corner No. 1 of each location embraced in the claim will be established at the angle nearest the public survey corner or mineral monument to which connection is made. If connection is made both to a corner of the public survey and to a mineral monument, corner No. 1 should be placed nearest the corner of the public survey.

707. Connect corner No. 1 of each location by course and distance with the nearest corner of the public survey or with a United States mineral monument if the claim lies within 2 miles of such corner or monument. If both are within the required distance, it will be connected with the nearest corner of the public survey. (7 L. D. 475; par. 135, Mining Circular, April 11, 1922.)

708. When the corner tied to is not the nearest *record* corner, a statement should be made that it is the nearest or most accessible corner that could be found after diligent search.

709. When a mining claim is situated within the limits of a township the survey of which is in good standing, but where no corner of the survey can be found within 2 miles of the claim, after diligent search, connection may be made with a mineral monument, which in turn will be connected with an established public survey corner.

710. From corner No. 1 the successive boundaries of each location will be run in regular manner, numbering the remaining corners in consecutive order.

711. A lode and a mill site embraced in one survey will be distinguished by the letters A and B, respectively, following the number of the survey. The corners of the mill site will be numbered independently of those of the lode. Corner No. 1 of the mill site will be connected with a corner of the lode claim as well as with a corner of the public survey or mineral monument.

712. When a placer claim includes lodes, or when several contiguous placer or lode locations are included as one claim in one survey, the corners of each location will be given a separate consecutive numerical designation, beginning with corner No. 1 in each case. In the former case, describe the placer claim first in the field notes.

CONFLICTS.

713. When the exterior lines of a claim conflict with the survey of another claim, the distances to the points of intersection and the courses and distances along the line intersected from an established corner of such conflicting claim to such points of intersection should be reported in the field notes: *Provided*, That where a corner of the conflicting survey falls within the claim being surveyed, this corner should be selected from which to give the tie. When the same line of a conflict is intersected by two lines of the survey, the tie will be given from the same corner of the conflicting survey at both intersections.

714. When the lines of two locations of the survey intersect, only the point of intersection will be given on the line being described.

715. Conflicts with unsurveyed locations will not be reported unless excluded from the net area claimed.

716. Surveyed claims owned by the applicant, in conflict with or contiguous to the survey, will be reported in the field notes.

717. A connecting line should be run from some corner of the survey to a corner of each conflicting survey, also to a corner of each conflicting unsurveyed location that is to be excluded.

718. Connection will also be given to any survey, the record position of which is within 100 feet of the lines of the survey being executed; also to any other neighboring survey, the location of which is not definitely fixed by the record. Such connections will be made and conflicts shown according to the boundaries of the neighboring or conflicting claims as each is marked, defined, and actually established upon the ground. The field notes will fully and specifically state how and by what visible evidence the several conflicting surveys were identified on the ground, as well as those which appear to conflict, according to their returned tie or boundary lines, and report all material errors or discrepancies found in such surveys. In the survey of a group of contiguous claims where any corners are common to two or more claims of the group, bearings should be mentioned but once and the corner described as a common corner in the claim first mentioned in the field notes.

MINERAL MONUMENTS.

719. When a survey is situated in a district where there are no corners of the public survey and no other monuments within 2 miles, a mineral monument will be established. The site, when practicable, should be some prominent point, giving good visibility from every direction, and the site should be so chosen that the permanency of the monument will not be endangered by snow, rock, or land movements or other natural causes. Its position with reference to latitude and longitude should be recorded as accurately as the known data and the instruments used will afford.

720. The monument should consist of a stone not less than 30 inches long, 20 inches wide, and 6 inches thick, set two-thirds in the ground, with a conical mound of stone 4 feet high and 6 feet base alongside. The letters "U S M M" followed by the number of the survey in connection with which it is established will be plainly chiseled upon the stone. The exact reference point

will be indicated on the monument by a cross (x) chiseled on the top. Any necessary departure from the prescribed material and size of monument is to be explained.

721. From the monument the precise course and distance will be taken to two or more bearing trees or rocks, and to any well-known and permanent objects in the vicinity, such as buildings, shafts, mouths of adits, prominent rocks, or the confluence of streams. Bearing trees will be properly scribed "B T" and the bearing rocks chiseled "B R" together with the number of the mineral monument; the exact point on the tree or stone to which connection is made to be indicated by a cross or other unmistakable mark. Bearings should also be taken to prominent mountain peaks, and the approximate distance and direction ascertained to the nearest town or mining camp. A detailed description of the mineral monument, with a topographic map of its location, will be furnished.

CORNER MONUMENTS.

722. Corner monuments may consist of the following material, given in the order of preference:

(A) Tubular iron posts with flaring base, cement core, and brass cap for marking with steel dies, of the type adopted for public land surveys;

(B) A stone at least 24 inches long, set 16 inches in the ground, with a conical mound of stone, $1\frac{1}{2}$ feet high, 2 feet base, alongside; or,

(C) A rock in place.

If none of the foregoing material is available, a concrete post, 24 inches long, 6 inches square, set 16 inches in the ground, or hardwood post at least 3 feet long by 4 inches square, set 24 inches in the ground, and surrounded by a substantial mound of stone or earth, may be used. Should it become necessary to vary from these instructions, the returns will contain a full statement of the reason therefor.

723. All corners will be established in a permanent and workmanlike manner, and the distinguishing initial letter or letters, corner, and survey numbers will be neatly chiseled or scribed on the side facing the claim. The precise corner point will be permanently indicated on the monument. When a rock in place

is used, its dimensions above ground will be stated, and a cross chiseled at the exact corner point. Corners common to two or more locations will bear the initial letter and corner number of each location.

724. In case the point for the corner is inaccessible or unsuitable, a witness corner will be established, which will bear the letters "W C" in addition to the regular markings. When practicable the witness corner should be located upon a line of the survey and as near as possible to the true corner point, with which it must be connected by course and distance. The reason for the establishment of a witness corner will be stated in the field notes.

725. The position of all corners should be recorded by course and distance to bearing trees, rocks, and other permanent objects, as prescribed in the establishment of mineral monuments, and when no objects are available the field notes should so state.

TOPOGRAPHY.

726. Note carefully all topographic features of the claim, taking distances on the lines to intersections with all streams, gulches, ditches, ravines, mountain ridges, roads, trails, etc., with their widths, courses, and other data that may be required for mapping purposes. If the claim is situated within a town site, all important municipal improvements, and the street and block system, will be located for mapping purposes.

FIELD NOTES.

727. Field notes and other reports must be typewritten in black-record ink, and upon the proper blanks, which will be furnished by the public survey office upon application. No interlineations or erasures are permissible, and no abbreviations or symbols may be used excepting those shown in section 550, Chapter VIII, and as employed in the specimen field notes, appendix, page 517.

728. The mineral surveyor will prepare and file a preliminary plat on tracing cloth, drawn on a scale of 200 feet to an inch, if practicable, in conformity with the specimen plat herewith, the lines of the claim surveyed being shown heavier in contrast

with conflicting claims. A copy of such calculations of areas as are made by double meridian distances and of all triangulations or traverse lines will also be furnished.

729. In order that the results of the survey may be reported in a uniform manner, the field notes and preliminary plat will be prepared in strict conformity with the specimen field notes and plat, which are made part of these instructions. They are designed to furnish all needed information concerning the manner of describing the boundaries, corners, lode lines, connections, intersections, conflicts, and improvements, and of stating the magnetic variation, area, location, and other data connected with the survey of mineral claims, and to prescribe certain forms of affidavits for the surveyor and his assistants.

730. Throughout the description of the survey, after each reference to the lines or corners of a location, give the name thereof, and if unsurveyed state the fact. If reference is made to a location included in a prior official survey, the survey number will be given, followed by the name of the location.

731. The total area of each location in a group embraced by its exterior boundaries, and also the area in conflict with each intersecting survey or claim, should be stated. When locations of the survey conflict with each other, such conflicts should be stated only in connection with the location from which the conflicting area is excluded.

732. The field notes and plat of survey should not show exclusions, or attempt to specify the net area of the claim. These are matters for the applicant to state in connection with his application for patent, and the notices posted and published. The field notes should merely show the total and net areas of conflict, so that any exclusion desired may be readily made.

733. If any prior conflicting survey is not to be excluded by the claimant in his application for patent, the fact should be stated in a separate report filed with the survey returns, so that the statement of area can be properly examined.

734. The field notes should state specifically whether the claim is upon surveyed or unsurveyed public lands, giving in the former case the quarter section, township, and range in which it is located, and in the latter the township and range as

nearly as can be determined by the information at hand. When upon surveyed lands, the section boundaries should be indicated by full lines and quarter sections by broken lines.

735. The title-page should contain the post-office address of the claimant or his authorized agent.

IMPROVEMENTS.

736. In Revised Statutes, 2325, it is directed that at least \$500 shall be expended upon a mineral claim as a prerequisite to patent.

737. In preparing the certificate of the value of the improvements, the form shown in the specimen field notes will be followed.

738. Only actual expenditures and mining improvements made by the claimant or his grantors, having a direct relation to the development of the claim, are to be included in the estimate. Labor or improvements, within the meaning of the statute, are deemed to have been had on a mining claim, whether it consists of one location or several, when the labor is performed or the improvements are made for its development—that is, to facilitate the extraction of the metals it may contain. (6 L. D. 222.)

739. The expenditures required may be made on the surface or in running a tunnel, drifts, or crosscuts for the development of the claim. Improvements of any other character, such as buildings, machinery, or roadways, will be excluded from the estimate unless it is clearly shown that they are associated with actual excavations, such as cuts, tunnels, and shafts, and are essential to the practical development and to actually facilitate the extraction of mineral. Mills for ore treatment, or roadways, tramways, or trails built for transporting the extracted ore from the mine, are not to be included.

740. All mining and other improvements on the claim will be located by course and distance from corners of the survey, or from points on the indicated lode line, specifying with particularity the dimensions and character of each. The improvements upon each location should be numbered consecutively, the point of discovery always being No. 1. Improvements made by a former locator who has abandoned his claim are not to be included in the estimate, but should be described by separate statement in the field notes and shown on the plat.

741. The field notes will show in detail the value of each mining improvement included in the estimate of expenditures, and when a tunnel or other improvement has been made for the development of other claims in connection with the one for which survey is made, the name, ownership, and survey number, if any, of each claim to be credited, and the value of the interest credited to each will be stated.

742. When a lode and mill site are included in the same survey, an expenditure of \$500 is required upon the lode claim only.

743. When a survey embraces several locations held in common, constituting one entire claim whether lode or placer, an expenditure of \$500 for each location embraced in the group will be required.

744. It is held in 35 Land Decisions, 361 (syllabus), that—

Where several contiguous mining claims are held in common and expenditures are made upon an improvement intended to aid in the common development of all of the claims so held, and which is of such character as to redound to the benefit of all, such improvement is properly called a common improvement.

Each of a group of contiguous mining claims held in common and developed by a common improvement has an equal, undivided interest in such improvement, which is to be determined by a calculation based upon the number of claims in the group and the value of the common improvement.

There is no authority in law for an unequal assignment of credits out of the cost of an improvement made for the common benefit of a number of mining claims, or the apportionment of a physical segment of an improvement of that character to any particular claim or claims of the number, such an arbitrary judgment of credits as the exigencies of the case may seem to require being utterly at variance with the essential idea inherent in the term "a common improvement."

In any patent proceedings where a part of a group of mining claims is applied for and reliance is had upon a common improvement, the land department should be fully advised as to the total number of claims embraced in the group, as to their ownership, and as to their relative situations, properly delineated upon an authenticated map or diagram. Such information should always be furnished in connection with the first proceeding involving an application of credit from the common improvement, and should be referred to and properly supplemented in each subsequent patent application in which a like credit is sought to be applied.

745. It is also held in 36 Land Decisions, 551 (syllabus), that—

A common improvement or system, offered for patent purposes, although of sufficient aggregate value and of the prerequisite benefit to all the mining claims of a group, can not be accepted as it then stands in full satisfaction of the statutory requirement as to such of the claims the location of which it preceded, the law requiring that an expenditure of at least \$500 shall succeed the location of every claim.

If the requisite benefit to the group is shown, or to the extent of such of the claims as are so benefited, and the elements of contiguity and common interest in the claims concerned appear; if the improvement represents a total value sufficient for patent purposes for the number of claims so involved; if for each claim located after the partial construction of the improvement the latter has been subsequently extended so as to represent an added value of not less than \$500, each is entitled under the law to a share of the value of the common improvement in its entirety, no claim receiving more or less than another from that source, participating therein without distinction or difference, and as to each the statutory requirement is satisfied.

746. The explanatory statement in such cases should be given in the field notes or affidavit at the conclusion of the description of the improvements included in the estimate of expenditure, and should be as full and explicit as the facts in the case warrant, dealing only with improvements, conditions, and circumstances as they actually existed at the time of survey or examination.

747. If the value of the labor and improvements upon a mineral claim is less than \$500 at the time of survey, authority is given to file thereafter supplemental proof showing \$500 expenditure made prior to the expiration of the period of publication. The information on which to base this proof must be derived by the mineral surveyor, who makes the actual survey, from a careful examination upon the premises.

748. Only improvements made by the claimant or his grantors subsequent to the location of the claim are available under the statutes for patent expenditure. The public survey office certifies to this fact and as the certificate is based on the report of the mineral surveyor, the latter should exercise special care to see that such improvements only are reported.

DESCRIPTIVE REPORTS ON PLACER CLAIMS.

749. By General Land Office circular approved April 11, 1922, paragraph 167, the mineral surveyor is required to make a full examination of all placer claims at the time of survey, and to file with his field notes a descriptive report, under oath, duly corroborated by one or more disinterested persons and covering the following items:

(A) The quality and composition of the soil, and the kind and amount of timber and other vegetation;

(B) The location and size of streams, and such other matter as may appear upon the surface of the claims;

(C) The character, extent, and position of all surface and underground workings for mining purposes;

(D) The proximity of centers of trade or residence;

(E) The proximity of well-known systems of lode deposits or of individual lodes;

(F) The use or adaptability of the claim for placer mining, including the availability of water in sufficient quantity for practical operations;

(G) Works or expenditures made by the claimant or his grantors for the development of the claim; and,

(H) The true position of all known mines, salt licks, salt springs, and mill sites. When none is known to exist on the claim, the fact will be so stated.

AMENDED SURVEYS.

750. Amended surveys are ordered only by the General Land Office, and inasmuch as the conditions and circumstances peculiar to each separate case and the object sought by the required amendment are set forth in the instructions from that office, and alone govern all special matters relative to the manner of making such surveys and the form and subject matter to be embraced in the field notes thereof, but few general rules can be laid down.

751. The amended surveys are to be made in strict conformity with, or be embraced within, the lines of the original survey. If the amended and original surveys are identical, that fact will be distinctly stated in the field notes. If not identical, the

bearing and distance are to be given from each established corner of the amended survey to the corresponding corner of the original survey. The lines of the original survey, as found upon the ground, are to be laid down upon the preliminary plat in such manner as to contrast and show their relation to the lines of the amended survey.

752. The field notes of the amended survey are to be prepared on the same size and form of blanks as are required for the field notes of the original survey, and the abbreviation "Am." will be used after the survey number wherever it occurs.

PLATS.

753. The order of approval of surveys of mineral claims is prescribed by General Land Office circular dated April 11, 1922:

The mining survey first applied for shall have the priority of action in all stages of office procedure, including the delivery thereof, over any other survey of the same ground or any portion thereof. The survey of a claim which conflicts with one previously applied for will not be approved until the survey first applied for has been completed, examined, platted, and approved.

754. Chapter IX is devoted to the subject of plat making and in so far as applicable will be followed. In addition, the following instructions relating especially to mineral plats will be observed. The returns of the survey when filed in the public survey office will be carefully examined and compared with the records to determine that all conflicts with prior approved surveys are correctly shown, that all connecting lines given are in harmony with the record, that all material errors found in prior surveys are fully reported, and that the calculations of intersections and of conflicting areas are correct. The final plat will be prepared on the standard form, drawn on a scale of 200 feet to an inch when practicable. (See Specimen Mineral Plat, Insert No. 4.) The scale should be large enough to illustrate clearly the field notes, showing the improvements, conflicts, and physical features described therein, together with all courses and distances of intersecting lines and connecting lines, where space will permit. Any topographic features described in the field notes tending to confuse or obscure the plat may be omitted, but as the copy of the plat

posted on the claim is a notice to the public of the ground applied for, all wagon roads, streams, and other objects that may aid in locating the surveyed ground should be shown. In case the entire survey can not be shown on the form plat on a scale large enough to be clear, two or more sheets may be used and numbered consecutively, each sheet bearing the inscription, "Survey No. -----, Sheet No. -----." The last sheet, carrying the certificate of approval, should be on the form plat and the extra sheets on blank sheets of the same width, and not longer than the form plat.

755. The approval of a mineral survey is final, no acceptance being required as in the case of the public land subdivisive surveys. When approved, the plat will be forwarded to the General Land Office for reproduction, and upon its return two copies will be mounted; one for filing with the district land office, and one for the claimant, together with a transcript of the field notes, to accompany his application for patent. One unmounted copy will be furnished the claimant for posting, and an extra copy when a mill site is included in the survey.

INDEX.

MEMORANDUM.—*Subdivisions* of a subject are indented on the left margin and the principal subject is repeated when the subdivision extends to a new page. *Explanatory notes* are shown in *italics*.

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APPENDIX.

SPECIMEN FIELD NOTES AND PLATS.

The following *list* will assist in locating the *forms of record* supplied by the specimen field notes which are carried in the Manual appendix :

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SPECIMEN FIELD NOTES
OF THE SURVEY OF THE
THIRD STANDARD PARALLEL NORTH,
ALONG THE SOUTH BOUNDARY OF TOWNSHIP 13 NORTH,
THROUGH RANGES 21, 22, 23, AND 24 EAST;
THE SIXTH GUIDE MERIDIAN EAST,
THROUGH TOWNSHIPS 13, 14, 15, AND 16 NORTH,
BETWEEN RANGES 24 AND 25 EAST;
AND THE
WEST AND NORTH BOUNDARIES OF
TOWNSHIP 13 NORTH, RANGE 24 EAST.

Note: Remainder of title omitted.

Third standard parallel north, along the south boundary of
T. 13 N., R. 21 E.

Chains.

The survey was executed with a engineer's transit, Serial No., Model No., property of the General Land Office. The horizontal circle has a diameter of 5 $\frac{1}{4}$ ins. and two double opposite verniers reading to 30"; the diameter of the vertical circle is 5 ins., with one double vernier reading to single minutes. The instrument was in good condition and, having been placed in satisfactory adjustment prior to beginning the survey and tested and found free from appreciable error, was approved by the district cadastral engineer on Aug. 10, 1927.

As the line to be established runs over a country that is heavily timbered, but mostly without a dense undergrowth, the secant method was selected; the controlling meridian was established by observation upon Polaris, as shown in the field notes; the bearing of the secant was deflected from the meridian by repetition of angles and was carried forward by transit line, taking the mean of direct and reversed sights at each instrument station, and removing all obstructing timber.

The measurements were made with two steel tapes, one 5 chs. and one 8 chs. in length; each tape is graduated every link for the first 100 lks. and thereafter at intervals of 10 lks. The tapes were tested by comparison with a standard and found correct. Both sets of measurements were made on the slope; the vertical angles were determined by clinometers in good adjustment; the field notes show the horizontal equivalents.

Aug. 16, 1927, at the point of beginning, in latitude 36° 59.6' N., and longitude 105° 04.3' W., as shown in the data furnished with the special instructions, I make a series of three observations for the determination, and verification, of time, latitude and azimuth, to be employed on the survey, as follows:

(1) An hour angle observation of Polaris west of the meridian, making four readings, two each with the telescope in direct and reversed positions, marking the mean point in the line thus determined, on a peg driven firmly in the ground, 12.60 chs. N. of station.

Mean watch time of observation, a. m.	5 ^h 07 ^m 20 ^s
Mean altitude of Polaris	38° 03' 00"

(2) An altitude observation of the sun, first setting on the sun's upper and right limbs, then, after reversal of the instrument, setting on the lower and left limbs; the horizontal angles are measured from the mean point in the line determined by the Polaris observation.

Mean watch time of observation, a. m.	8 ^h 45 ^m 44 ^s
Mean vertical angle	40° 59' 45"
Mean horizontal angle	105° 12' 00"
Reduced bearing of point on peg	N. 0° 25' 04" W.
Reduced watch slow of l. m. t.	3 ^m 30 ^s

(3) A noon observation of the sun, first setting on the sun's lower limb and noting the transit of the west limb, then, after reversal of the instrument, setting on the upper limb and noting the transit of the east limb.

Mean observed altitude	66° 54' 00"
Mean watch time of observation	12 ^h 00 ^m 48 ^s
Reduced latitude	36° 59' 44" N.
Reduced watch slow of l. m. t.	3 ^m 28 ^s

Chains.

(1) Having verified the watch error and latitude, I complete the reduction of the hour angle observation of Polaris, with the following results:

Mean azimuth of Polaris, west.....	0° 25' 10"
Reduced latitude.....	36° 59' 30" N.
Bearing of the secant in lat. of sta.....	N. 89° 58' 00" E.
Bearing of point on peg.....	N. 0° 25' 10" W.
Angle to be turned.....	90° 23' 10"

Turning from the mean point in the line determined by the Polaris observation, I set a flag on the secant; the multiple angle of four repetitions reads 361° 32' 30", which indicates an angle of 90° 23' 07½".

The observed magnetic variation is—°—E.

Beginning at the standard cor. of Tps. 13 N., Rs. 20 and 21 E., which is a granite stone, 12x8x10 ins. above ground, firmly set, marked and witnessed as described in the official record.

East, with the establishment of the third standard parallel north, along the S. bdy. of sec. 31, T. 13 N., R. 21 E., on a transit line describing the secant, which starts from a point 4 lks. S. of the Tp. cor., and bears N. 89° 58' E.

Over gently rolling land, through scattering pine and spruce.

28. 10 Enter heavy timber, bears NW. and SE.

Diff. bet. meas. of 40.00 chs., by two sets of chainmen, is 2 lks.; position of middle point—

By 1st set, 40.01 chs.

By 2d set 39.99 chs.; the mean of which is

40. 00 N. 2 lks. from the secant,

Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for standard ¼ sec. cor., with brass cap mkd.

S C
± S 31
1927

from which

A yellow pine, 10 ins. diam., bears N. 64½° E., 48 lks. dist., mkd. ¼ S 31 S C B T.

A blue spruce, 8 ins. diam., bears N. 14¼° W., 127 lks. dist., mkd. ¼ S 31 S C B T.

46. 50 Enter clearing, bears N. 35° E. and S. 35° W.

47. 00 A wagon road, following the line of the clearing.

58. 00 A settler's cabin bears N., 16 chs. dist.

63. 50 Enter heavy timber, bears N. and S.

Diff. bet. meas. of 80.00 chs., by two sets of chainmen, is 4 lks.; position of middle point—

By 1st set, 80.02 chs.

By 2d set, 79.98 chs.; the mean of which is

Chains.
80.00

On the secant,

Set an iron post, 3 ft. long, 2 ins. diam., 27 ins. in the ground, for standard cor. of secs. 31 and 32, with brass cap mkd.

	S C		
T 13 N	R 21 E		
S 31	S 32		

1927

from which

A yellow pine, 9 ins. diam., bears N. $31\frac{1}{4}^{\circ}$ E., 22 lks. dist., mkd. T 13 N R 21 E S 32 S C B T.A yellow pine, 8 ins. diam., bears N. 67° W., 114 lks. dist., mkd. T 13 N R 21 E S 31 S C B T.

Land, gently rolling.

Soil, loam; 1st rate.

Timber, yellow pine and blue spruce, with some juniper.

East, along the S. bdy. of sec. 32, on a transit line describing the secant, which bears N. $89^{\circ} 58.7' E$.

Over rolling land, through heavy pine and juniper.

12.00 Begin descent of 60 ft. over NE. slope.

18.40 Turkey Creek, 20 lks. wide, course S. $50^{\circ} E$.; asc. 175 ft. over broken SW. slope.

Diff. bet. meas. of 40.00 chs., by two sets of chainmen, is 4 lks.; position of middle point—

By 1st set, 40.02 chs.

By 2d set, 39.98 chs.; the mean of which is

40.00 S. 1 lk. from the secant,

Point falls on a sandstone boulder, $7\frac{1}{2} \times 2$ ft. above ground, which I mark for standard $\frac{1}{4}$ sec. cor., seating a brass tablet, $3\frac{1}{4}$ ins. diam., 3 in. stem, with top mkd.

	S C		
$\frac{1}{4}$ S 32			

1927

from which

A juniper, 8 ins. diam., bears N. $33\frac{1}{4}^{\circ} E$., 22 lks. dist., mkd. $\frac{1}{4}$ S 32 S C B T.A juniper, 11 ins. diam., bears N. $84\frac{1}{2}^{\circ} W$., 192 lks. dist., mkd. $\frac{1}{4}$ S 32 S C B T.46.20 A sandstone rim rock, 12 ft. high, bears N. $45^{\circ} W$. and S. $60^{\circ} E$.; thence over nearly level land.

55.72 A bench mark of the U. S. Geological Survey, published elevation 7,946.987 ft. above mean sea level, bears South, 5.62 chs. dist.; a brass tablet seated in a sandstone boulder, conforming to the record.

Diff. bet. meas. of 80.00 chs., by two sets of chainmen, is 6 lks.; position of middle point—

By 1st set, 80.03 chs.

By 2d set, 79.97 chs.; the mean of which is

Chains.
80.00

S. 2 lks. from the secant,

Set an iron post, 3 ft. long, 2 ins. diam., 18 ins. in the ground to bedrock, and in a mound of stone to top, for standard cor. of secs. 32 and 33, with brass cap mkd.

	S C	
T 13 N	R 21 E	
S 32	S 33	

1927

from which

A yellow pine, 9 ins. diam., bears N. $42\frac{3}{4}^{\circ}$ E., 27 lks. dist., mkd. T 13 N R 21 E S 33 S C B T.

A large sandstone outcropping, the highest point of which bears N. 57° $35'$ W., 87 lks. dist., mkd. S 32 X B O.

Land, rolling, west of creek; level table-land above top of slope east of creek. Soil, rich loam, 1st rate; sandy loam, 2d rate; and stony, 4th rate. Timber, mostly juniper, with some yellow pine and blue spruce.

NOTE.—The field notes of the survey of the S. bdy. of secs. 33, 34, and 35 continue on the same form, and are omitted here. The field notes of the S. bdy. of sec. 36 have been varied in order to show certain other forms of record.

East, along the S. bdy. of sec. 36, on a transit line describing the secant, which bears S. 89° $58.7'$ E.

Over level land, through dense undergrowth.

Diff. bet. meas. of 40.00 chs., by two sets of chainmen, is nothing;

40.00 N. 2 lks. from the secant,

Set a sandstone, $24 \times 10 \times 6$ ins., 16 ins. in the ground, for standard $\frac{1}{4}$ sec. cor., mkd. S C $\frac{1}{4}$ on N. face; and raise a mound of stone, 2 ft. base, $1\frac{1}{2}$ ft. high, N. of cor.

45.00 Begin gradual descent.

Diff. bet. meas. of 48.92 chs., by two sets of chainmen, is nothing;

48.92 Bank of Crystal Lake, bears N. 42° E. and S. 37° W.

N. 2.4 lks. from the secant,

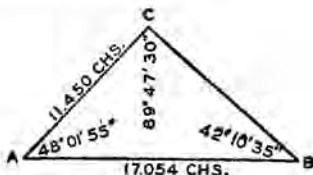
Set a sandstone, $27 \times 8 \times 8$ ins., 18 ins. in the ground, for meander cor. of frac. sec. 36, mkd.

6 grooves on N.,
M C on E., and
6 grooves on W. face; and raise a mound of stone,
2 ft. base, $1\frac{1}{2}$ ft. high, W. of cor.

In order to determine the distance across the lake by triangulation, I use the above station on the secant as point A, and set a flag B on the secant

Chains.

on the opposite side of the lake; point C is taken northeasterly on the west side; the mean distance from A to C is 11.450 chs.,
 By 1st set of chainmen=11.451 chs.
 By 2d set of chainmen=11.449 chs.



All angles by 3 repetitions, with a closing error of $0^{\circ} 0' 20''$ balanced to 180° , as follows:

At point A = $48^{\circ} 01' 55''$,
 At point B = $42^{\circ} 10' 35''$,
 At point C = $89^{\circ} 47' 30''$.

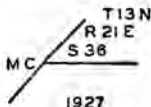
Distance across lake = 17.054 chs.

65.974 Point B.

66.00 Bank of lake, bears N. 50° E. and S. 45° W.

N. 3.3 lks. from the secant,

Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for meander cor. of frac. sec. 36, with brass cap mkd.



from which

A yellow pine, 8 ins. diam., bears N. $62\frac{1}{2}^{\circ}$ E., 29 lks. dist., mkd. T 13 N R 21 E S 36 M C B T.

A blue spruce, 14 ins. diam., bears N. $78\frac{3}{4}^{\circ}$ E., 312 lks. dist., mkd. T. 13 N R 21 E S 36 M C B T.

Enter heavy spruce, bears N. 50° E. and S. 45° W.; asc. 215 ft. over stony NW. slope.

Diff. bet. meas. of 80.00 chs., by two sets of chainmen, is 1 lk.; position of middle point—

By 1st set, 80.005 chs.
 By 2d set, 79.995 chs.; the mean of which is

80.00 N. 4 lks. from the secant,

Chains.

Set an iron post, 3 ft. long, 3 ins. diam., 24 ins. in the ground, for standard cor. of Tps. 13 N., Rs. 21 and 22 E., with brass cap mkd.

S C	
T 13 N	
R 21 E	R 22 E
S 36	S 31

1927

from which

A blue spruce, 12 ins. diam., bears N. $37\frac{1}{4}^{\circ}$ E., 114 lks. dist., mkd. T
13 N R 22 E S 31 S O B T.

A blue spruce, 9 ins. diam., bears N. $64\frac{1}{4}^{\circ}$ W., 127 lks. dist., mkd. T
13 N R 21 E S 36 S C B T.

Land, nearly level, west of lake; broken, east of lake.

Soil, sandy loam, 2d rate; and stony, 3d rate.

Timber, blue spruce with some yellow pine and aspen; undergrowth, oak brush.

Aug. 21: At this point, in order to verify the alinement of the secant, I make an altitude observation of the sun, first setting on the sun's upper and right limbs, then, after reversal of the instrument, setting on the lower and left limbs; the horizontal angles are measured from a back-sight flag D on the secant.

Mean watch time of obsn., a. m.	9 ^h 08 ^m 58 ^s
Mean vertical angle	44° 54' 15"
Mean horizontal angle	158° 06' 30"
Reduced bearing of flag D	N. 89° 57' 27" W.

As the theoretical bearing of the secant at this point is N. 89° 58.0' W., the observation indicates that the line has been carried forward acceptably.

*Third standard parallel north, along the
south boundary of T. 13 N., R. 22 E.*

To lay off a deflection angle of $3' 55''$, in order to describe a secant through Range 22 East, I set a back-sight flag E, 3.96 lks. (2.61 ft.) to the south of the back-sight flag D previously described, the latter point being located on the secant at 45.00 chs. running E. on the S. bdy. of sec. 36; then, to verify the angle at the station on the secant at the standard Tp. cor., subtended by the two flags, I make 6 repetitions and find that the multiple angle reads $0^{\circ} 23' 30''$.

East, with the establishment of the third standard parallel north, along the S. bdy. of sec. 31, T. 13 N., R. 22 E., on a transit line describing the secant, which starts from a point 4 lks. S. of the Tp. cor., and bears N. $89^{\circ} 58'$ E.

Ascend 65 ft. over stony NW. slope; through heavy pine.

3. 50 Ridge, bears N. 60° E. and S. 60° W.; desc. 240 ft. over SE. slope.

22. 30 Base of ridge, bears N. 65° E. and S. 65° W.; continue gradual descent.

Diff. bet. meas. of 38.40 chs., by two sets of chainmen, is 2 lks.; position of middle point—

By 1st set, 38.41 chs.

By 2d set, 38.39 chs.; the mean of which is

Chains.
38.40

N. 2.1 lks. from the secant,

Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for witness standard $\frac{1}{4}$ sec. cor., with brass cap mkd.

W C
S C
 $\frac{1}{4}$ S 31

1927

from which

A yellow pine, 9 ins. diam., bears North, 16 lks. dist., mkd. W C $\frac{1}{4}$ S 31 S C B T.

A yellow pine, 10 ins. diam., bears N. $57\frac{1}{2}^\circ$ W., 92 lks. dist., mkd. W C $\frac{1}{4}$ S 31 S C B T.

40.00 True point for standard $\frac{1}{4}$ sec. cor. falls in the bed of a dry creek channel, 60 lks. wide, course N. 70° E.; water in pools south of line; asc. gradually.

Diff. bet. meas. of 54.96 chs., by two sets of chainmen, is 3 lks.; position of middle point—

By 1st set, 54.975 chs.

By 2d set, 54.945 chs.; the mean of which is

54.90 N. 1.2 lks. from the secant,

Intersect the W. bdy. of the Las Animas Land Grant.

Set an iron post, 3 ft. long, 3 ins. diam., 24 ins. in the ground, for closing cor. of frac. T. 13 N., R. 22 E., with brass cap mkd.

T 13 N
R 22 E / LA
S 31 / LG
CC — PL /
1927

from which

A yellow pine, 11 ins. diam., bears N. $22\frac{1}{4}^\circ$ W., 57 lks. dist., mkd. T 13 N R 22 E S 31 C C B T.

A yellow pine, 7 ins. diam., bears N. $74\frac{1}{4}^\circ$ W., 135 lks. dist., mkd. T 13 N R 22 E S 31 C C B T.

From this point the 14th Mi. Cor. of the grant boundary bears N. $33^\circ 38'$ E., 27.84 chs. dist.; a sandstone, 16x12 ins., standing firmly 6 ins. above the top of a mound of stone, 5 ft. base, 3 ft. high, marked and witnessed as described in the official record.

From the same point the 15th Mi. Cor. of the grant boundary bears S. $33^\circ 38'$ W., 51.96 chs. dist.; a pine tree, 34 ins. in diameter; the surface scars on the tree, and on the bearing trees, and the kind and position of the latter, agree with the official record; I do not uncover the marks.

Chains.

Land, gently rolling and broken.
Soil, sandy loam, 2d rate; and stony, 4th rate.
Timber, yellow pine.

Thence I extend the secant on a blank line across the grant.

Diff. bet. meas. of 392.78 chs., by two sets of chainmen, is 8 lks.; position of middle point—

By 1st set, 392.82 chs.

By 2d set, 392.74 chs.

East, along the S. bdy. of sec. 36, on a transit line describing the secant, which bears S. 89° 58.3' E.

47.74 N. 2.4 lks. from the secant,

Intersect the E. bdy. of the grant.

Set a sandstone, 32x10x8 ins., 22 ins. in the ground, for closing cor. of frac. T. 13 N., R. 22 E., mkd.

13 N on N.,

C C 22 E and 1 groove on E., and

L A L G on W. face; and raise a mound of stone,

2 ft. base, 1½ ft. high, E. of cor.

From this point the 7th Mi. Cor. of the grant boundary bears S. 0° 42' E., 19.12 chs. dist.; a sandstone bowlder, 8x5x3 ft. above ground, marked and witnessed as described in the official record.

From the same point the 8th Mi. Cor. of the grant boundary bears N. 0° 42' W., 60.62 chs. dist.; a sandstone, 12x8x6 ins. above ground, firmly set, marked and witnessed as described in the official record.

Thence over nearly level land.

Diff. bet. meas. of 32.26 chs., by two sets of chainmen, is nothing;

80.00 N. 4 lks. from the secant,

Set a sandstone, 36x10x8 ins., 24 ins. in the ground, for standard cor. of Tps. 13 N., Rs. 22 and 23 E., mkd.

S C 13 N on N.,

23 E on E., and

22 E on W. face; and raise a mound of stone,

5 ft. base, 3 ft. high, N. of cor.

Land, nearly level.

Soil, sandy loam and stony; 3d rate.

No timber.

Aug. 24: At this point, in order to verify the alinement of the secant, I make a series of three altitude observations of the sun for azimuth, each with the telescope in direct and reversed positions, observing opposite limbs of the sun; the horizontal angles are measured from a back-sight flag on the secant.

Chains.

Observation	Telescope	Sun	Watch time	Vertical angle	Horizontal angle
First.....	Direct.....	α	9 ^h 04 ^m 30 ^s *	43°50'00''	157°28'30''
Do.....	Reversed.....	β	9 06 12	43 36 30	157 50 30
Mean.....			9 ^h 05 ^m 21 ^s *	43°43'15''	157°39'30''
Second.....	Direct.....	α	9 ^h 09 ^m 00 ^s *	44°39'00''	156°25'00''
Do.....	Reversed.....	β	9 11 05	44 32 00	156 43 00
Mean.....			9 ^h 10 ^m 02 ^s *	44°35'30''	156°35'30''
Third.....	Direct.....	α	9 ^h 13 ^m 05 ^s *	45°25'00''	155°30'00''
Do.....	Reversed.....	β	9 15 00	45 13 00	155 50 00
Mean.....			9 ^h 14 ^m 02 ^s *	45°19'00''	155°40'00''

By first observation flag bears.....	N. 89° 58' 15'' W.
By second observation flag bears.....	N. 89° 58' 00'' W.
By third observation flag bears.....	N. 89° 58' 26'' W.
Mean true bearing of flag.....	N. 89° 58' 14'' W.
Theoretical bearing of the secant.....	N. 89° 58' 00'' W.

Indicated discrepancy between observations for meridian on Aug. 16 and 24, including the accumulated error in the alinement of the secant..... $0^{\circ} 00' 14''$

NOTE.—The field notes of the survey of the third standard parallel north, along the S. bdy. of Tps. 13 N., Rs. 23 and 24 E., continue on the same form, and are omitted here. An entry indicates that at the standard cor. of Tps. 13 N., Rs. 24 and 25 E., an angle was turned from the secant to the meridian and that the verification of the alinement of the secant would be found in the observation for meridian made for the survey of the sixth guide meridian east.

MEMORANDUM.

The alinement of the secant is to be verified always by an azimuth observation at the end of the run; if the line is to be continued more than 12 miles a new meridian will ordinarily be employed for control at intervals of not to exceed 12 miles.

The form of the record of the survey of a standard parallel by the tangent method will be similar to that of the specimen field notes by the secant method, and does not need to be extended here. The tangent method may as well be employed if the parallel runs over a country that is comparatively free from heavy timber and dense undergrowth.

If the solar transit method is employed the resulting line will conform to the parallel without making offsets. There is no other essential difference in the form of the record. This method will be given preference in regions that are heavily timbered or covered by very dense undergrowth, where the work incident to opening a transit line would add unnecessarily to the cost of the survey.

Ordinarily only one set of measurements will be required on the standard parallel if the special instructions provide that the township is to be subdivided.

A summary description of the region crossed by a standard parallel will be supplied at the close of the field notes, or the information may be carried in the general description of the subdivisive survey.

AUGUST 28, 1927.

Sixth guide meridian east, through T. 13 N., bet. Rs. 24 and 25 E.

Chains.

Aug. 29, 1927, at the standard cor. of Tps. 13 N., Rs. 24 and 25 E., in latitude $30^{\circ} 59.6' N.$, and longitude $104^{\circ} 38.3' W.$, as computed by reference to the values given for the standard cor. of Tps. 13 N., Rs. 20 and 21 E., I make a noon observation of the sun for time, and an observation upon Polaris at eastern elongation for meridian, as follows:

Watch time of transit of sun's west limb.....	11 ^h 54 ^m 48 ^s
Watch time of transit of sun's east limb.....	11 56 56
Mean.....	11 ^h 55 ^m 52 ^s
Reduced watch slow of l. m. t.....	5 ^m 10 ^s

At 9^h 10.0^m p. m., l. m. t., or 9^h 04.8^m watch time, I observe Polaris at eastern elongation, making 6 settings, 3 each with the telescope in direct and reversed positions, accumulating the horizontal angle, measured by the method of repetitions, counting from a signal light at my flag point 16.40 chs. N. of station.

Horizontal angle, 6 repetitions.....	8° 13' 30''
Reduced angle.....	1° 22' 15''
Azimuth of Polaris at e. e.....	1° 21' 48''
True bearing of point on peg.....	N. 0° 00' 27'' W.

In order to mark the true meridian I set a second tack point, 0.21 lks. (0.14 ft.) to the east of the original point; then, to verify the angle at the standard Tp. cor., subtended by the 2 points on the peg, I make 10 repetitions and find that the multiple angle reads $0^{\circ} 04' 30''$.

The observed magnetic variation is $-^{\circ} -' E.$

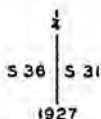
Thence from the standard cor. of Tps. 13 N., Rs. 24 and 25 E.,

North, with the establishment of the sixth guide meridian east, through T. 13 N., bet. Rs. 24 and 25 E., bet. secs. 31 and 36.

Over nearly level land.

Diff. bet. meas. of 40.00 chs., by two sets of chainmen, is nothing;

40.00 Set an iron post, 3 ft. long, 1 in. diam., 26 ins. in the ground, for $\frac{1}{4}$ sec. cor., with brass cap mkd.



18x18x12 ins., N. and S. of post, 3 ft. dist.

dig pits.

43.50 Begin gradual ascent.

Chains.
67.00

Top of ascent; enter heavy juniper and piñon, bears NE. and SW.; descend over gradual NW. slope.

Diff. bet. meas. of 80.00 chs., by two sets of chainmen, is 1 lk.; position of middle point—

By 1st set, 79.905 chs.

By 2d set, 80.005 chs.; the mean of which is

80.00 Set a sandstone, 24x10x6 ins., 16 ins. in the ground, for cor. of secs. 25, 30, 31, and 36, mkd. with 5 notches on N. and 1 notch on S. edge; from which

A juniper, 10 ins. diam., bears N. $64\frac{3}{4}^{\circ}$ E., 70 lks. dist., mkd. T 13 N 14 25 E S 30 B T.

A juniper, 12 ins. diam., bears S. $69\frac{3}{4}^{\circ}$ E., 41 lks. dist., mkd. T 13 N 14 25 E S 31 B T.

A juniper, 10 ins. diam., bears S. $79\frac{1}{2}^{\circ}$ W., 59 lks. dist., mkd. T 13 N 14 25 E S 36 B T.

A juniper, 20 ins. diam., bears N. $74\frac{3}{4}^{\circ}$ W., 220 lks. dist., mkd. T 13 N 14 25 E S 25 B T.

Land, level and gently rolling.

Soil, sandy loam, 2d rate; and stony, 4th rate.

Timber, juniper and piñon.

North, bet. secs. 25 and 30.

Descend gradually through heavy juniper and piñon.

21.50 An ungraded wagon road, bears NW. and SE., from Fort Myer to Valley City.

23.20 An arroyo, course SW.; asc. 100 ft. over SE. slope.

Diff. bet. meas. of 40.00 chs., by two sets of chainmen, is 2 lks.; position of middle point—

By 1st set, 39.99 chs.

By 2d set, 40.01 chs.; the mean of which is

40.00 Set a sandstone, 21x8x6 ins., 14 ins. in the ground, for $\frac{1}{4}$ sec. cor., mkd. $\frac{1}{4}$ on W. face; from which

A juniper, 8 ins. diam., bears N. $60\frac{1}{4}^{\circ}$ E., 28 lks. dist., mkd. $\frac{1}{4}$ S 30 B T.

A juniper, 11 ins. diam., bears West, 89 lks. dist., mkd. $\frac{1}{4}$ S 25 B T.

64.20 Top of ascent; leave timber, bears N. 60° E. and S. 60° W.; desc. gradually.

76.00 An arroyo, course S. 65° W.; asc. 50 ft. to sec. cor.

Diff. bet. meas. of 80.00 chs., by two sets of chainmen, is 3 lks.; position of middle point—

By 1st set, 79.985 chs.

By 2d set, 80.015 chs.; the mean of which is

Chains.

80.00

Set an iron post, 3 ft. long, 2 ins. diam., 26 ins. in the ground, for cor. of secs. 19, 24, 25, and 30, with brass cap mkd.

	T 13 N	
R 24 E		R 25 E
S 24		S 19
S 25		S 30
	1927	

of stone, 2 ft. base, $1\frac{1}{2}$ ft. high, W. of cor.

raise a mound

Land, rolling and broken.

Soil, sandy loam, 2d rate; and stony, 4th rate.

Timber, juniper and piñon.

North, bet. secs. 19 and 24.

Asc. over broken land.

2.10

Top of ascent; enter scattering piñon and dense undergrowth.

Diff. bet. meas. of 40.00 chs., by two sets of chainmen, is nothing;

40.00

Set an iron post, 3 ft. long, 1 in. diam., 26 ins. in the ground, for $\frac{1}{4}$ sec. cor., with brass cap. mkd.

	↑	
S 24		S 19
	1927	

of stone, 2 ft. base, $1\frac{1}{2}$ ft. high, W. of cor.

raise a mound

56.00

Leave scattering timber.

64.20

An arroyo, course N. 60° W.; asc. 85 ft. to sec. cor.

Diff. bet. meas. of 80.00 chs., by two sets of chainmen, is 1 lk.; position of middle point—

By 1st set, 80.005 chs.

By 2d set, 79.995 chs.; the mean of which is

80.00

Set an iron post, 3 ft. long, 2 ins. diam., 24 ins. in the ground, for cor. of secs. 13, 18, 19, and 24, with brass cap mkd.

	T 13 N	
R 24 E		R 25 E
S 13		S 18
S 24		S 19
	1927	

of stone, 2 ft. base, $1\frac{1}{2}$ ft. high, W. of cor.

raise a mound

Chains.

Land, broken.
Soil, sandy loam and stony; 3d rate.
Timber, scattering piñon; undergrowth, sagebrush.

NOTE.—The field notes of the survey of the line bet. secs. 13 and 18, and bet. secs. 7 and 12, continue on the same form, and are omitted here.

North, bet. secs. 1 and 6.

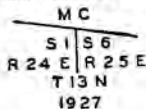
Desc. 40 ft. over broken NE. slope, through dense undergrowth.

7.90 A graded wagon road, bears N. 80° W. and S. 80° E., from Ft. Myer to Douglass P. O.

Diff. bet. meas. of 9.10 chs., by two sets of chainmen, is nothing;

9.10 Right bank of the South Fork of Trapper River, course S. 80° E.; banks 2 to 6 ft. high; water at present low stage from 1 to 3 ft. deep.

Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for meander cor. of frac. secs. 1 and 6, with brass cap mkd.



of stone, 2 ft. base, 1½ ft. high, S. of cor. raise a mound

Distance across river by steel tape measurement, by both sets of chainmen, 4.60 chs.

13.70 Left bank of river.

Set a washed flint bowlder, 32x14x8 ins., 2½ ins. in the ground, for meander cor. of frac. secs. 1 and 6, mkd.

1 groove on N.,
6 grooves on E.,
M C on S., and
6 grooves on W. face; and raise a mound of stone,
5 ft. base, 3 ft. high, N. of cor.

Asc. 160 ft. over broken S. slope.

29.80 Ridge, bears E. and W.; desc. 60 ft.; enter scattering juniper and piñon.

Diff. bet. meas. of 40.00 chs., by two sets of chainmen, is 2 lks.; position of middle point—

By 1st set, 39.99 chs.
By 2d set, 40.01 chs.; the mean of which is

40.00 Point falls on a sandstone bowlder, 8x5x2 ft. above ground, which I mark for ¼ sec. cor., seating a brass tablet, 3½ ins. diam., 3 in. stem, with top mkd.



from which

- Chains.*
 A piñon, 8 ins. diam., bears S. $54\frac{1}{4}^{\circ}$ E., 297 lks. dist., mkd. $\frac{1}{4}$ S 6 D T.
 A juniper, 9 ins. diam., bears S. 65° W., 84 lks. dist., mkd. $\frac{1}{4}$ S 1 B T.
 46.60 An arroyo, course N. 75° E.; continue over nearly level land.
 67.60 Leave scattering timber.
 Diff. bet. meas. of 80.00 chs., by two sets of chainmen, is 4 lks.; position of middle point—
 By 1st set, 79.98 chs.
 By 2d set, 80.02 chs.; the mean of which is
 80.00 Set an iron post, 3 ft. long, 3 ins. diam., 26 ins. in the ground, for cor. of Tps. 13 and 14 N., Rs. 24 and 25 E., with brass cap mkd.

		T	14	N		
R	24	E		R	25	E
S	36			S	31	
		—				
		S	1	S	6	
		T	13	N		
			1927			

of stone, 5 ft. base, 3 ft. high, S. of cor.

raise a mound

Land, southern portion broken, balance level.

Soil, sandy loam, 2d rate; and stony, 3d rate.

Timber, juniper and piñon; undergrowth, sagebrush.

SEPTEMBER 2, 1927.

*Sixth guide meridian east,
 through T. 14 N., bet. Rs. 24 and 25 E.*

NOTE.—The field notes of the survey of the sixth guide meridian east, through Tps. 14, 15, and 16 N., bet. Rs. 24 and 25 E., continue in the same form, and all but the last mile are omitted here. An entry shows an observation for meridian at the cor. of Tps. 14 and 15 N., Rs. 24 and 25 E., for the verification of the alinement to that point, and for the control of the balance of the survey.

*Sixth guide meridian east,
 through T. 16 N., bet. Rs. 24 and 25 E.*

North, bet. secs. 1 and 6.

Over broken W. slope, through heavy pine, juniper, and piñon, and dense undergrowth; asc. 25 ft. to top of spur.

- 3.00 Spur from ridge, slopes W.; desc. gradually over steep W. slope.
 12.70 Gulch, course S. 30° W.; asc. 350 ft. to spur.
 20.80 Spur from ridge, slopes SW.; continue ascent of 125 ft. over steep W. slope.
 Diff. bet. meas. of 40.00 chs., by two sets of chainmen, is 4 lks.; position of middle point—
 By 1st set, 40.02 chs.
 By 2d set, 39.98 chs.; the mean of which is

Chains.
40.00

Set an iron post, 3 ft. long, 1 in. diam., 15 ins. in the ground to bed rock, and in a mound of stone to top, for $\frac{1}{4}$ sec. cor., with brass cap mkd.



from which

A yellow pine, 14 ins. diam., bears S. $36\frac{1}{4}^{\circ}$ E., 54 lks. dist., mkd. $\frac{1}{4}$ S 6 B T.

A yellow pine, 12 ins. diam., bears S. $72\frac{1}{4}^{\circ}$ W., 96 lks. dist., mkd. $\frac{1}{4}$ S 1 B T.

41.00 Spur from ridge, slopes W.; desc. 125 ft.

44.20 Deep draw, drains W.; steep ascent of 300 ft.

57.00 Top of steep ascent; continue gradual ascent.

67.00 Divide bet. South Fork and North Fork of Trapper River, bears East and S. 75° W.; desc. 225 ft. to cor.

Diff. bet. meas. of 81.44 chs., by two sets of chainmen, is 6 lks.; position of middle point—

By 1st set, 81.47 chs.

By 2d set, 81.41 chs.; the mean of which is

81.44 Intersect the Fourth Standard Parallel North.

Set an iron post, 3 ft. long, 3 ins. diam., 12 ins. in the ground to bedrock, and in a mound of stone to top, for closing cor. of Tps. 16 N., Rs. 24 and 25 E., with brass cap mkd.



from which

A juniper, 12 ins. diam., bears S. $33\frac{1}{4}^{\circ}$ E., 58 lks. dist., mkd. T 16 N R 25 E S 6 C C B T.

A yellow pine, 9 ins. diam., bears S. $72\frac{1}{4}^{\circ}$ W., 129 lks. dist., mkd. T 16 N R 24 E S 1 C C B T.

From point of intersection the standard $\frac{1}{4}$ sec. cor., S. bdy. sec. 36, T. 17 N., R. 24 E., bears S. $89^{\circ} 56'$ E., 12.76 chs. dist.; a sandstone, 12x18 ins. above ground, mkd. and witnessed as described in the official record.

From the same point the standard cor. of secs. 35 and 36, T. 17 N., R. 24 E., bears N. $89^{\circ} 56'$ W., 27.18 chs. dist.; a sandstone, 14x8 ins., standing firmly 8 ins. above the top of a mound of stone, 4 ft. base, 2 ft. high, marked and witnessed as described in the official record.

Land, mountainous.

Soil, sandy and stony; 3d and 4th rates.

Timber, yellow pine, juniper, and piñon; undergrowth, service and oak brush.

Chains.

Sept. 11: At the closing Tp. cor., in order to verify the alinement of the sixth guide meridian east, I bisect Polaris, follow the motion of the star to eastern elongation, at 8h 19.1m p.m., l. m. t., and mark the direction upon a peg driven firmly in the ground 8 cbs. N.; I then reverse the instrument, again bisect Polaris, and mark the direction upon the peg. Without changing the instrument in horizontal motion, I sight to Polaris to make certain that the settings were made at elongation; there appeared to be no deviation in azimuth for some 15 or 20 minutes.

Sept. 12: I lay off the azimuth of Polaris, $1^{\circ} 22' 06''$, to the west of the mean direction determined by the observation and set a point for the test-meridian; then, by direct and reversed sights, I ascertain that the angle subtended by the last back-sight flag, near the top of the divide on the guide meridian as established, is less than $0^{\circ} 01' 00''$ from this line.

MEMORANDUM.

Ordinarily only one set of measurements will be required on the guide meridian where the special instructions provide that the township is to be subdivided.

A summary description of the region crossed by a guide meridian will be supplied at the end of the field notes, or it may be included in the general description of the subdivisional survey.

SEPTEMBER 12, 1927.

West boundary of T. 13 N., R. 2½ E.

MEMORANDUM.

The field notes of the survey of a meridional township boundary will ordinarily take the form of the specimen field notes of the sixth guide meridian east, with only one set of measurements.

NOTE.—Specimen field notes omitted.

North boundary of T. 13 N., R. 2½ E.

Sept. 19, 1927, at the cor. of Tps. 13 and 14 N., Rs. 24 and 25 E., in latitude $37^{\circ} 04.8' N.$, and longitude $104^{\circ} 38.3' W.$, as computed by reference to the values given for the standard cor. of Tps. 13 N., Rs. 20 and 21 E., I turn 90° from a flag point previously located on the sixth guide meridian east, and run

West, on a random line, making proper offsets to the north from the tangent to the parallel at intervals of 40.99 chs., setting temp. $\frac{1}{4}$ sec. and sec. cors. along the line bet. Tps. 13 and 14 N., R. 24 E. At 479.25 chs., the parallel intersects a N. and S. line, 25 lks. S. of the cor. of Tps. 13 and 14 N., Rs. 23 and 24 E. The correction is 4.2 lks. N. per mile, counting from the point of beginning.

Thence

S. $89^{\circ} 58' E.$, bet. secs. 6 and 31, marking and blazing the true line.

Asc. over SW. slope, through dense undergrowth.

30. 25 Ridge, bears N. $15^{\circ} E.$ and S. $15^{\circ} W.$

- Chains.
34.00 Head of draw, drains S.
- 39.25 Set an iron post, 3 ft. long, 1 in. diam., 26 ins. in the ground, for $\frac{1}{4}$ sec. cor., with brass cap mkd.
- | | | |
|---------------|---|------|
| | S | 31 |
| $\frac{1}{4}$ | S | 6 |
| | | 1927 |
- raise a mound
- of stone, 2 ft. base, $1\frac{1}{2}$ ft. high, N. of cor.
- 46.90 Ridge, bears N. 15° E. and S. 15° W.; desc. 100 ft. over gradual E. slope.
- 77.50 Draw, drains NE.; asc. gradually.
- 79.25 Set an iron post, 3 ft. long, 2 ins. diam., 26 ins. in the ground, for cor. of secs. 5, 6, 31, and 32, with brass cap mkd.
- | | | | | | |
|---|----|---|----|----|------|
| T | 14 | N | R | 24 | E |
| S | 31 | S | 32 | | |
| S | 6 | S | 5 | | |
| T | 13 | N | | | |
| | | | | | 1927 |
- raise a mound
- of stone, 2 ft. base, $1\frac{1}{2}$ ft. high, W. of cor.
- Land, rolling mountainous.
Soil, sandy; 2d and 3d rate.
No timber; undergrowth, sagebrush.
-
- S. $89^{\circ} 58'$ E., bet. secs. 5 and 32.
- Over rolling N. slope, changing to E. slope; through dense undergrowth.
- 29.50 Gulch, course SE.; asc. to spur,
- 35.50 Point of spur from ridge, slopes S.; leave undergrowth and enter scattering juniper; desc. gradually.
- 40.00 Set a sandstone, $24 \times 8 \times 6$ ins., 16 ins. in the ground, for $\frac{1}{4}$ sec. cor., mkd. $\frac{1}{4}$ on N. face; dig pits, $18 \times 18 \times 12$ ins., E. and W. of stone, 3 ft. dist.
- 44.50 Draw, drains S.; asc. gradually.
- 53.00 Top of slope; desc. 50 ft. to creek.
- 60.00 Crooked Wash Creek, 30 lks. wide, dry, course S. 20° W.; asc. 150 ft.
- 77.00 Ridge, bears N. and S.; desc. gradually to cor.
- 80.00 Set a sandstone, $20 \times 10 \times 8$ ins., 13 ins. in the ground, for cor. of secs. 4, 5, 32, and 33, mkd. with 4 notches on E. and 2 notches on W. edge; from which
- A juniper, 20 ins. diam., bears N. $36^{\circ} 35'$ W., 423 lks. dist., mkd. T 14
N R 24 E S 32 B T.
- Raise a mound of stone, 2 ft. base, $1\frac{1}{2}$ ft. high, W. of cor.

Chetas.

Land, rolling mountainous.
Soil, sandy and stony; 3d rate.
Timber, scattering juniper; undergrowth, greasewood and sagebrush.

NOTE.—The field notes of the survey of the line bet. secs. 4 and 33, 3 and 34, and bet. secs. 2 and 35, continue on the same form, and are omitted here.

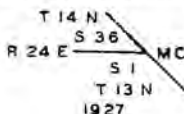
S. 89° 58' E., bet. secs. 1 and 36.

Descend gradually through heavy juniper and piñon and dense undergrowth.

11.40 A graded wagon road, bears N. 55° W. and S. 35° E., from Ft. Myer to Douglass P. O.

16.20 Right bank of the South Fork of Trapper River, course S. 50° E.; banks 2 to 5 ft. high, water at present low stage from 1 to 3 ft. deep.

Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for meander cor. of frac. secs. 1 and 36, with brass cap mkd.



from which

A juniper, 14 ins. diam., bears N. 70¼° W., 142 lks. dist., mkd. T 14 N R 24 E S 36 M C B T.

A juniper, 10 ins. diam., bears S. 21¼° W., 98 lks. dist., mkd. T 13 N R 24 E S 1 M C B T.

Width of river about 4.50 chs.; distance across on line by steel tape measurement, 7.15 chs.

23.35 Left bank of river.

Set a washed flint boulder, 28x16x8 ins., 21 ins. in the ground, for meander cor. of frac. secs. 1 and 36, mkd.

6 grooves on N.,
1 groove on E., and
6 grooves on S., and
M C on W. face; and raise a mound of stone,
5 ft. base, 3 ft. high, E. of cor. *

Asc. 150 ft. over broken SW. slope, through scattering piñon.

40.00 Set an iron post, 3 ft. long, 1 in. diam., 26 ins. in the ground, for ¼ sec. cor., with brass cap mkd.



from which

A piñon, 9 ins. diam., bears S. 29° 40' W., 387 lks. dist., mkd. ¼ S 1 B T.

Raise a mound of stone, 2 ft. base, 1½ ft. high, N. of cor.

Chains. 43.70	Ridge, bears NW. and SE.; desc. 35 ft.
65.20	Base of slope, bears NW. and SE.; leave scattering timber; continue over nearly level land.
80.00	The cor. of Tps. 13 and 14 N., Rs. 24 and 25 E. Land, mostly broken; eastern part nearly level. Soil, sandy loam, 2d rate; and stony, 3d rate. Timber, juniper and piñon; undergrowth, sagebrush.

MEMORANDUM.

A summary description of the region crossed by the township exteriors will be supplied at the close of the field notes, excepting where it may be included in the general description of the subdivisional survey.

A table of latitudes and departures of the boundaries of the townships whose exteriors have been duly completed, showing proper allowances for convergency, and the reduced closing errors, will be filed with the proper supervising officer with the *field tablets*, computation sheets and other data that pertain to the survey.

The following is an example:

Boundaries of T. 13 N., R. 24 E.

	True bearing.	Dis- tance.	N.	S.	E.	W.
		<i>Chains.</i>	<i>Chains.</i>	<i>Chains.</i>	<i>Chains.</i>	<i>Chains</i>
3d Stan. Par. N.	East	480.00	480.00	-----	480.00	-----
6th Guide Mer. E.	North	480.00	480.00	-----	-----	-----
North boundary	N. 89° 58' W.	479.25	.25	-----	-----	479.25
West boundary	South	480.00	-----	480.00	-----	-----
Convergency	-----	-----	-----	-----	-----	.55
Totals	-----	-----	480.25	480.00	480.00	479.80
			480.00	-----	479.80	-----
Error in latitude	-----	-----	0.25	-----	-----	-----
Error in departure	-----	-----	-----	-----	0.20	-----

The table will not be carried to the field notes.

NOTE.—This completes the field work directed in the special instructions. Names of assistants omitted. Certificates omitted.

SEPTEMBER 21, 1927.

SPECIMEN FIELD NOTES
OF THE SURVEY OF THE
SUBDIVISIONAL AND MEANDER LINES OF
TOWNSHIP 15 NORTH, RANGE 20 EAST,
OF THE PRINCIPAL MERIDIAN,
IN THE STATE OF MONTANA

Executed by

ROBERT ACRES, U. S. Cadastral Engineer.

Under special instructions dated April 1, 1925, which provided for the surveys included under Group No. 123, bearing the approval of the Commissioner of the General Land Office under date of April 10, 1925, and assignment instructions dated May 20, 1925, addressed to the above-named engineer.

Survey commenced June 1, 1925.

Survey completed June 30, 1925.

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7	8	9	10	11	12
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18	17	16	15	14	13
510	503			497	497
19	20	21	22	23	24
505	505	503		497	498
30	29	28	27	26	25
504	503			509	511
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Subdivision of T. 15 N., R. 20 E.

Chains.

The subdivisional survey of township 15 north, range 20 east, was executed with a light-mountain solar transit made by _____, Serial No. _____, constructed in accordance with the standard specifications of the General Land Office. The horizontal circle has a diameter of $4\frac{1}{2}$ ins., with two double opposite verniers reading to single minutes; the vertical circle has a diameter of 4 ins., with one double vernier reading to single minutes; the telescope has fixed stadia wires, ratio 1:132, with a focal constant of 1.2 lks. The instrument is equipped with the improved Smith solar attachment; radius of latitude arc $2\frac{1}{2}$ ins., and of declination arc $3\frac{1}{2}$ ins., each with verniers reading to single minutes. The instrument was in good condition, and having been placed in satisfactory adjustment prior to beginning the survey, and tested and found free from appreciable error, was approved by the district cadastral engineer on May 25, 1925. I examined all the instrumental adjustments before making the field tests hereinafter recorded.

The directions of the subdivisional lines were determined by solar transit method. The measurements were made with a _____ steel tape, 5 chs. in length, graduated every link for the first 100 lks., and the balance at intervals of 10 lks. The tape was tested by comparison with a _____ standard and found correct. The measurements were made on the slope, and the vertical angle of each interval was ascertained by a clinometer in good adjustment; the horizontal equivalents are entered in the field note record. Some of the distances were determined by stadia method as shown in the record.

The data furnished with the special instructions gives the geographic position for the SE. cor. of the Tp., as follows: latitude $45^{\circ} 45.0' N.$, and longitude $107^{\circ} 54.0' W.$

June 1, 1925, in camp on the Yellowstone River near the center of the NE $\frac{1}{4}$ of sec. 35, at $3^h 00.7^m$ a. m., l. m. t., or $3^h 12.3^m$ a. m. by my watch, which reads correct 105th meridian time as determined by radio signals. I observe Polaris at eastern elongation, making two sights each with the telescope in direct and reversed positions, and place a tack at the mean point, on a peg driven firmly in the ground 8 chs. N. After sunrise, I lay off the azimuth of Polaris, $1^{\circ} 34' 42''$, and make a meridian mark on a second peg, 22.04 lks. (14.68 ft.) to the west of the mean point in the line determined by the observation; I verify the angle by a vernier reading of the instrument.

In order to verify the latitude of this station and the reading of my watch, I make a meridian observation of the sun, first setting on the lower limb and noting the transit of the west limb, then, after reversal of the instrument, setting on the upper limb and noting the transit of the east limb, as follows:

Mean observed altitude.....	66° 18' 30''
Reduced latitude.....	45° 45' 45''
Mean watch time of observation.....	12 ^m 00 ^m 24 ^s
Watch fast of l. m. t.....	11 ^m 46 ^s
Same, by reference to radio time signals and calculated difference in longitude.....	11 ^m 36 ^s

Every 30 min. from 8 to 10.30 a. m. and from 1.30 to 6 p. m., I make proper settings on the arcs of the solar attachment and ascertain that the resulting orientation of the instrument, when compared with the meridian established by Polaris observation, has a maximum error of less than $1' 30''$.

I repeat the tests of the arcs daily by noon observation, and verify the meridional indications at frequent intervals throughout the survey.

The observed magnetic declination is $-^{\circ} -' E.$

Chains.

I make the following test of the stadia wire interval:

Horizontal length of base by steel tape measurement.....	17.180 chs.
Mean of 10 rod readings at different hours during the day, vertical rod.....	8.703 ft.
Vertical angle of test.....	+5° 41'
	K=131.487.
Reduced error in 10 chs., correction to be subtracted.....	4.0 lks.

I commence the subdivisional survey at the cor. of secs. 1, 2, 35, and 36, on the S. bdy. of the Tp., which is a sandstone, 8x6x5 ins. above ground, firmly set, marked and witnessed as described in the official record.

N. 0° 01' W., bet. secs. 35 and 36.

Over level bottom land.

- 20.00 Enter scattering ash and cottonwood.
 29.30 S.E. cor. of field; leave scattering timber.
 31.50 A settler's cabin bears West, 6.00 chs. dist.
 39.50 Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for witness $\frac{1}{4}$ sec. cor., with brass cap mkd.



18x18x12 ins., N. and S. of post, 3 ft. dist.

dig pIts,

Enter an ungraded road, bears N. along section line, and E. to Mound City.

- 40.00 True point for $\frac{1}{4}$ sec. cor. falls in road.
 Deposit a sandstone, 14x8x5 ins., mkd. X, 24 ins. in the ground.
 50.50 N.E. cor. of field.
 51.50 Road to Bozeman bears N. 70° W.
 57.50 Enter heavy ash and cottonwood, and dense undergrowth, bears N. 54° E. and S. 54° W.
 72.00 Leave undergrowth.
 80.00 Set an iron post, 3 ft. long, 2 ins. diam., 27 ins. in the ground, for cor. of secs. 25, 26, 35, and 36, with brass cap mkd.



from which

A green ash, 13 ins. diam., bears N. 22° E., 26 lks. dist., mkd. T 15 N R 20 E S 25 R T.

Chains.

- A green ash, 23 ins. diam., bears S. $71\frac{1}{4}^{\circ}$ E., 37 lks. dist., mkd. T 15 N R 20 E S 36 B T.
- A green ash, 17 ins. diam., bears S. 64° W., 41 lks. dist., mkd. T 15 N R 20 E S 36 B T.
- A cottonwood, 13 ins. diam., bears N. $21\frac{1}{4}^{\circ}$ W., 36 lks. dist., mkd. T 15 N R 20 E S 26 B T.

Land, level bottom; northern 20 chs. subject to overflow.
Soil, alluvial, silt and loam; 1st rate.
Timber, green ash and cottonwood; undergrowth, willow.

S. $89^{\circ} 57'$ E., on a random line bet. secs. 25 and 36.

40.00 Set temp. $\frac{1}{4}$ sec. cor.

79.96 Intersect E. bdy. of Tp., 3 lks. N. of cor. of secs. 25, 30, 31, and 36, which is a sandstone, 8x5x5 ins. above ground, marked and witnessed as described in the official record.

Thence

N. $89^{\circ} 56'$ W., on true line bet. secs. 25 and 36.

Over level bottom land, through scattering ash and cottonwood.

10.20 Cherry Creek, 12 lks. wide, course NW.

39.98 Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for $\frac{1}{4}$ sec. cor., with brass cap mkd.

$$\begin{array}{r} 4 \text{ S } 25 \\ \hline 1 \text{ S } 36 \\ \hline 1925 \end{array}$$

from which

A green ash, 8 ins. diam., bears N. $64\frac{1}{4}^{\circ}$ W., 124 lks. dist., mkd. $\frac{1}{4}$ S 25 B T.

A green ash, 7 ins. diam., bears S. $65\frac{1}{4}^{\circ}$ W., 189 lks. dist., mkd. $\frac{1}{4}$ S 36 B T.

79.96 The cor. of secs. 25, 26, 35, and 36.

Land, level bottom; mostly subject to overflow.
Soil, alluvial, silt and loam; 1st rate.
Timber, green ash and cottonwood.

N. $0^{\circ} 01'$ W., bet. secs. 25 and 26.

Over level bottom land, through heavy ash and cottonwood.

25.36 Right bank of Yellowstone River, course N. 81° E.; banks 2 to 12 ft. high; water is high at present stage and from 1 to 8 ft. deep.

Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for meander cor. of frac. secs. 25 and 26, with brass cap mkd.

$$\begin{array}{r} \text{M C} \\ \hline \text{S } 26 \text{ | } \text{S } 25 \\ \text{T } 15 \text{ N | } \text{R } 20 \text{ E} \\ \hline 1925 \end{array}$$

from which

Chains.

A cottonwood, 12 ins. diam., bears S. $18\frac{1}{4}^{\circ}$ E., 16 lks. dist., mkd. T 15
N R 20 E S 25 M C B T.

A green ash, 11 ins. diam., bears S. $74\frac{1}{2}^{\circ}$ W., 25 lks. dist., mkd. T 15
N R 20 E S 26 M C B T.

Stadia to left bank of river: 12.096 and 12.088 ft., $-0^{\circ} 10'$.

49.46 Left bank of river.

Set a washed granite boulder, $34 \times 9 \times 7$ ins., 24 ins. in the ground, for meander
cor. of frac. secs. 25 and 26, mkd.

5 grooves on N.,
1 groove on E.,
M C on S., and
5 grooves on W. face; from which

A green ash, 10 ins. diam., bears N. $34\frac{1}{4}^{\circ}$ E., 228 lks. dist., mkd. T 15
N R 20 E S 25 M C B T.

Raise a mound of stone, 5 ft. base, 3 ft. high N. of cor.

Enter scattering timber.

52.60 Bluff, 20 ft. high, bears E. and W.; leave timber.

63.80 Telephone line, bears E. and W.

80.00 Set an iron post, 3 ft. long, 2 ins. diam., 26 ins. in the ground, for cor. of
secs. 23, 24, 25, and 26, with brass cap mkd.

T 15 N	R 20 E
S 23	S 24
S 26	S 25
1925	

18x18x12 ins., in each sec., 3 ft. dist.

dig pits,

Land, nearly level; 52 chs. bottom land subject to overflow.
Soil, alluvial, silt and loam, 1st rate; and sandy, 2d rate.
Timber, green ash and cottonwood, south of river.

S. $89^{\circ} 56'$ E., on a random line bet. secs. 24 and 25.

40.00 Set temp. $\frac{1}{4}$ sec. cor.

79.98 Intersect E. bdy. of Tp., 3 lks. N. of cor. of secs. 19, 24, 25, and 30, which is
a sandstone, $12 \times 9 \times 5$ ins., poorly mkd. with 4 notches on one edge and 2
notches on opposite edge, lying on the ground on the east side of a small
mound of stone.

At point for cor.,

Set an iron post, 3 ft. long, 2 ins. diam., 27 ins., in the ground, for cor. of
secs. 19, 24, 25, and 30, with brass cap mkd.

T 15 N	
R 20 E	R 21 E
S 24	S 19
S 25	S 30
1925	

of stone, 2 ft. base, $1\frac{1}{2}$ ft. high, W. of cor.

raise a mound

Chains.

Thence

N. 89° 55' W., on true line bet. secs. 24 and 25.

Over level land.

38.00 Fletcher's dinner station and corral bears South, 8 chs. dist.

39.99 Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for $\frac{1}{4}$ sec. cor., with brass cap mkd.

$$\begin{array}{r} \frac{1}{4} \quad 5 \quad 24 \\ \hline 5 \quad 25 \\ \hline 1925 \end{array}$$

18x18x12 ins., E. and W. of post, 3 ft. dist.

dig pits,

70.00 A graded road, bears N. 73° W. and S. 73° E., from Mound City to Lewis-town.

79.98 The cor. of secs. 23, 24, 25, and 26.

Land, level.

Soil. sandy; 2d and 3d rate.

No timber.

NOTE.—The field notes continue in the regular order and on the same form; the record of 3 miles omitted.

S. 89° 55' E., on a random line bet. secs. 12 and 13.

80.03 Intersect E. bdy. of Tp., 7 lks. N. of cor. of secs. 7, 12, 13, and 18, which is a sandstone, 8x5x8 ins. above ground, firmly set, marked and witnessed as described in the official record.

Thence

N. 89° 52' W., on true line bet. secs. 12 and 13.

Over nearly level land.

31.49 Intersect the NE. bdy. of the Rancho San Blas.

Set an iron post, 3 ft. long, 2 ins. diam., 27 ins. in the ground, for closing cor. of frac. secs. 12 and 13, with brass cap mkd.

$$\begin{array}{r} \text{T 15 N} \\ \text{RSB} \diagdown \text{S 12} \text{CC} \\ \text{LG} \diagup \text{S 13} \text{R 20 E} \\ \hline 1925 \end{array}$$

of stone, 2 ft. base, 1½ ft. high, E. of cor.

raise a mound

From this point the 5th Ml. Cor. of the grant boundary bears S. 33° 00' E., 7.00 chs. dist.; a limestone, 15x8x5 ins. above ground, firmly set, marked and witnessed as described in the official record.

Chains.

Thence on a blank line across the grant.

40. 01½ Point for ¼ sec. cor.

67. 07 Intersect the NW. bdy. of the grant.

Set a granite stone, 25x7x6 ins., 16 ins. in the ground, for closing cor. of frac. secs. 12 and 13, mkd.

2 grooves on N.,
 R S B L G on E.,
 4 grooves on S., and
 C C and 6 grooves on W. face; and raise a mound of stone,
 2 ft. base, 1½ ft. high, W. of cor.

From this point the 3½ Mi. Cor. of the grant boundary bears N. 19° 30' W.,
 12.00 chs. dist.; a flint stone, 12x6x8 ins. above ground, firmly set, marked
 and witnessed as described in the official record.

The closing corner is located on the top of a ridge bearing N. 15° W. and
 S. 15° E.; thence over rough stony ground.

76. 00 Begin descent over broken SW. slope.

80. 03 The cor. of secs. 11, 12, 13, and 14.

Land, eastern part, level; western part, mountainous.
 Soil, sandy loam, 2d rate; and stony, 4th rate.
 No timber.

N, 0° 01' W., bet. secs. 11 and 12.

Ascend over broken SW. slope.

11. 00 Top of ascent, bears N. 50° W. and S. 50° E.; thence over nearly level land.

36. 00 Intersect the NW. bdy. of the Rancho San Blas.

Set an iron post, 3 ft. long, 2 ins. diam., 26 ins. in the ground, for closing cor. of frac. secs. 11 and 12, with brass cap mkd.



from which

A lone juniper, 20 ins. diam., bears S. 34° 25' W., 484 lks. dist., mkd.
 T 15 N R 20 E S 11 C C B T.

Raise a mound of stone, 2 ft. base, 1½ ft. high, S. of cor.

From this point Cor. No. 7 of the grant boundary bears N. 19° 30' W.,
 7.40 chs. dist.; a granite boulder, 8x4x1½ ft. above ground, marked and
 witnessed as described in the official record.

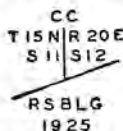
Chains.

Thence on a blank line across the grant.

40.00 Point for $\frac{1}{4}$ sec. cor.

44.32 Intersect the NW. bdy. of the grant.

Set an iron post, 3 ft. long, 2 ins. diam., 15 ins. in the ground to bedrock, with a granite stone, 10x7x8 ins., mkd. X, deposited at the base, and in a mound of stone to top, for closing cor. of frac. secs. 11 and 12, with brass cap mkd.



From this point Cor. No. 7 of the grant boundary bears S. 73° 00' W., 2.58 chs. dist., previously described.

Thence over rolling ground.

60.80 A creek, 6 lks. wide, course SE.

80.00 Set a granite stone, 24x10x7 ins., 16 ins. in the ground, for cor. of secs. 1, 2, 11, and 12, mkd. with 1 notch on E. and 5 notches on S. edge; and raise a mound of stone, 2 ft. base, 1½ ft. high, W. of cor.

Land, mountainous.

Soil, sandy clay, 3d rate; and stony, 4th rate.

Timber, a few scattering juniper.

S. 89° 52' E., on a random line bet. secs. 1 and 12.

40.00 Set temp. $\frac{1}{4}$ sec. cor.

80.04 Intersect E. bdy. of Tp., 7 lks. N. of cor. of secs. 1, 6, 7, and 12, which is an oak post, 4 ins. sq., 12 ins. above ground, firmly set, marked and witnessed as described in the official record.

Thence

N. 89° 49' W., on true line bet. secs. 1 and 12.

Over rolling land.

3.50 Enter a grove of heavy oak timber, bears North and S. 20° W.

18.07 A burr oak, 12 ins. diam., on line, mkd. with two hacks each on E. and W. sides.

40.02 Set a granite stone, 28x11x9 ins., 18 ins. in the ground, for $\frac{1}{4}$ sec. cor., mkd. $\frac{1}{4}$ on N. face; from which

A burr oak, 9 ins. diam., bears N. 19½° W., 22 lks. dist., mkd. $\frac{1}{4}$ S 1 B T.

A burr oak, 11 ins. diam., bears S. 65¾° W., 129 lks. dist., mkd. $\frac{1}{4}$ S 12 B T.

41.10 A ravine, course S. 20° W.

49.60 A ravine, course S. 30° W.

Chains.

- 69.00 Leave grove, bears NE. and SE.
- 80.04 The cor. of secs. 1, 2, 11, and 12.
Land, rolling mountainous.
Soil, sandy clay, 3d rate; and stony, 4th rate
Timber, burr oak.
-
- N. 0° 01' W., on a random line bet. secs. 1 and 2.
- 40.00 Set temp. $\frac{1}{4}$ sec. cor.
- 79.77 Intersect N. bdy. of the Tp. at the cor. of secs. 1, 2, 35, and 36, which is a limestone, 16x6x5 ins., mkd. with 1 notch on E. and 5 notches on W. edge, loosely set, with small mound of stone on the W.
- At point for cor.
- Set an iron post, 3 ft. long, 2 ins. diam., 10 ins. in the ground to bedrock, with the original stone deposited at the base, and in a mound of stone to top, for cor. of secs. 1, 2, 35, and 36, with brass cap mkd.
- | | | | | | |
|---|----|------|---|----|----|
| T | 16 | N | R | 20 | E |
| | S | 35 | | S | 36 |
| | S | 2 | | S | 1 |
| | T | 15 | N | | |
| | | 1925 | | | |
- Thence
- S. 0° 01' E., on true line bet. secs. 1 and 2.
- Over rolling land.
- 30.50 An arroyo, course N. 70° E.
- 39.77 Set a limestone, 20x10x6 ins., 13 ins. in the ground, for $\frac{1}{4}$ sec. cor., mkd. $\frac{1}{4}$ on W. face; and raise a mound of stone, 2 ft. base, 1 $\frac{1}{2}$ ft. high, W. of cor.
- 79.77 The cor. of secs. 1, 2, 11, and 12.
Land, rolling mountainous.
Soil, sandy clay; 3d rate.
No timber.
-
- Thence from the cor. of secs. 2, 3, 34, and 35, on the S. bdy. of the Tp., which is a sandstone, 14x8x8 ins. above ground, firmly set, marked and witnessed as described in the official record.
- N. 0° 02' W., bet. secs. 34 and 35.
- Over level bottom land.
- 40.00 Set a sandstone, 28x10x8 ins., 21 ins. in the ground, for $\frac{1}{4}$ sec. cor., mkd. $\frac{1}{4}$ on W. face; and raise a mound of stone, 2 ft. base, 1 $\frac{1}{2}$ ft. high, W. of cor.

- Chains.*
 42.00 Leave bottom land, bears N. 70° E. and S. 70° W.; ascend sandy ridge.
 46.00 Top of wind-blown sand ridge, bears N. 70° E. and S. 70° W.
 50.00 Foot of sand ridge; thence over nearly level land.
 80.00 Set an iron post, 3 ft. long, 2 ins. diam., in a concrete form, 8 ins. upper diam., 14 ins. lower diam., and 36 ins. long, 24 ins. in the ground, for cor. of secs. 26, 27, 34, and 35, with brass cap mkd.

T 15 N	R 20 E
S 27	S 26
S 34	S 35
1925	

No suitable accessory.

Land, south-half, level bottom subject to overflow; north-half, level sandy plain.
 Soil, alluvial, silt and loam, 1st rate; and sandy, 3d rate.
 No timber.

- S. 89° 57' E., on a random line bet. secs. 26 and 35.
 40.00 Set temp. $\frac{1}{4}$ sec. cor.
 48.13 Left bank of river; set temp. meander cor.
 Stadia to right bank: 9.063 and 9.051 ft., level.
 66.32 Right bank of river; set temp. meander cor.
 80.06 Intersect N. and S. line, 3 lks. S. of cor. of secs. 25, 26, 35, and 36.
 Thence
 N. 89° 58' W., on true line bet. secs. 26 and 35.
 Over level bottom land, through heavy ash and cottonwood.
 13.74 Right bank of Yellowstone River, course N. 20° W.; banks 2 to 10 ft. high; water is high at present stage and from 1 to 8 ft. deep.
 Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for meander cor. of frac. secs. 26 and 35, with brass cap mkd.

M C	T 15 N
	S 26
	S 35
	R 20 E
1925	

from which

A green ash, 9 ins. diam., bears N. 49 $\frac{1}{4}$ ° E., 26 lks. dist., mkd. T 15 N R 20 E S 26 M C B T.

A cottonwood, 13 ins. diam., bears S. 38 $\frac{1}{2}$ ° E., 21 lks. dist., mkd. T 15 N R 20 E S 35 M C B T.

Chains. 31.93	Left bank of river. Set a washed granite boulder, 40x12x8 ins., 30 ins. in the ground, for meander cor. of frac. secs. 26 and 35, mkd. 5 grooves on N., M C on E., 1 groove on S., and 5 grooves on W. face; and raise a mound of stone, 5 ft. base, 3 ft. high, W. of cor. Ascend gradually through scattering timber.
37.50	Leave timber.
40.03	Set a granite stone, 24x12x8 ins., 16 ins. in the ground, for $\frac{1}{4}$ sec. cor., mkd $\frac{1}{4}$ on N. face; from which A green ash, 14 ins. diam., bears N. 28° 50' E., 328 lks. dist., mkd. $\frac{1}{4}$ S 26 B T. A green ash, 9 ins. diam., bears S. 78° 05' E., 278 lks. dist., mkd. $\frac{1}{4}$ S 35 B T.
70.50	An ungraded road, bears N. 68° W. and S. 68° E., from Mound City to Bozeman.
80.06	The cor. of secs. 26, 27, 34, and 35. Land, east of river, level bottom subject to overflow; west of river, level upland. Soil, alluvial, silt and loam, 1st rate; and sandy, 3d rate. Timber, green ash and cottonwood.
NOTE.—The field notes continue in the regular order, and on the same form; the record of 13 miles omitted.	
	N. 0° 03' W., bet. secs. 21 and 22. Over level land.
13.90	Enter marsh, bears N. 60° E. and N. 80° W.
40.00	Set a brass tablet, 3½ ins. diam., 3 in. stem, in a cylindrical concrete form, 36 ins. long, 6 ins. diam., 24 ins. in the ground, for $\frac{1}{4}$ sec. cor., with top mkd. <div style="text-align: center;"> <p style="text-align: center;">S 21 S 22 1926</p> </div>
	No suitable accessory.
53.60	Leave marsh, bears N. 30° W. and S. 60° E.

Chains.
80.00

Set a brass tablet, $3\frac{1}{2}$ ins. diam., 3 in. stem, in a concrete form, 8 ins. upper diam., 14 ins. lower diam., 36 ins. long, 24 ins. in the ground, for cor. of secs. 15, 16, 21, and 22, with top mkd.

T 15 N R 20 E	
S 16	S 15
S 21	S 22
1925	

No suitable accessory.

Land, level; 39.70 chs., swamp and overflowed.

Soil, rich loam; 1st rate.

No timber.

NOTE.—The field notes continue in the regular order, and on the same form; the record of 17 miles omitted.

The cor. of secs. 5, 6, 31, and 32, on the S. bdy. of the Tp., is a limestone $15 \times 8 \times 6$ ins., poorly mkd. with 5 notches on one edge and 1 notch on opposite edge, lying on the ground on the east side of a small mound of stone.

At point for cor.

Set an iron post, 3 ft. long, 2 ins. diam., 27 ins. in the ground, for cor. of secs. 5, 6, 31, and 32, with brass cap mkd.

T 15 N R 20 E	
S 31	S 32
S 6	S 5
T 14 N	
1925	

of stone, 2 ft. base, $1\frac{1}{2}$ ft. high, W. of cor.

raise a mound

N. $0^\circ 05'$ W., bet. secs. 31 and 32.

Over level land.

40.00 Set a brass tablet, $3\frac{1}{2}$ ins. diam., 3 in. stem, in a cylindrical concrete form, 36 ins. long, 6 ins. diam., 24 ins. in the ground, for $\frac{1}{4}$ sec. cor., with top mkd.

$\frac{1}{4}$	
S 31	S 32
1925	

No suitable accessory.

80.00 Set an iron post, 3 ft. long, 2 ins. diam., 27 ins. in the ground, for cor. of secs. 29, 30, 31, and 32, with brass cap mkd.

T 15 N R 20 E	
S 30	S 29
S 31	S 32
1925	

of stone, 2 ft. base, $1\frac{1}{2}$ ft. high, W. of cor.

raise a mound

Chains.

Land, level.
Soil, sandy; 3rd rate.
No timber.

S. 89° 57' E., on a random line bet. secs. 29 and 32.

40.00 Set temp. $\frac{1}{4}$ sec. cor.

79.96 Intersect N. and S. line, 7 lks. N. of cor. of secs. 28, 29, 32, and 33.

Thence

N. 89° 54' W., on true line bet. secs. 29 and 32.

Over level land.

14.50 Base of slope, bears N. 30° E. and S. 30° W.

16.50 Top of slope.

23.50 A spring bears South, 2.50 chs. dist.

39.98 Set a brass tablet, $3\frac{1}{2}$ ins. diam., 3 in. stem, in a cylindrical concrete form, 36 ins. long, 6 ins. diam., 24 ins. in the ground, for $\frac{1}{4}$ sec. cor., with top mkd.

	S	29
$\frac{1}{4}$	S	32
	1925	

No suitable accessory.

79.96 The cor. of secs. 29, 30, 31, and 32

Land, level.
Soil, sandy; 3d rate.
No timber.

N. 89° 57' W., on a random line bet. secs. 30 and 31.

40.00 Set temp. $\frac{1}{4}$ sec. cor.

78.35 Intersect W. bdy. of Tp. at the cor. of secs. 25, 30, 31, and 36, where I find the evidence of four pits, one in each section, NE., SE., SW., and NW., with a part of an old stake bearing incomplete scribe marks lying in the SE. pit.

At point for cor.

Set an iron post, 3 ft. long, 2 ins. diam., 27 ins. in the ground, for cor. of secs. 25, 30, 31, and 36, with brass cap mkd.

	T I S N		
R	19 E		R 20 E
S	25		S 30
S 36			S 31
	1925		

18x18x12 ins., in each sec. $5\frac{1}{4}$ ft. dist.

renew the pits

Chains.

Thence

S. 89° 57' E., on true line bet. secs. 30 and 31.

Over level land.

38.35 Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for ¼ sec. cor., with brass cap mkd.



18x18x12 ins., E. and W. of post, 3 ft. dist.

dig pits,

78.35 The cor. of secs. 29, 30, 31, and 32.

Land, level.

Soil, sandy clay; 2d rate.

No timber.

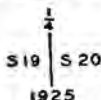
NOTE.—The field notes continue in the regular order and on the same form; the record of 3 miles omitted.

N. 0° 05' W., bet. secs. 19 and 20.

Descend over stony N. slope.

2.00 Base of slope, bears N. 80° E. and S. 80° W.

40.00 Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for ¼ sec. cor., with brass cap mkd.

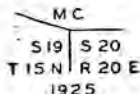


of stone, 2 ft. base, 1½ ft. high, W. of cor.

raise a mound

44.50 South bank of Lins Lake, bears N. 74° W. and East.

Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for meander cor. of frac. secs. 19 and 20, with brass cap mkd.



from which

A boxelder, 8 ins. diam., bears S. 77½° E., 221 lks. dist., mkd. T 15 N R 20 E S 20 M C B T.

A green ash, 10 ins. diam., bears West, 327 lks. dist., mkd. T 15 N R 20 E S 19 M C B T.

Chains.

Land, gently rolling.
Soil, rich loam; 1st rate.
Timber, scattering green ash and box elder along lake shore.

Thence from the cor. of secs. 16, 17, 20, and 21.

N. $89^{\circ} 54'$ W., bet. secs. 17 and 20.

Descending gradually over gently rolling land.

20.50 An ungraded wagon road, bears N. and S.

28.70 Irrigation ditch, bears N. 30° E. and S. 30° W.; enter cultivated field.

36.50 Leave field; enter heavy ash and boxelder, bears N. 30° E. and S. 30° W.

40.00 Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for $\frac{1}{4}$ sec. cor., with brass cap mkd.

$$\begin{array}{r} \text{S } 17 \\ \frac{1}{4} \\ \hline \text{S } 20 \\ 1925 \end{array}$$

from which

A box elder, 12 ins. diam., bears N. $22\frac{1}{4}^{\circ}$ W., 119 lks. dist., mkd. $\frac{1}{4}$ S 17 B T.

A green ash, 13 ins. diam., bears S. $70\frac{1}{2}^{\circ}$ W., 28 lks. dist., mkd. $\frac{1}{4}$ S 20 B T.

43.20 East bank of Lins Lake, bears N. 19° E. and S. $39\frac{3}{4}^{\circ}$ W.

A green ash, 8 ins. diam., for meander cor. of frac. secs. 17 and 20, mkd.

S 17 on N.,
T 15 N R 20 E on E.,
S 20 on S., and
M C on W. side;

from which

A green ash, 10 ins. diam., bears N. $40\frac{3}{4}^{\circ}$ E., 20 lks. dist., mkd. T 15 N R 20 E S 17 M C B T.

A box elder, 6 ins. diam., bears S. $62\frac{1}{4}^{\circ}$ E., 114 lks. dist., mkd. T 15 N R 20 E S 20 M C B T.

Land, gently rolling.
Soil, loam; 1st rate.
Timber, mostly green ash and box elder, with some cottonwood.

NOTE.

The line bet. secs. 8 and 17 is established next by running from the cor. of secs. 8, 9, 16, and 17, N. $89^{\circ} 54'$ W., parallel to the S. bdy. of sec. 17, 80.00 chs., with $\frac{1}{4}$ sec. cor. at 40.00 chs.

The line bet. secs. 17 and 18 is then established by running from the cor. of secs. 7, 8, 17, and 18, S. $0^{\circ} 05'$ E., parallel to the E. bdy. of sec. 17, 20.19 chs., to the north bank of Lins Lake.

Chains.

The line bet. secs. 7 and 18 is established by random and true line method with closing sec. cors. on the E. and W. bdrs. of the Lake City Townsite, but without a $\frac{1}{4}$ sec. cor. as the point for the same falls within the townsite. The field notes call for a point for the $\frac{1}{4}$ sec. cor. at 40.00 chs. from the east.

The remaining 4 miles of the regular subdivisional lines are established in the normal manner, and at the $\frac{1}{4}$ sec. cor. on the line bet. secs. 5 and 8 the bearing and distance to the U. S. Mineral Monument, located in the SW $\frac{1}{4}$ SE $\frac{1}{4}$, sec. 5, is determined and recorded.

IVY ISLAND.

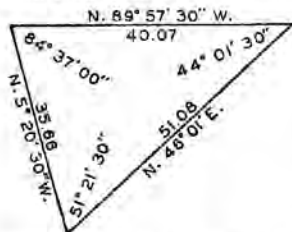
In order to establish the line bet. secs. 18 and 19, which crosses Ivy Island in Lius Lake, I return to the meander cor. of frac. secs. 17 and 20, and sight N. $89^{\circ} 51' W.$, on an extension of the section line, to a temp. point on the SE. bank of the island.

At the point on the island I observe the bearing to the meander cor. of frac. secs. 19 and 20, on the south bank of the lake, and by calculation determine that this position is 80.04 chs. N. of the S. bdy of sec. 19. I then move the temp. point 4 lks. south.

From the adjusted point the meander cor. of frac. secs. 19 and 20 bears S. $5^{\circ} 20' 30'' E.$, and the meander cor. of frac. secs. 17 and 20 bears S. $89^{\circ} 57' 30'' E.$

As a base for the triangulation I employ the meanders of the lake in sec. 20, hereinafter described, which reduce to an equivalent direct line between the meander corners with a bearing of N. $46^{\circ} 01' E.$, and a length of 51.08 chs.

The calculated angles of the triangle are shown in the following diagram:



The resulting distances across the lake are N. $89^{\circ} 57' 30'' W.$, 40.07 chs., and N. $5^{\circ} 20' 30'' W.$, 35.66 chs.

The latter course and distance reduce to a northing of 35.50 chs., and a westing of 3.32 chs.; the allowance for the bearing of the E. bdy. of sec. 19, continued to the theoretical point for the cor. of secs. 17, 18, 19, and 20, in the lake, is 5 lks., making the net westing 3.27 chs.

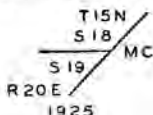
N. $89^{\circ} 58' W.$, bet. secs. 18 and 19.

Over water.

3. 27 The adjusted point on the SE. bank of Ivy Island; the bank bears N. $47\frac{1}{4}^{\circ} E.$ and S. $47\frac{1}{4}^{\circ} W.$

Chains.

Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for meander cor. of frac. secs. 18 and 19, with brass cap mkd.



from which

A burr oak, 9 ins. diam., bears N. $16\frac{1}{4}^\circ$ W., 29 lks. dist., mkd. T 15 N R 20 E S 18 M C B T.

A green ash, 8 ins. diam., bears S. $78\frac{3}{4}^\circ$ W., 127 lks. dist., mkd. T 15 N R 20 E S 19 M C B T.

Thence over level land, across Ivy Island.

7.38 The SW. bank of the island, bears N. $5\frac{1}{2}^\circ$ W. and S. 52° E.

Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for meander cor. of frac. secs. 18 and 19, with brass cap mkd.



of stone, 2 ft. base, $1\frac{1}{2}$ ft. high, E. of cor.

raise a mound

Land, nearly level; being higher to the north side of the island.

Soil, rich loam, 1st rate; and stony, 3d rate.

Timber, scattering burr oak and green ash.

MEANDERS OF IVY ISLAND.

Thence with the meanders of Ivy Island in sec. 18.

Along the top of a well-defined escarpment situated at the upper side of a gravelly beach.

N. $5^\circ 30'$ W., 2.90 chs.

N. $35^\circ 00'$ W., 1.60 chs.

S. $45^\circ 15'$ W., 1.40 chs.

S. $56^\circ 00'$ W., 2.30 chs.

N. $73^\circ 30'$ W., 4.50 chs.

N. $38^\circ 00'$ W., 6.40 chs. On this course the bank increases in height from 3 to 15 ft., and the beach becomes narrow and rocky.

N. $12^\circ 00'$ E., 4.20 chs.

N. $59^\circ 15'$ E., 5.30 chs. On this course the bank becomes a nearly vertical cliff, 35 ft. above mean high water.

Chains.

East, 2.60 chs.

S. 36° 00' E., 3.80 chs.

S. 56° 15' E., 6.40 chs. On this course leave cliff; bank gradually becomes lower, down to a height of about 4 ft.

S. 29° 00' E., 7.00 chs.

S. 47° 15' W., 3.40 chs. The meander cor. of frac. secs. 18 and 19.

Land, rolling.

Soil, loam, 1st rate; and stony, 3d rate.

Timber, scattering burr oak and green ash; undergrowth, ivy.

Thence in sec. 19.

Along the top of a low bank, from 1 to 4 ft. in height, on the upper side of a gravelly beach.

S. 47° 15' W., 2.50 chs.

N. 53° 10' W., 2.84 chs. The meander cor. of frac. secs. 18 and 19, and place of beginning.

Land, level.

Soil, loam, 1st rate; and gravelly, 2d rate.

Timber, scattering burr oak and green ash; no undergrowth.

The detail of the improvements on the island is carried to the general description at the close of the field notes, and to the plat of the survey.

DIAMOND ROCK.

In order to survey a small island called Diamond Rock, in Lins Lake, in sec. 18, I proceed to the meander cor. of frac. Tps. 15 N., Rs. 19 and 20 E., on the south bank of the lake, which is a limestone, 14 x 8 x 8 ins. above ground, firmly set, marked and witnessed as described in the official record.

N. 71° 30' E., on a connecting line.

Over water.

Distance by stadia: 10.752 and 10.761 ft., level.

21.44 The SW. bank of Diamond Rock at mean high water elevation.

Set a brass tablet, 3½ ins. diam., 3 in. stem, in solid rock, for auxiliary meander cor. in sec. 18, with top mkd.

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S 18
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of stone, 2 ft. base, 1½ ft. high, N.E. of cor.

raise a mound

Chains.

From this point the meander cor. of frac. Tps. 15 N., Rs. 19 and 20 E., on the north bank of the lake, bears N. 25° 02' W.; the connecting distance, by triangulation, with the crossing distance on the W. bdy. of the Tp. as the base, is 48.03 chs.; a juniper post, 4 ins. sq., 1 ft. above ground, firmly set, marked and witnessed as described in the official record.

Thence with the meanders of the island.

Along the top of a low, but well-defined bank, on the upper side of a gravelly beach.

N. 16° 50' W., 2.70 chs.

N. 61° 15' E., 2.50 chs.

S. 48° 30' E., 3.50 chs.

S. 33° 00' W., 2.20 chs.

N. 86° 46' W., 3.19 chs. The auxiliary meander cor.

Land, level.

Soil, gravelly loam; 2d rate.

No timber.

MEANDERS OF LINS LAKE.

I return to the meander cor. of frac. Tps. 15 N., Rs. 19 and 20 E., on the south bank of the lake, heretofore described.

Thence with the meanders of Lins Lake in sec. 19.

NOTE.—The detail of 15 courses, running to the meander cor. of frac. secs. 19 and 20, omitted.

Thence in sec. 20.

Along the top of a well-defined bank, from 2 to 4 ft. in height, on the upper side of a gravelly beach; through scattering ash and oak.

S. 89° 45' E., 6.10 chs.

N. 57° 00' E., 12.00 chs.

N. 37° 30' E., 10.50 chs.

N. 46° 00' E., 5.00 chs.

N. 23° 15' E., 9.90 chs. On this course enter a belt of heavy ash and oak, parallel to the bank.

N. 39° 45' E., 10.48 chs. The meander cor. of frac. secs. 17 and 20.

Land, level.

Soil, gravelly loam; 2d rate.

Timber, green ash and burr oak.

NOTE.—The meanders continue around the north bank of the lake through secs. 17 and 18, on the same form; the record omitted.

Chains.

CLEAR LAKE.

I return to the $\frac{1}{4}$ sec. cor. on the N. bdy. of sec. 33.

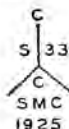
S. $0^{\circ} 03' E.$, on the theoretical bearing of the N. and S. center line of sec. 33.

Over level land.

3.50 Spring branch, 8 lks. wide, course S. $80^{\circ} E.$

24.00 North bank of Clear Lake, bears S. $53^{\circ} E.$ and S. $52^{\circ} W.$

Set an iron post, 3 ft. long, 1 in. diam., 27 ins. in the ground, for special meander cor., with brass cap mkd.



of stone, 2 ft. base, $1\frac{1}{2}$ ft. high, N. of cor.

raise a mound

Thence with the meanders of the lake.

Along the top of a well-defined bank, from 6 to 10 ft. in height.

S. $53^{\circ} 00' E.$, 17.00 chs. At 11.00 chs. enter grove of scattering ash and oak; at end of course, the outlet of a spring branch, 12 lks. wide.

S. $3^{\circ} 00' E.$, 13.00 chs. At 7.00 chs. leave scattering timber.

S. $0^{\circ} 30' W.$, 7.20 chs. At end of course, the outlet of the lake, 20 lks. wide, course SE.

S. $70^{\circ} 00' W.$, 15.10 chs. Along a belt of heavy ash and oak, parallel to the bank.

N. $63^{\circ} 45' W.$, 10.00 chs. At 7.00 chs. leave timber.

N. $13^{\circ} 00' W.$, 21.00 chs. At end of course, the outlet of a spring branch, 8 lks. wide.

N. $52^{\circ} 00' E.$, 17.34 chs. Along scattering timber for 8 chs. At end of course, the special meander cor.

Land, level and gently rolling.

Soil, loam; 1st rate.

Timber, green ash and burr oak.

MEANDERS OF THE YELLOWSTONE RIVER.

I proceed to the meander cor. of frac. Tps. 15 N., Rs. 20 and 21 E., on the right bank of the Yellowstone River, which is a sandstone, 16x9x7 ins. above ground, firmly set, marked and witnessed as described in the official record.

Thence upstream with the meanders of the right bank of the river, in sec. 25.

Chains.

Over bottom land, along a well-defined cut-bank, from 2 to 12 ft. high, through heavy ash and cottonwood.

S. 85° 00' W., 13.00 chs.

S. 72° 00' W., 7.10 chs.

S. 64° 30' W., 13.00 chs.

S. 40° 30' W., 5.40 chs. At end of course, mouth of Cherry Creek, 14 lks. wide.

S. 77° 45' W., 7.00 chs.

N. 76° 00' W., 7.40 chs.

S. 80° 00' W., 12.00 chs.

S. 81° 08' W., 19.43 chs. The meander cor. of frac. secs. 25 and 26.

Land, level bottom; subject to overflow.

Soil, alluvial, silt and loam; 1st rate.

Timber, green ash and cottonwood.

Thence in sec. 26.

NOTE.—The meanders of the right bank are continued upstream in secs. 26 and 35, to the S. bdy. of the Tp.; the field notes then show the meanders of the left bank running downstream in secs. 35, 26, and 25, all on the same form; the record is omitted.

LAKE CITY TOWN SITE.

By an examination on the ground and in consultation with the surveyor who was employed by the applicants for the subdivision of the Lake City town site, I ascertain that a preliminary survey was initiated at the $\frac{1}{4}$ sec. cor. on the W. bdy. of sec. 7, with the intention of conforming the N. bdy. of the town site to the E. and W. center line of this section, when officially established. A calculated position for the W. $\frac{1}{8}$ sec. cor. on that line was adopted as the temp. NW. cor. of the town site, and the temp. NE. cor. was placed at a point where a line running south would include all contemplated improvements; the temporary E. and W. bdrs. were run south to Lins Lake. I find that this general plan can be adhered to.

Transit methods, without the use of the solar attachment, were employed in the survey of the boundaries and subdivision of secs. 7 and 18, and in the survey of the E. bdy. of the town site, the azimuths being referred to a meridian established by Polaris observation, as follows:

(NOTE.—Record of observation upon Polaris at eastern elongation, at the cor. of secs. 7, 8, 17, and 18, omitted.)

I proceed with the subdivision of secs. 7 and 18, and with the establishment of the town-site boundaries, with the following true-line results.

I return to the true point for the $\frac{1}{4}$ sec. cor. on the S. bdy. of sec. 7, thence N. 0° 05' W., on the N. and S. center line.

40.00 Intersect the E. and W. center line.

80.04 The $\frac{1}{4}$ sec. cor. on the N. bdy. of sec. 7.

Chains.

Thence from the $\frac{1}{4}$ sec. cor. on the E. bdy. of sec. 7.N. $89^{\circ} 56' W.$, on the E. and W. center line.

- 25.80 Set an iron post, 3 ft. long, 3 ins. diam., in a concrete form, 8 ins. upper diam., 14 ins. lower diam., 36 ins. long, 24 ins. in the ground, for NE. cor. of town site, with brass cap mkd.



From this point the temp. NE. cor. bears North, 7 lks. dist.; a limestone, $21 \times 14 \times 9$ ins., mkd. NE COR L C; I remove the stone.

Thence continue on the E. and W. center line, along the N. bdy. of the town site.

- 40.00 Intersect the N. and S. center line.

Set an iron post, 3 ft. long, 1 in. diam., in a concrete form, 8 ins. upper diam., 14 ins. lower diam., 36 ins. long, 24 ins. in the ground, for center $\frac{1}{4}$ sec. cor., with brass cap mkd.



- 60.00 Set an iron post, 3 ft. long, 3 ins. diam., in a concrete form, 8 ins. upper diam., 14 ins. lower diam., 36 ins. long, 24 ins. in the ground, for W. $\frac{1}{4}$ sec. cor. and NW. cor. of town site, with brass cap mkd.



From this point the temp. NW. cor. bears N. $81^{\circ} 45' E.$, 14 lks. dist.; an oak post, 4 ins. sq., 4 ft. long, mkd. NW COR L C; I remove the post.

Thence continue on the E. and W. center line.

- 77.885 The $\frac{1}{4}$ sec. cor. on the W. bdy. of sec. 7, which is a limestone, $12 \times 8 \times 10$ ins. above ground, firmly set, marked and witnessed as described in the official record.

Thence from the NE. cor. of the town site.

S. $0^{\circ} 05' E.$, on the E. bdy. of the town site.

- 40.00 The closing cor. of secs. 7 and 18.

Thence in sec. 18.

Chains.
7.53

The north bank of Lins Lake.

Set an iron post, 3 ft. long, 3 ins. diam., in a concrete form, 8 ins. upper diam., 14 ins. lower diam., 36 ins. long, 24 ins. in the ground, for auxiliary meander cor. and SE. cor. of town site, with brass cap mkd.

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From this point the temp. SE. cor. bears West, 6 lks. dist.; a limestone, 18x9x6 ins., mkd. SE COR L C; I remove the stone.

Thence from the W. $\frac{1}{16}$ sec. cor. on the E. and W. center line of sec. 7, and NW. cor. of town site.

S. $0^{\circ} 05' E.$, on the N. and S. center line of the SW $\frac{1}{4}$ and W. bdy. of the town site.

40.00 The closing cor. of secs. 7 and 18 at the point for the W. $\frac{1}{16}$ sec. cor.

Thence in sec. 18, on the N. and S. center line of the NW $\frac{1}{4}$.

20.50 The north bank of Lins Lake.

Set an iron post, 3 ft. long, 3 ins. diam., in a concrete form, 8 ins. upper diam., 14 ins. lower diam., 36 ins. long, 24 ins. in the ground, for special meander cor. and SW. cor. of town site, with brass cap mkd.

	W
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	T S
W	
S M C	
1925	

From this point the temp. SW. cor. bears East, 4 lks. dist.; a limestone 16x8x6 ins., mkd. SW COR L C; I remove the stone.

MEMORANDUM.

The segregation of the mineral claims in secs. 4 and 5 and the computation of the areas of the surrounding fractional lots that are subject to entry as agricultural land are derived by aid of the field notes and plats of the mineral patent surveys, which show the connecting courses and distances to the U. S. Mineral Monument located in the SW $\frac{1}{4}$ SE $\frac{1}{4}$, sec. 5. The position of the latter monument, with reference to the quarter-section corner on the south boundary of the section, is shown in the record of the subdivisional survey. Ordinarily, the courses and distances along the boundaries of the mineral claims can not be shown at the scale of the township plat, in addition to the more essential information.

The survey of the boundaries of the Rancho San Blas was made under the provisions of the public land laws (R.S., 2447; Manual, sec. 8, subsec. 118), prior to the subdivision of the township.

The location of the right of way of the Montana & Manitoba R. R. with reference to the subdivisional survey is ascertained by notation of the intersections on the section boundaries, and by aid of the map filed with the application for a right of way across public land. The land occupied by the railroad is not segregated from the public lands excepting within a town site.

FINAL TEST OF SOLAR ATTACHMENT.

June 30: At the cor. of secs. 7, 8, 17, and 18, at 6^h 45^m a. m., app. t., I set off 45° 48' 30" N., on the lat. arc; 23° 13' N., on the decl. arc; and orient the instrument with the solar; the line of sight agrees with the meridian established by Polaris observation.

At 4^h 30^m p. m., app. t., I set off 45° 48' 30" N., on the lat. arc; 23° 11' N., on the decl. arc; and repeat the test of the solar; the line of sight agrees with the meridian established by Polaris observation.

JUNE 30, 1925.

GENERAL DESCRIPTION.

A considerable variety of land and soil are found in Township 15 North, Range 20 East. The general elevation of the township is about 4,500 ft. above sea level; the summit of the Little Snowy Mountains, which extends into secs. 2 and 3, is about 1,200 ft. higher. Most of the northern and northeastern portion of the township is rough and stony, the central part gently rolling, and the southern part nearly level. The soil of the bottom land along the Yellowstone River is an alluvial silt and loam; much of the soil in the central part of the township is a black loam, but the southwestern part is very sandy. There is one small alkali flat which is located along the line between secs. 23 and 24. There is a heavy stand of cottonwood and green ash along the right bank of the river in sec. 25, a grove of heavy burr oak along the line between secs. 1 and 12, and a good growth of yellow pine, burr oak and fir timber over most of the mountain region.

The Yellowstone River crosses the southeastern part of the township; it is a meandering stream, under surveying rules, but there is no navigation on the river, owing principally to the swift current and occasional rapids; there is a ferry operating in sec. 35. There is some actual navigation on Lins Lake, which is a deep and permanent body of water; only the upper end of the lake extends into this township. Clear Lake is a permanent body of water, and meanderable under the Manual regulations. There is an extensive marsh in secs. 16, 21, and 22, which evidently was the bed of a former shallow lake; the marsh, and a group of springs which are situated along the line between secs. 9 and 16, drain into Lins Lake. There are three good springs in secs. 28 and 32, all of considerable flow, which are tributary to Clear Lake.

The most important developments at the present time are the gold-bearing quartz mineral claims in secs. 4 and 5, and the Montana & Manitoba R. R., which crosses the northwestern part of the township. There is a limestone quarry in the NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 9, which may be considerably expanded if there should be a demand for building stone in this vicinity. The proposed Lake City town site is well chosen and offers many advantages. The applicants for the town site subdivision are making a bona fide effort to encourage an interest in the situation.

There are three settlers in secs. 17 and 20 who have small fields in cultivation, under irrigation; three additional settlers, one in sec. 19, one in sec. 25, and one in sec. 35, have made their first improvements, and one of them has about 40 acres in cultivation. The settlement will doubtless be considerably increased whenever there is a demand for the land, but at the present time the predominating interest is in stock grazing, as there is an excellent growth of native grass over most of the township, which flourishes excepting during periods of drouth, and the township affords an unusual water supply. There are several small cottages on Ivy Island, in Lins Lake, which are occupied at intervals during the summer months, but apparently no one has made a permanent settlement on the island.

At several corner points in the subdivision of the township the site conditions are such that a superior monumentation was desirable. In most of these places this was secured by the employment of an iron post, or a tablet, set in a concrete form shaped as a frustrum of a cone, 8 ins. upper diam., 14 ins. lower diam., 36 ins. long, which were constructed at the points where required. In a few places a tablet was used, set in a cylindrical form of concrete, 36 ins. long, 6 ins. in diam.; a number of these were constructed in camp, allowed to thoroughly set, then transported to the points where needed. There were no trees or stone in those situations where no accessories are recorded, and the soil was not sufficiently firm for pits.

The average of a considerable number of readings over all parts of the township gives a value of $18^{\circ} 10' E.$ for the mean magnetic declination. There is a range of $20'$ in local attraction.

FIELD ASSISTANTS.

*Names.**Capacity.*

..... Chairman.

..... Chairman.

..... Flagman.

..... Axman.

CERTIFICATE OF UNITED STATES CADASTRAL ENGINEER.

I, Robert Acres, United States cadastral engineer, hereby certify upon honor, that in pursuance of special instructions bearing date of the 1st day of April, 1925, received from the district cadastral engineer for Montana, with assignment instructions dated May 20, 1925, I have surveyed the subdivisinal and meander lines of Township No. 15 North, Range No. 20 East, of the Principal Meridian, in the State of Montana, which are represented in the foregoing field notes as having been executed by me and under my direction; and that said survey has been made in strict conformity with said instructions, the Manual of Instructions for the Survey of the Public Lands of the United States, and in the specific manner described in the foregoing field notes.

(Signed) ROBERT ACRES,
U. S. Cadastral Engineer.

HELENA, MONT., March 31, 1926.

CERTIFICATE OF APPROVAL.

OFFICE OF U. S. SUPERVISOR OF SURVEYS,
Denver, Colo., September 15, 1926.

The foregoing field notes of the survey of the subdivisinal and meander lines of Township No. 15 North, Range No. 20 East, of the Principal Meridian, Montana, executed by Robert Acres, United States cadastral engineer, under special instructions dated April 1, 1925, and assignment instructions dated May 20, 1925, having been critically examined, and the necessary corrections made prior to their certification by the engineer, the said field notes, and the survey as described, are hereby approved.

(Signed)
U. S. Supervisor of Surveys.

CERTIFICATE OF TRANSCRIPT.

I certify that the foregoing transcript of the field notes of the above-described surveys in T. 15 N., R. 20 E., is a true copy of the original field notes on file in the public survey office.

(Signed)
U. S. Supervisor of Surveys.

SPECIMEN FIELD NOTES.
MINERAL SURVEY NO. 20220 A AND B.
PUEBLO LAND DISTRICT.

FIELD NOTES

OF THE SURVEY OF THE MINING CLAIM OF
THE GOLD MINING COMPANY

KNOWN AS THE JIM DANDY, PRINCE, AND PROTECTOR LODES
AND DUMP MILL SITE,

Cottonwood Mining District, Chaffee County, Colo.

Sections 7, 8, 17, and 18, Township 16 South, Range 80 West, of the Sixth
Principal Meridian.

Surveyed under instructions dated February 9, 1928, by H. B. Sands,
U. S. Mineral Surveyor.

Survey commenced March 2, 1928; completed March 14, 1928.

Address of claimant's agent, John Jones, 561 Foster Building, Denver,
Colo.

Dates of amended locations: Protector lode, June 16, 1926; Prince lode,
August 10, 1927.

Dates of locations: Jim Dandy lode, July 26, 1912; Dump Mill site,
August 10, 1927.

Survey No. 20220 A.

Feet.

Mineral Survey No. 20220 A and B was made with a Precise Transit No., model No., with horizontal limb 6.25 ins. diam., having two double opposite verniers, and full vertical circle 5 ins. diam., having one double vernier; the verniers read to one minute of arc; the eyepiece is equipped with a colored glass shade set in the dust shutter for making direct observations upon the sun. The instrument was in good condition at the time of the survey and all adjustments were in good order. An a. m. altitude observation of the sun for time and azimuth, and at noon on the meridian for latitude, were made at the point of beginning, the details of which observations are shown in the calculation sheets herewith submitted for examination. All azimuths in this record are referred to the true meridian thus determined, by the method of deflection angles and calculated courses.

The lines were measured with a steel tape 500 feet in length, graduated every foot for 100 ft., and the remainder at intervals of 10 ft.; and a steel tape 50 feet in length, graduated to feet, tenths and hundredths; both tapes were compared with a standard at the time of beginning the survey, and found correct.

All lines and connections of this survey were run by direct methods where the lines are accessible; the inaccessible lines were run by traverse methods, as shown by the calculation sheets herewith submitted.

The magnetic variation observed at each corner of the survey gave a uniform value of 15° 30' E.

JIM DANDY LODE.

Beginning at Cor. No. 1 of the Jim Dandy Lode, where I—

Set a granite stone, 26x10x8 ins., 14 ins. in the ground to bedrock, surrounded by a mound of stone to top, for Cor. No. 1, mkd. J D—1—PRI—1—20220 A; from which

The cor. of secs. 7, 8, 17, and 18, T. 16 S., R. 80 W., 6th Prin. Mer., bears S. 55° 40' W., 212.5 ft. dist.; an iron post, 2 ins. diam., 12 ins. above ground, firmly set, marked and witnessed as described in the official record.

Cor. No. 1 Sur. No. 19557 Alley lode bears N. 55° 19' W., 360 ft. dist.

Cor. No. 1 Sur. No. 19142 I. X. L. lode, claimant herein, bears S. 49° 48' W., 642.7 ft. dist.

Cor. No. 3 Sur. No. 18837 C. O. D. lode bears N. 58° 45' E., 208.47 ft. dist.

A yellow pine, 14 ins. diam., bears N. 10° 00' E., 38.3 ft. dist., mkd. J D 1—20220 A B T.

A distant peak, known as Barren Mt., bears N. 55° 57' W.

Thence N. 28° 50' W.

170.28 Intersect line 3-4 Sur. No. 19142 I. X. L. lode at a point from which Cor. No. 3 bears N. 61° 27' E., 871.43 ft. dist.

370.28 Intersect line 4-1 Sur. No. 19557 Alley lode at a point from which Cor. No. 4 bears N. 44° 30' E., 1,332.42 ft. dist.

456.67 Intersect line 4-1 Protector lode of this survey.

535.9	<p>Feet.</p> <p>Cor. No. 2. Set a white oak post, 36 ins. long, 5 ins. sq., 24 ins. in the ground, and in a mound of stone, for Cor. No. 2, mkd. J D -2- PRI -2- 20220 A; from which</p> <p>A granite rock in place, 34x46 ins., 26 ins. above the ground, bears S. 24° 00' E., 10.5 ft. dist., mkd. X B R-JD-2-20220 A.</p> <p>Thence N. 50° 23' E.</p>
679.32	Intersect line 3-4 Protector lode of this survey.
1,150.19	Intersect line 4-1 Sur. No. 20062 Copper lode at a point from which Cor. No. 4 bears S. 59° 25' E., 94.5 ft. dist.
1,230.73	Intersect line 1-2 Sur. No. 12071 Major lode at a point from which Cor. No. 2 bears S. 11° 00' E., 101.3 ft. dist.
1,291.67	Intersect line 3-4 Sur. No. 19557 Alley lode at a point from which Cor. No. 4 bears S. 45° 30' E., 26.31 ft. dist.
1,500.0	<p>Cor. No. 3.</p> <p>On line 3-4 Sur. No. 20062 Copper lode.</p> <p>On granite bedrock outcrop, even with the general surface, point for Cor. No. 3, mkd. X-J D-3-20220 A; from which</p> <p>Cor. No. 4 Sur. No. 20062 Copper lode bears S. 34° 45' W., 330.0 ft. dist.; identical with Cor. No. 2 Sur. No. 12071 Major lode.</p> <p>A silver spruce, 16 ins. diam., bears N. 40° 00' E., 47.0 ft. dist., mkd. J D 3-20220 A B T.</p> <p>Thence S. 28° 50' E.</p>
241.9	Intersect line 2-3 Sur. No. 12071 Major lode at a point from which Cor. No. 2 bears S. 79° 00' W., 310.46 ft. dist.
404.5	Intersect line 1-2 Sur. No. 19910 Golden lode, claimant herein, at a point from which Cor. No. 1 bears S. 47° 12' W., 620.0 ft. dist.
535.9	<p>Cor. No. 4.</p> <p>This corner falls on a rock slide where a permanent monument can not be established; from this point</p> <p>Cor. No. 1 Sur. No. 19910 Golden lode bears S. 59° 20' W., 601.9 ft. dist.</p> <p>Thence S. 50° 23' W.</p>
99.66	A granite bowlder, 26x48 ins., 36 ins. above ground, for witness Cor. No. 1, mkd. X-W C-J D-4-20229 A.
612.92	Intersect Cor. No. 3 Sur. No. 19142 I. X. L. lode established on line 6-4 Sur. No. 19910 Golden lode at a point from which Cor. No. 1 bears N. 28° 33' W., 96.46 ft. dist.
1,500.0	Cor. No. 1, and place of beginning.
	PRINCE LODGE.
	Beginning at Cor. No. 1 of the Prince Lode, which is identical with Cor. No. 1 of the Jim Dandy lode of this survey, and agrees with a corner of the location.

Feet.	
	Thence N. 28° 50' W.
170.28	Intersect line 3-4 Sur. No. 19142 I. X. L. lode at a point from which Cor. No. 4 bears S. 61° 27' W., 628.57 ft. dist.
370.28	Intersect line 4-1 Sur. No. 19557 Alley lode at a point from which Cor. No. 1 bears S. 44° 30' W., 167.58 ft. dist.
456.67	Intersect line 4-1 Protector lode of this survey.
535.9	Cor. No. 2, which is identical with Cor. No. 2 of the Jim Dandy lode of this survey, and agrees with a corner of the location.
	Thence S. 41° 58' W.
215.3	Intersect line 1-2 Sur. No. 19557 Alley lode at a point from which Cor. No. 1 bears S. 45° 30' E., 149.14 ft. dist.
356	Center of wagon road, bears N. 15° W. and S. 15° E.
598.76	Intersect line 1-2 Sur. No. 4923 Idella lode at a point from which Cor. No. 1 bears N. 24° 48' E., 399.35 ft. dist.
750.32	Intersect line 4-1 Protector lode of this survey.
891	Left bank of Chalk Creek, 18 ft. wide, course S. 42° E.
930	Wagon road, bears N. 40° W. and S. 40° E.
1,504.0	Cor. No. 3.
	Set a schist rock, 28x10x6 ins., 18 ins. in the ground, for Cor. No. 3, mkd. PRI-3-20220 A; from which
	A silver spruce, 14 ins. diam., bears N. 10° 00' E., 15.0 ft. dist., mkd. PRI-3-20220 A B T.
	A yellow pine, 26 ins. diam., bears S. 45° 00' E., 22.0 ft. dist., mkd. PRI-3-20220 A B T.
	A corner of the location bears N. 28° 50' W., 12.5 ft. dist.
	Thence S. 28° 50' E.
331.8	Intersect line 1-2 Sur. No. 4923 Idella lode at a point from which Cor. No. 1 bears N. 24° 48' E., 1,461.0 ft. dist.
507.8	Cor. No. 4.
	Set a brass tablet, 3½ ins. diam., 3 in. stem, in a concrete post, 24 ins. long, 6 ins. sq., 16 ins. in the ground, for Cor. No. 4, with top mkd. PRI-4-20220 A; from which
	Cor. No. 2 Sur. No. 4923 Idella lode bears N. 38° 50' W., 157.72 ft. dist.
	A point on granite bedrock outcrop, even with the general surface, bears S. 26° 00' E., 20.0 ft. dist., mkd. XBR-PRI-4-20220 A.
	A corner of the location bears S. 28° 50' E., 16.1 ft. dist.

Feet.	
	Thence N. 43° 00' E.
220.0	Cor. No. 2 Dump Mill Site of this survey.
480	Creek, 2 ft. wide, course North.
065	Wagon road, bears N. 55° W. and S. 55° E.
772	Right bank of Chalk Creek, 16 ft. wide, course S. 47° E.
880.0	Cor. No. 1 Dump Mill Site of this survey.
1,084.8	Intersect line 1-2 Sur. No. 19142 I. X. L. lode at a point from which Cor. No. 1 bears S. 61° 27' W., 240.5 ft. dist.
1,108	Wagon road, bears N. 42° W. and S. 42° E.
1,237.6	Intersect the line bet. secs. 17 and 18, at a point from which the cor. of secs. 7, 8, 17, and 18, bears North, 68.3 ft. dist., previously described.
	Enter T. & S. Entry No. 2614.
1,331.0	Intersect the line bet. secs. 8 and 17, at a point from which the cor. of secs. 7, 8, 17, and 18, bears N. 89° 59' W., 63.7 ft. dist.
	Leave T. & S. Entry No. 2614.
1,494.9	Cor. No. 1, and place of beginning.

PROTECTOR LODE.

Beginning at Cor. No. 1 of the Protector Lode—

A granite rock in place, 14x56 ins., 18 ins. above ground, for Cor. No. 1, mkd. X-PRO-1-20220 A; from which

The cor. of secs. 7, 8, 17, and 18, bears N. 88° 16' E., 640.1 ft. dist.; previously described.

Cor. Nos. 1 of the Jita Dandy and the Prince lodes of this survey bears N. 80° 19' E., 827.1 ft. dist.

Thence N. 42° 11' W.

245.44	Intersect line 3-4 Sur. No. 4923 Idella lode at a point from which Cor. No. 4 bears N. 24° 48' E., 518.26 ft. dist.
310	Left bank of Chalk Creek, 20 ft. wide, course S. 2° E.
600.0	Cor. No. 2.
	Set a galvanized iron post, 3 ft. long, 2 ins. diam., 24 ins. in the ground, for Cor. No. 2, with brass cap mkd. PRO-2-20220 A; from which
	Cor. No. 4 Sur. No. 4923 Idella lode bears N. 65° 29' E., 500.8 ft. dist.
	Cor. No. 2 Sur. No. 20100 Silver lode, claimant herein, bears N. 39° 44' E., 381.6 ft. dist.
	A yellow pine, 12 ins. diam., bears N. 30° 00' W., 35.0 ft. dist., mkd. PRO-2-20220 ABT.
	A yellow pine, 14 ins. diam., bears S. 51° 00' W., 22.0 ft. dist., mkd. PRO-2-20220 ABT.

	Thence N. 47° 49' E.
70	Right bank of Chalk Creek, 19 ft. wide, course S. 30° E.
557.88	Intersect line 1-2 Sur. No. 20100 Silver lode at a point from which Cor. No. 2 bears S. 64° 25' W., 187.91 ft. dist.
625	Wagon road, bears N. 22° W. and S. 22° E.
1,390.0	A granite cliff, 120 ft. high, bears N. 80° E. and S. 80° W., for witness Cor. No. 3, mkd. X-WC-PRO-3-20220 A, at a point 5 ft. above the base.
1,500.0	Cor. No. 3.
	'This corner falls at an inaccessible point on the cliff, described above, where a monument can not be established.
	Thence S. 42° 11' E.
40	Base of cliff, bears N. 82° E. and S. 80° W.
280.77	Intersect line 1-2 Sur. No. 20100 Silver lode at a point from which Cor. No. 2 bears S. 64° 25' W., 1,170.98 ft. dist.
342.02	Intersect line 2-3 Sur. No. 19557 Alley lode at a point from which Cor. No. 2 bears S. 44° 30' W., 903.05 ft. dist.
553.3	Intersect line 2-3 Jim Dandy lode of this survey.
609.0	Cor. No. 4.
	Set a granite stone, 25x10x9 ins., 16 ins. in the ground, for Cor. No. 4, mkd. PRO-4-20220 A; from which
	Cor. No. 4 Sur. No. 19557 Alley lode bears N. 48° 28' E., 613.35 ft. dist.
	No local bearing objects or bearing trees available.
	Thence S. 47° 49' W.
606.94	Intersect the common line 1-2 Jim Dandy and Prince lodes of this survey.
889.61	Intersect line 1-2 Sur. No. 19557 Alley lode at a point from which Cor. No. 2 bears N. 45° 30' W., 206.06 ft. dist.
1,054	Wagon road, bears N. 15° W. and S. 15° E.
1,312.10	Intersect line 1-2 Sur. No. 4923 Idella lode at a point from which Cor. No. 1 bears N. 24° 48' E., 440.63 ft. dist.
1,431.05	Intersect line 2-3 Prince lode of this survey.
1,590.0	Cor. No. 1, and place of beginning.
	LODE LINES.
	The presumed course of the vein of each of the several lode locations embraced in this survey, counted from the respective points of discovery, is as follows:
	Jim Dandy lode, S. 50° 23' W., 496 ft.; and, N. 50° 23' E., 1,004 ft.
	Prince lode, S. 42° 25' W., 651 ft.; and, N. 42° 25' E., 849 ft.
	Protector lode, S. 47° 49' W., 73 ft.; and, N. 47° 49' E., 1,427 ft.

Survey No. 20220 B.

<i>Feet.</i>		DUMP MILL SITE.
		Beginning at Cor. No. 1 of the Dump Mill Site, on line 4-1 Prince lode of this survey, where I
		Set a brass tablet, 3½ ins. diam., 3-in. stem, in a concrete post, 24 in long, 6 ins. sq., 16 ins. in the ground, and surrounded by a mound of stone, for Cor. No. 1, with top mkd. DMS-1-20220 B; from which
		The cor. of secs. 7, 8, 17, and 18, bears N. 36° 28' E., 410.3 ft. dist.; pr vously described.
		Thence S. 43° 00' W.
92		Left bank of Chalk Creek.
215		Wagon road.
400		Creek.
600.0		Cor. No. 2, on line 4-1 Prince lode of this survey.
		A yellow pine stump, 18 ins. diam., 3 ft. high, squared to 10x10 ins., mkd. DMS-2-20220 B; from which
		A yellow pine stump, 18 ins. diam., 26 ins. high, bears S. 80° 00' E., 17.5 ft. dist., mkd. DMS-2-20220 B B T.
		Thence S. 47° 00' E.
220		Creek, 2 ft. wide, course N. 50° E.
330.0		Cor. No. 3.
		Set a granite stone, 24x14x8 ins., 12 ins. in the ground to bed rock, surrounded by a mound of stone to top, for Cor. No. 3, mkd. DMS-3-20220 B.
		No local bearing objects or bearing trees available.
		Thence N. 43° 00' E.
390		Wagon road, bears N. 40° W. and S. 40° E.
425		Right bank of Chalk Creek, 23 ft. wide, course S. 35° E.
660.0		Cor. No. 4.
		Set a granite stone, 26x10x8 ins., 14 ins. in the ground to bedrock, surrounded by a mound of stone to top, for Cor. No. 4, mkd. DMS-4-20220 B; from which
		A yellow pine, 16 ins. diam., bears N. 15° 00' E., 20.0 ft. dist., mkd. DMS-4-20220 B B T.
		Thence N. 47° 00' W.
330.0		Cor. No. 1, and place of beginning.
		The Dump Mill Site contains 5.00 acres.

Survey No. 20220 A and B.

AREAS.		Acres.
Total area, Jim Dandy lode.....		18. 129
Area in conflict with—		
Tract A, hereinafter described.....		0. 450
Sur. No. 12071 Major lode.....		1. 095
Sur. No. 19142 I. X. L. lode.....		1. 708
Sur. No. 19557 Alley lode.....		2. 815
Sur. No. 19557 Alley lode, exclusive of its conflict with Sur. No. 12071 Major lode.....		2. 767
Sur. No. 19910 Golden lode.....		1. 572
Sur. No. 19910 Golden lode, exclusive of its conflict with Tract A.....		1. 122
Sur. No. 20062 Copper lode.....		0. 357
Sur. No. 20062 Copper lode, exclusive of its conflict with:		
(1) Sur. No. 12071 Major lode.....		0. 082
(2) Sur. No. 19557 Alley lode.....		0. 246
(3) Surs. Nos. 12071 and 19557 Major and Alley lodes.....		0. 030
Total area, Prince lode.....		17. 008
Area in conflict with—		
T. & S. Entry No. 2614.....		0. 050
Sur. No. 4923 Idella lode.....		3. 258
Sur. No. 19142 I. X. L. lode.....		3. 744
Sur. No. 19142 I. X. L. lode, exclusive of its conflict with T. & S. Entry No. 2614.....		3. 694
Sur. No. 19557 Alley lode.....		0. 675
Total area, Protector lode.....		20. 661
Area in conflict with—		
Sur. No. 4923 Idella lode.....		3. 829
Sur. No. 19557 Alley lode.....		4. 776
Sur. No. 20100 Silver lode.....		3. 036
Jim Dandy lode of this survey.....		0. 981
Jim Dandy lode of this survey, exclusive of its conflict with Sur. No. 19557 Alley lode.....		0. 000
Prince lode of this survey.....		0. 650
Prince lode of this survey, exclusive of its conflict with:		
(1) Sur. No. 4923 Idella lode.....		0. 628
(2) Sur. No. 19557 Alley lode.....		0. 342
(3) Surs. Nos. 4923 and 19557 Idella and Alley lodes.....		0. 320
Total area, Dump Mill Site.....		5. 000

TRACT A.

That portion of Sur. No. 19910 Golden lode in conflict with Jim Dandy lode of this survey, excluded by said Golden lode in favor of a location now abandoned, is bounded and described as follows:

Beginning at Cor. No. 4 Jim Dandy lode—
Thence N. 28° 50' W., 131.4 ft., to line 1-2 Golden lode;
Thence S. 47° 12' W., 275.6 ft., to a point on same line;

Thence N. 79° 00' E., 237.6 ft., to line 4-1 Jim Dandy lode;
Thence N. 50° 23' E., 42.0 ft., to place of beginning.

Tract A contains 0.450 acres.

LOCATION.

This survey is located in the SE $\frac{1}{4}$ sec. 7, SW $\frac{1}{4}$ sec. 8, NW $\frac{1}{4}$ sec. 17, and NE $\frac{1}{4}$ sec. 18, of T. 16 S., R. 80 W., of the sixth principal meridian.

The survey of the Jim Dandy and Protector lodes and the Dump Mill Site is identical with the respective location or amended location as marked on the ground.

EXPENDITURE OF \$500

I certify that the value of the labor and improvements made upon or for the benefit of each of the lode locations embraced in said mining claim by the claimant or its grantors is not less than \$500, and that said improvements consist of:

- No. 1. The discovery cut of the Jim Dandy lode, the face of which being the discovery point, is on the lode line 496 ft. from a point on line 1-2, 301.3 ft. from Cor. No. 1; 6 ft. wide, 15 ft. face, runs N. 50° 23' E., 30 ft. to face and portal of tunnel 5x7 ft. in size, running N. 50° E., 23 ft. to breast; at breast is a winze 5x5 ft., 20 ft. deep; tunnel and winze timbered. Value of cut, tunnel and winze, \$380.
- No. 2. A tunnel 5x7 ft. in size, the portal of which bears N. 70° 57' E., 373.5 ft., from Cor. No. 2 Jim Dandy lode, and runs N. 51° 03' E., 148 ft., thence N. 31° 45' E., 17.5 ft., thence N. 50° 31' E., 49 ft. to breast; partly caved Value, \$2,300.
- No. 3. A trench, the west end of which bears N. 38° 12' E., 395 ft., from Cor. No. 1 Jim Dandy lode; 4 ft. wide, 8 ft. deep, running N. 48° E., 40 ft. Value, \$125.
- No. 1. The discovery cut of the Prince lode, the face of which being the discovery point, is on the lode line 849 ft., S. 42° 25' W., from the center of line 1-2; 6 ft. wide, 13 ft. face; running N. 42° 25' E., 20 ft. to face. Value, \$100.
- No. 2. A shaft, the center of which bears N. 20° 42' E., 450 ft., from Cor. No. 4 Prince lode; 4x7 ft., 3 ft. deep. Value, \$130.
- No. 1. The discovery shaft of the Protector lode, the center of which being the discovery point, is on the center line 73 ft. from the center of line 1-2; 6x8 ft., 18 ft. deep, partly timbered. Value, \$200.

An interest in a common improvement described as follows:

A tunnel 6x7 ft. in size, the portal of which bears S. 34° 00' W., 668 ft., from Cor. No. 1 Prince lode; running N. 3° 30' E., 230 ft., to Sta. 1; thence N. 23° 30' E., 280 ft., to pt. A, and 350 ft., to Sta. 2; thence N. 7° 45' E., 19 ft., to pt. B, 100 ft., to pt. C, and 210 ft., to breast at date of survey. At pt. A, a drift 5x7 ft. in size, runs N. 74° 30' E., 55.6 ft. to breast. At pt. B, a drift 5x7 ft. in size, runs N. 58° E., 70.8 ft. to breast and foot of raise 5x5 ft., 16 ft. high. At pt. C is the beginning of a stope, 70 ft. long, 4 ft. wide, and averaging 30 ft. in height. Value of tunnel, drifts, raise, and stope, \$14,200. Value of one-eighth interest, \$1,775.

This improvement is in course of construction for the development of the three lodes of this survey and Sur. No. 19142 I. X. L. lode, Sur. No. 19910

Golden lode, Sur. No. 20100 Silver lode, and the Lead King and Daisy lodes, unsurveyed, which are all the contiguous lode claims owned in common within the range of benefit of said tunnel.

The surface rises rapidly to the north and east from the portal of the tunnel and the extension in its present course, with necessary laterals, affords the most practical and economical means of developing each of the stated lodes at depth.

Five hundred dollars or over has been expended in this improvement in such a manner as tends to the development of each lode of this survey subsequent to its location and to the time since which common ownership and contiguity have prevailed; therefore an undivided one-eighth interest in its value is hereby credited to each of said lodes and a like interest apportioned to each of the other stated lodes of the common group.

The first 165 ft. of this tunnel, valued at \$2,400 was credited to Sur. No. 19142 L. X. L. lode.

An undivided one-half interest in the first 290 ft., valued at \$2,200, was credited to Sur. No. 19910 Golden lode.

An undivided one-fifth interest in the first 510 ft., valued at \$1,520, was credited to Sur. No. 20100 Silver lode.

Except as above stated, no portion of or interest in this improvement has been credited heretofore as patent expenditure to any lode claim.

OTHER IMPROVEMENTS.

A cut 6 ft. wide, the face of which bears S. 17° 42' W., 402 ft., from Cor. No. 2 Prince lode; runs East 20 ft., to 12 ft. face.

A shaft, 4x6 ft., 10 ft. deep, the center of which bears N. 37° 17' E., 318 ft., from Cor. No. 1 Jim Dandy lode.

Claimant of each unknown.

A plank ore bin, 14x20 ft., 3 ft. deep, the north corner of which bears S. 3° 00' W., 210 ft., from Cor. No. 1 Dump Mill Site; the long sides bear N. 20° W.

Claimant herein.

A frame compressor house and shop, the NE. corner of which bears S. 25° 00' E., 80 ft., from Cor. No. 1 Dump Mill Site; 16x30 ft. in size; the long sides bear N. 85° W.

Claimant herein.

A frame bunk house, the NE. corner of which bears S. 50° 00' W., 690 ft. from Cor. No. 1 Prince lode; 20x50 ft. in size; the long sides bear N. 86° W.

Claimant herein.

A bridge, the east end of which bears S. 3° 00' W., 153 ft., from Cor. No. 1 Dump Mill Site; of logs and planks, 10 ft. wide and 30 ft. long, bearing N. 50° E.

Claimant herein.

OTHER CORNER DESCRIPTIONS.

Sur. No. 4923 Idella Lode: Cors. Nos. 1, 3, and 4 are granite stones, firmly set and properly marked; Cor. No. 2 has been destroyed. Line 3-4 was found to be approximately correct as approved; line 4-1 was found to be S. 65° 05' E., 299.4 ft., instead of S. 65° 12' E., 300 ft., as approved; line 1-2 is shown as approved. From Cor. No. 1 the cor. of secs. 7, 8, 17, and 18, bears S. 31° 56' E., 596.9 ft., instead of S. 33° 47' E., 605.0 ft., as approved.

Sur. No. 12671 Major lode: Cor. No. 2 is a pine post, firmly set and properly marked; no other corners could be found. All lines shown as approved. Owing to the absence of Cor. No. 1, the apparent error in the connecting line to the cor. of secs. 7, 8, 17, and 18, could not be verified.

Sur. No. 18837 O. O. D. lode: Cor. No. 3 is a granite stone, firmly set and properly marked.

Sur. No. 19142 I. X. L. lode: Cors. Nos. 2, 3, and 4 are pine posts, firmly set and properly marked; Cor. No. 1 could not be found. Lines 2-3 and 3-4 are correct as approved; lines 1-2 and 4-1 are shown as approved.

Sur. No. 19557 Alley lode: Cor. No. 1 is a pine post, and Cor. No. 4 is a granite stone, both firmly set and properly marked; Cors. Nos. 2 and 3, including all accessories, have become obliterated, leaving no evidences of their original positions. Line 4-1 was found to be S. 44° 30' W., 1,500.0 ft., instead of S. 44° 20' W., 1,500.0 ft., as approved; lines 1-2 and 3-4 are shown at right angles to line 4-1, and each 300 ft. long as approved; this makes line 2-3 N. 44° 30' E., instead of N. 44° 20' E. as approved, and lines 1-2 and 4-3 each N. 45° 30' W., instead of N. 45° 40' W., as approved. From Cor. No. 4 of the Alley lode, Cor. No. 2 Sur. No. 12071 Major lode bears S. 21° 10' W., 128.7 ft., instead of S. 20° 35' W., 136 ft., as approved.

Sur. No. 19910 Golden lode: Cors. Nos. 1, 2, and 6 are granite stones, firmly set and properly marked. Lines 1-2 and 6-1 are correct as approved.

Sur. No. 20062 Copper lode: Cors. Nos. 1, 2, and 3 are pine posts, firmly set and properly marked. Cor. No. 4 is identical with Cor. No. 2 Sur. No. 12071 Major lode, described above. All lines are correct as approved.

Sur. No. 20100 Silver lode: Cors. Nos. 1 and 2 are granite stones, firmly set and properly marked. Line 1-2 is correct as approved.

(MEMO.—Here explain any allowable disagreement with the location certificate, and show the cause.)

LIST OF ASSISTANTS.

A list of the names of the individuals employed by H. B. Sands, United States mineral surveyor, to assist in running, measuring, and marking the lines, corners, and boundaries described in the foregoing field notes of the survey of the mining claim of the Gold Mining Co., known as the Jim Dandy, Prince and Protector Lodes, and Dump Mill Site, and showing the respective capacities in which they acted.

FRANK DENNIS, *Chairman.*

FINAL OATHS OF ASSISTANTS.

I, Frank Dennis, do solemnly swear that I assisted H. B. Sands, United States mineral surveyor, in marking the corners and surveying the boundaries of the mining claim of the Gold Mining Co., known as the Jim Dandy, Prince and Protector Lodes, and Dump Mill Site, represented in the foregoing field notes as having been surveyed by said mineral surveyor and under his direction; and that said survey has been in all respects, to the best of my knowledge and belief, faithfully and correctly executed, and the corner and boundary monuments established according to law and the instructions furnished.

(Signed) FRANK DENNIS, *Chairman.*

Subscribed and sworn to by the above-named person before me this 15th day of March, 1928.

[SEAL.]

(Signed) MARGARET R. BROWN,

Notary Public in and for the City and County of Denver, Colo.

My commission expires June 24, 1930.

FINAL OATH OF UNITED STATES MINERAL SURVEYOR.

I, H. B. Sands, United States mineral surveyor, do solemnly swear that, in pursuance of instructions received from the office cadastral engineer, at Denver, Colo., dated February 9, 1928, I have, in strict conformity to the laws of the United States, the official regulations and instructions thereunder, and the instructions of said office cadastral engineer, faithfully and correctly executed the survey of the mining claim of the Gold Mining Co., known as the Jim Dandy, Prince and Protector Lodes, and Dump Mill Site, situate in Cottonwood mining district, Chaffee County, Colo., in sections 7, 8, 17, and 18, Township No. 10 South, Range No. 80 West, of the Sixth Principal Meridian, and designated as survey No. 20220, A and B, as represented in the foregoing field notes, which accurately show the boundaries of said mining claim as distinctly marked by monuments on the ground, and described in the attached copy of each location certificate, which was received by me from the office cadastral engineer with said instructions, and that all corners of said survey have been established and perpetuated in strict accordance with the law, official regulations, and instructions thereunder; and I do further solemnly swear that the foregoing are the true and original field notes of said survey and my report therein, and that the labor expended and improvements made upon or for the benefit of each of the lode locations embraced in said mining claim by claimant or its grantors are as therein fully stated, and that the character, extent, location, and itemized value thereof are specified therein with particularity and full detail, and that no portion of or interest in said labor or improvements so credited to this claim has been included in the estimate of expenditures upon any other claim.

(Signed) H. B. SANDS,

U. S. Mineral Surveyor.

Subscribed and sworn to by the said H. B. Sands, United States mineral surveyor, before me, a notary public in and for the city and county of Denver, Colo., this 15th day of March, 1928.

[SEAL.]

(Signed)

MARGARET R. BROWN,

Notary Public.

My commission expires June 24, 1930.

(NOTE.—The copies of the location certificates received with the survey order will be attached to the returns following this page.)

CERTIFICATE OF APPROVAL OF FIELD NOTES AND SURVEY OF MINING CLAIM.

DEPARTMENT OF THE INTERIOR,

PUBLIC SURVEY OFFICE,

Denver, Colo., April 25, 1928.

I, office cadastral engineer at Denver, Colo., do hereby certify that the foregoing and hereto attached field notes and return of the survey of the mining claim of the Gold Mining Co., known as the Jim Dandy, Prince, and Protector Lodes, and Dump Mill Site, situate in Cotton-

wood mining district, Chaffee County, Colo., in sections 7, 8, 17, and 18, Township No. 16 South, Range No. 80 West, of the Sixth Principal Meridian, designated as survey No. 20220 A and B, executed by H. B. Sands, United States mineral surveyor, March 14, 1928, under my instructions dated February 9, 1928, have been critically examined and the necessary corrections and explanations made, and the said field notes and return, and the survey they describe, are hereby approved. The certified copy of each location certificate filed by the applicant for survey is on file in this office and a true copy of said certified copy of each location certificate is included and made a part of the transcript of the field notes.

(Signed)

Office Cadastral Engineer.

FINAL CERTIFICATE ON FIELD NOTES.

DEPARTMENT OF THE INTERIOR,
PUBLIC SURVEY OFFICE,

Denver, Colo., April 28, 1928.

I, office cadastral engineer at Denver, Colo., do hereby certify that the foregoing transcript of the field notes, return and approval of the survey of the mining claim of the Gold Mining Co., known as the Jim Dandy, Prince, and Protector Lodes, and Dump Mill Site, situate in Cottonwood mining district, Chaffee County, Colo., in sections 7, 8, 17, and 18, Township No. 16 South, Range No. 80 West, of the Sixth Principal Meridian, and designated as survey No. 20220 A and B, has been correctly copied from the originals on file in this office; that said field notes furnish such an accurate description of said mining claims as will, if incorporated into a patent, serve fully to identify the premises, and that such reference is made therein to natural objects or permanent monuments as will perpetuate and fix the locus thereof.

And I further certify that \$500 worth of labor has been expended or improvements made upon or for the benefit of each of the lode locations embraced in said mining claim by claimant or its grantors, and that said improvements consist of 2 cuts, 2 shafts, 2 tunnels, a winze, a trench, and an interest in a common improvement, value \$8,560, and that no portion of or interest in said labor or improvements has been included in the estimate of expenditures upon any other claim.

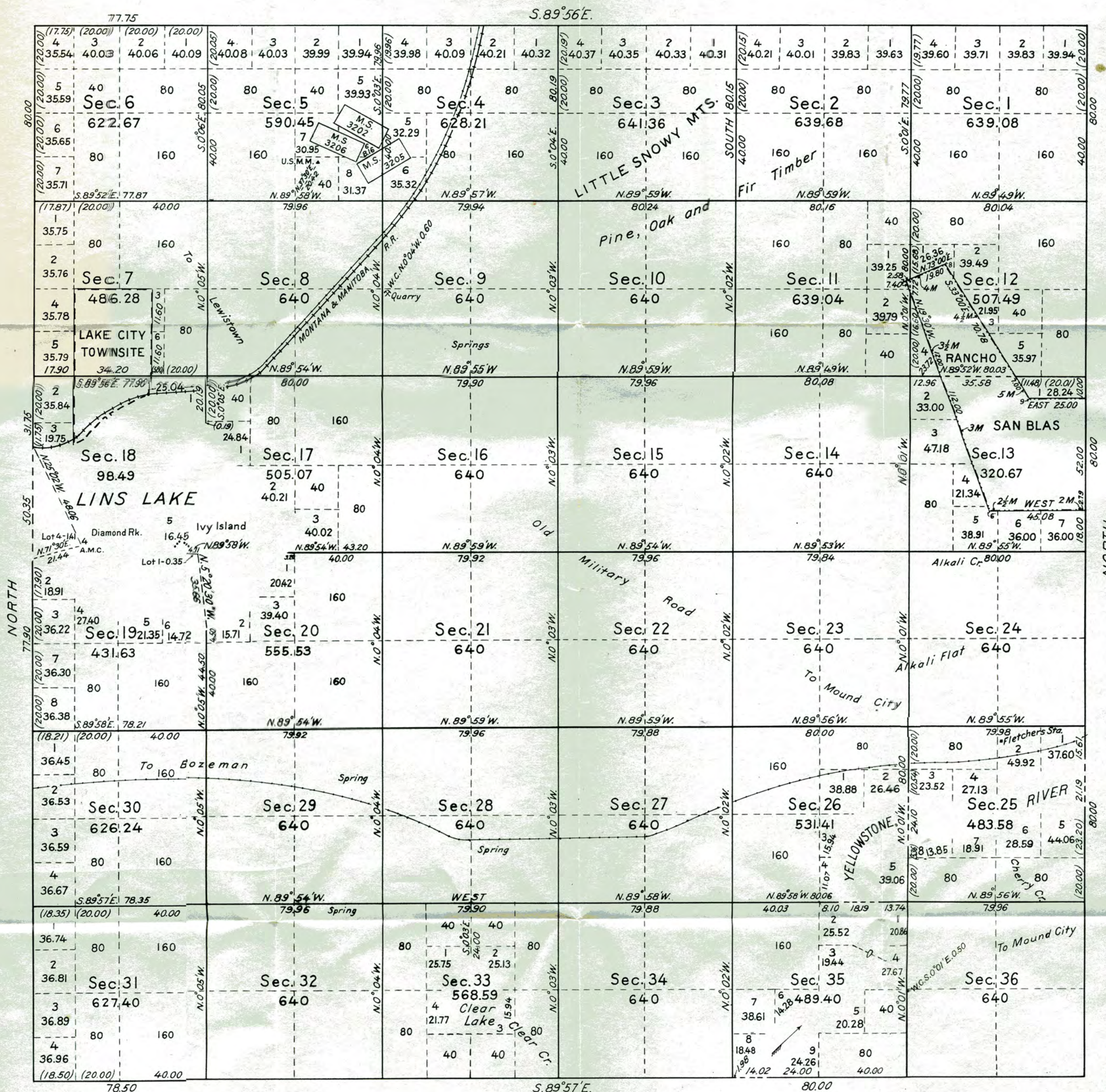
I further certify that the plat thereof, filed in the United States district land office at Pueblo, Colo., is correct and in conformity with the foregoing field notes.

(Signed)

Office Cadastral Engineer.



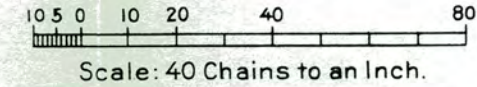
TOWNSHIP N^o 15 NORTH, RANGE N^o 20 EAST, OF THE PRINCIPAL MERIDIAN, MONTANA.



NORTH
FIFTH GUIDE MERIDIAN EAST

LIST OF MINERAL CLAIMS
 Survey No. 3202 GOLD DUST LODGE
 " " 3205 NUGGET
 " " 3206 PRIMROSE

Latitude 45°45'N.
 Longitude 107°54'W.



Area Surveyed, 20872.27 Acres.

Mean Magnetic Declination, 18°10'E.

Office of U.S. Supervisor of Surveys
 Denver, Colorado, September 15, 1926
 The above plat of Township No. 15 North, Range No. 20 East, of the Principal Meridian, Montana, is strictly conformable to the field notes of the survey thereof which have been examined and approved.

DEPARTMENT OF THE INTERIOR
 GENERAL LAND OFFICE
 Washington, D. C., October 1, 1926
 The survey represented by this plat having been correctly executed in accordance with the requirements of law and the regulations of this office, is hereby accepted.

U.S. Supervisor of Surveys.

Assistant Commissioner

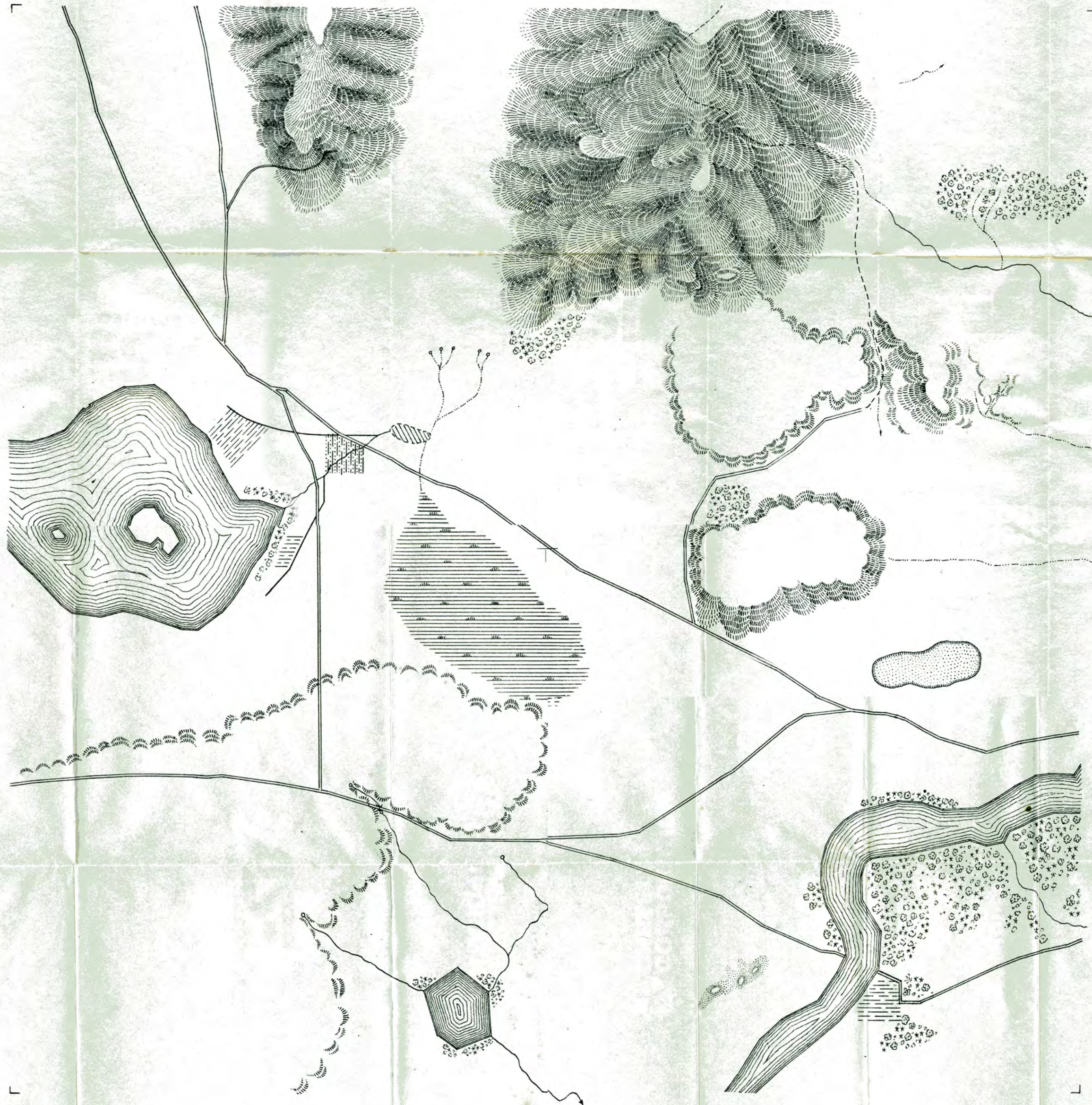
LINES DESIGNATED	BY WHOM SURVEYED	GROUP		MILEAGE		WHEN SURVEYED	
		N ^o	DATE	MLS.	CHS.	BEGUN	COMPLETED
Exterior	Geo. H. Robinson					Sept. 9, 1902	Oct. 4, 1902
Subdivisional	Robert Acres	123	April 1, 1925	57	24.02	June 1, 1925	June 30, 1925
Meander	"	"	"	12	19.26		
Miscellaneous	"	"	"		73.60		

A.B.C.D.E.F.G.H.I.J.K.L.M.N.O.P.Q.R.S.T.U.V.W.X.Y.Z.&

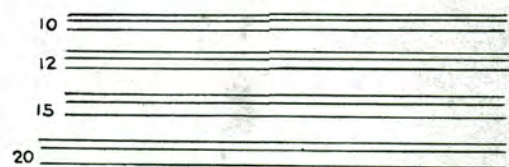
A.B.C.D.E.F.G.H.I.J.K.L.M.N.O.P.Q.R.S.T.U.V.W.X.Y.Z.&

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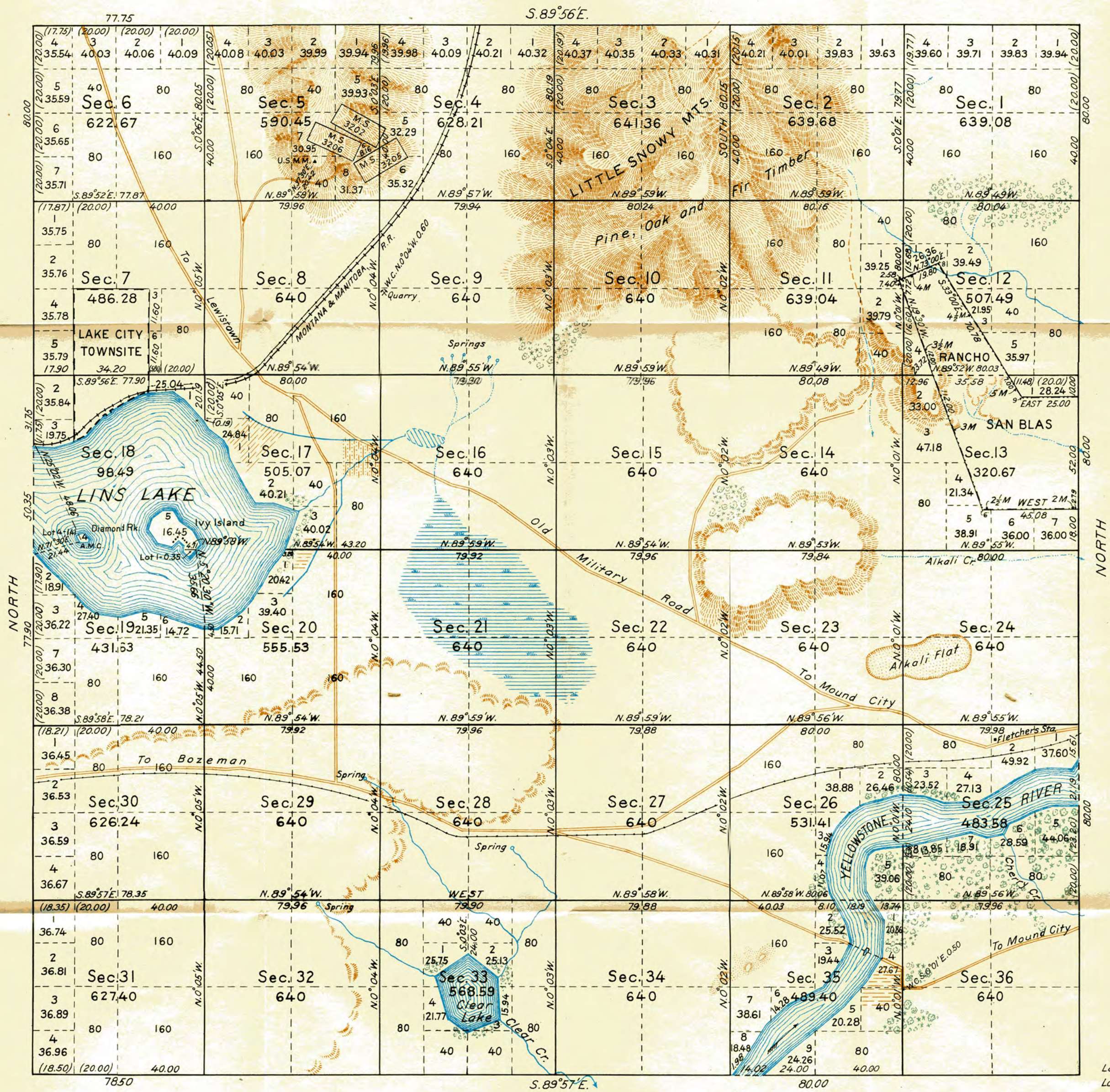


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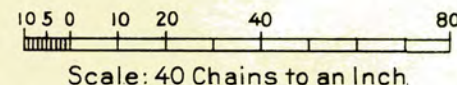
60 1 2 3 4 5 6 7 8 9 0

TOWNSHIP N^o 15 NORTH, RANGE N^o 20 EAST, OF THE PRINCIPAL MERIDIAN, MONTANA.



LIST OF MINERAL CLAIMS
 Survey No. 3202 GOLD DUST LODGE
 " " 3205 NUGGET "
 " " 3206 PRIMROSE "

Latitude 45°45'N.
 Longitude 107°54'W.



Mean Magnetic Declination, 18°10'E. Area Surveyed, 20872.27 Acres.

LINES DESIGNATED	BY WHOM SURVEYED	GROUP		MILEAGE		WHEN SURVEYED	
		N ^o	DATE	M.LS.	CHS.	BEGUN	COMPLETED
Exterior	Geo. H. Robinson					Sept. 9, 1902	Oct. 4, 1902
Subdivisional	Robert Acres	123	April 1, 1925	57	24.02	June 1, 1925	June 30, 1925
Meander	"	"	"	12	19.26		
Miscellaneous	"	"	"		73.60		

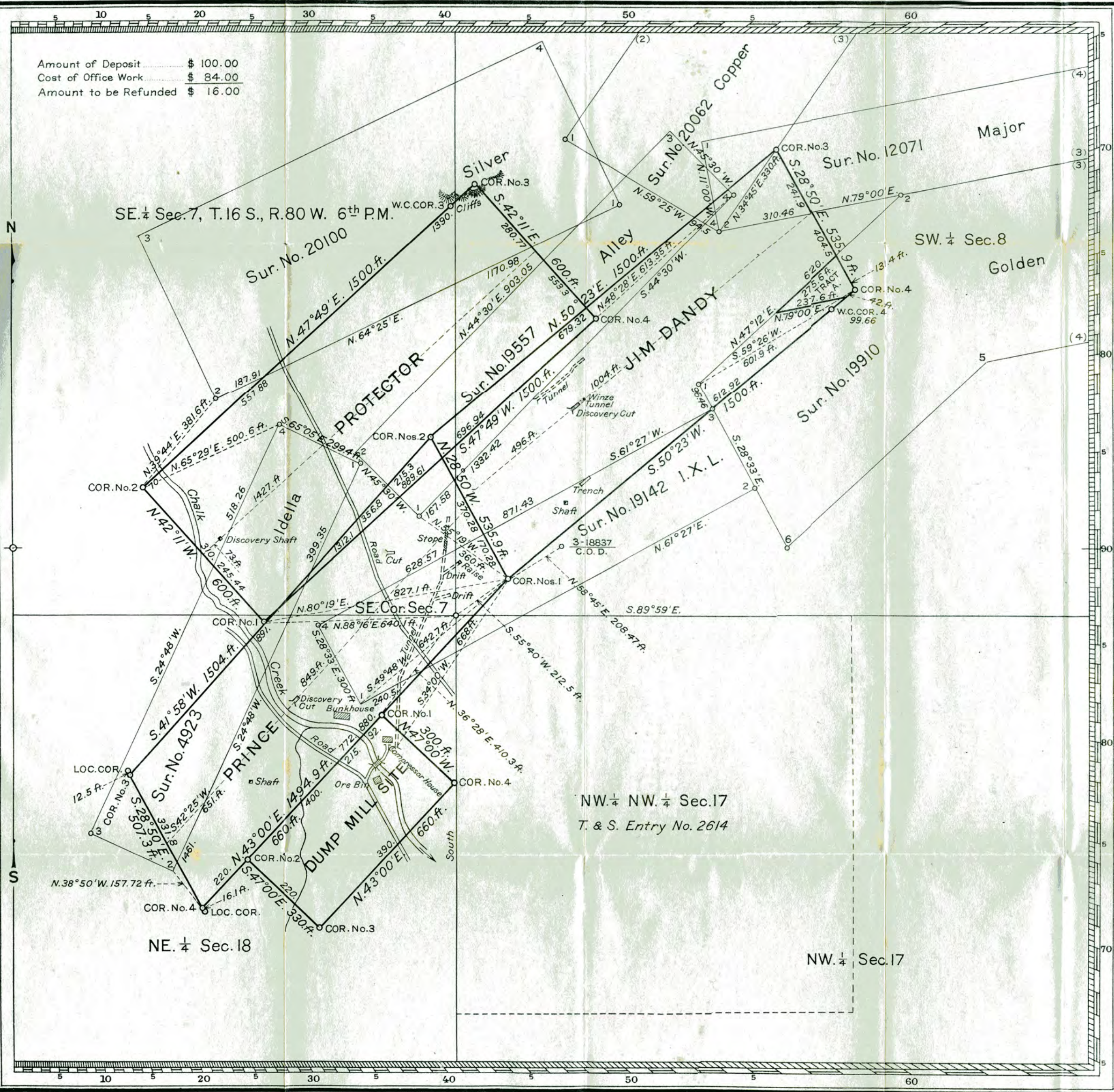
Office of U.S. Supervisor of Surveys
 Denver, Colorado, September 15, 1926
 The above plat of Township No. 15 North, Range No. 20 East, of the Principal Meridian, Montana, is strictly conformable to the field notes of the survey thereof which have been examined and approved.

DEPARTMENT OF THE INTERIOR
 GENERAL LAND OFFICE
 Washington, D. C., October 1, 1926
 The survey represented by this plat having been correctly executed in accordance with the requirements of law and the regulations of this office, is hereby accepted.

U.S. Supervisor of Surveys.

Assistant Commissioner.

Amount of Deposit \$ 100.00
 Cost of Office Work \$ 84.00
 Amount to be Refunded \$ 16.00



Mineral Survey No. 20220 A AND B.

Pueblo Land District.

PLAT
 OF THE CLAIM OF
THE GOLD MINING COMPANY.

KNOWN AS THE
**JIM DANDY, PRINCE AND PROTECTOR
 LODES AND DUMP MILL SITE.**

IN COTTONWOOD MINING DISTRICT,
 CHAFFEE COUNTY, COLORADO,

Containing an Area of _____ Acres.
 Scale of 300 Feet to the inch.

Variation 15°30' East
SURVEYED MARCH 14 - 1928, BY

H. B. Sands, U.S. Mineral Surveyor,

The Original Field Notes of the Survey of the Mining Claim from which this plat has been made under my direction, have been examined and approved, and are on file in this Office, and I hereby certify that they furnish such an accurate description of said Mining Claim as will, if incorporated into a patent, serve fully to identify the premises, and that such reference is made therein to natural objects or permanent monuments as will perpetuate and fix the locus thereof.

I further certify that Five Hundred Dollars worth of labor has been expended or improvements made upon, or for the benefit of, each ^{loade} location embraced in said mining claim by claimant The Gold Mining Company

or its grantors and that said improvements consist of two cuts, two shafts, two tunnels, a winze, a trench and an interest in a common improvement, Value \$8560.00

that the location of said improvements is correctly shown upon this plat, and that no portion of or interest in said labor or improvements has been included in the estimate of expenditures upon any other claim.

And I further certify that this is a correct plat of said Mining Claim made in conformity with said original field notes of the survey thereof, and the same is hereby approved.

Public Survey Office }
 Denver, Colorado } Office Cadastral Engineer
 April 23, 1928 }