DEPARTMENT OF THE INTERIOR

U.S. GENERAL LAND OFFICE

Bureau of Land Management

237

ADVANCE SHEETS

of Chapters I to VI, inclusive, of a
revision of the

MANUAL OF INSTRUCTIONS

FOR THE

SURVEY OF THE PUBLIC LANDS OF THE UNITED STATES

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

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DEPARTMENT OF THE INTERIOR

GENERAL LAND OFFICE

WASHINGTON, *June 16, 1919.*

GENTLEMEN: It has been deemed advisable to publish advance sheets of six chapters of a new edition of the Manual of Surveying Instructions, as follows: (I) Regulations Imposed by Law; (II) Instruments and Methods; (III) System of Rectangular Surveys; (IV) Corner Monuments; (V) Restoration of Lost Corners; and, (VI) Resurveys. These advance sheets will immediately supersede the related provisions of the Manual of 1902, except as may be found impracticable in the case of surveys already in process of execution, or in the instance of returns of surveys now in course of preparation, otherwise the provisions of the Manual of 1902 will remain in full force and effect.

Every member of the surveying service is requested to report to the undersigned any typographical errors which may be detected, to the end that the same may be removed from the completed edition.

Very respectfully,

CLAY TALLMAN,
Commissioner.

To the SURVEYING SERVICE OF THE GENERAL LAND OFFICE.

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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 twenty-nine 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 and 37 Stat., 1728); surveys in progress; United States Surveyor General 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 Surveyor General 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, and 19 Stat., 665); surveys in progress; United States Surveyor General 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 Surveyor General 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 Commissioner of State Land Office 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, and 3 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, and 26 Stat., 1551); surveys in progress; United States Surveyor General at Helena.

Nebraska.—Acquired under the Louisiana Purchase, in 1803, and admitted into the Union March 1, 1867 (14 Stat., 391, and 14 Stat., 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, and 13 Stat., 749); surveys in progress; United States Surveyor General 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, and 37 Stat., 1723); surveys in progress; United States Surveyor General 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, and 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, and 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); surveys 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 Surveyor General 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, and 26 Stat., 1549); surveys in progress; United States Surveyor General at Huron.

Utah.—Ceded by Mexico in 1848, and admitted into the Union January 4, 1896 (28 Stat., 107, and 29 Stat., 876); surveys in progress; United States Surveyor General 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, and 26 Stat., 1552); surveys in progress; United States Surveyor General 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 Surveyor General at Cheyenne.

District of Alaska.—Ceded by Russia in 1867; surveys in progress; United States Surveyor General 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 persons, 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 a the date of the admission of a State into the Union was such as to classify the same as navigable water.

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 Stats., 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 surveyor 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 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, 1784, 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, 1785, 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

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

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 provides 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 offi of which shall be called the Commissioner of the General La Office, whose duty it shall be, under the direction of the head the department, to superintend, execute, and perform all such a and things touching or respecting the public lands of the Unit States, and other lands patented or granted by the United Stat as have heretofore been directed by law to be done or performed the office of the Secretary of State, of the Secretary and Register the Treasury, and of the Secretary of War, or which shall hereaft by law be assigned to the said office."

The act of Congress approved April 24, 1820, provides for the sa of public lands in half-quarter sections, and requires that "in ever case of the division of a quarter section the line for the divisio thereof shall run north and south * * * and fractional section containing one hundred and sixty acres and upward, shall, in lik manner, as nearly as practicable, be subdivided into half-quart sections, under such rules and regulations as may be prescribed b the Secretary of the Treasury; but fractional sections containi 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 obstructin the survey of the public lands, and for the protection of surveyors, i 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 sub division of the public lands into quarter quarters; that in every ca of the division of a half-quarter section the dividing line should ru east and west; and that fractional sections should be subdivide under rules and regulations prescribed by the Secretary of th Treasury. Under the latter provision the Secretary directed th fractional sections containing less than 160 acres, or the residua portion of a fractional section, after the subdivision into as man quarter-quarter sections as it is susceptible of, may be subdivide into lots, each containing the quantity of a quarter-quarter sectio as nearly as practicable, by so laying down the line of subdivisio that they shall be 20 chains wide, which distances are to be marke on the plat of subdivision, as are also the areas of the quarter quarte and residuary fractions.

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

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

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

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

Duties of Commissioner.

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 anywise respecting such public lands; and, lso, such as relate to private claims of lands, and the issuing of atents for all grants of land under the authority of the Government. (R. S., 453.)

Power of Commissioner to make regulations.

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

Surveyor general, how and where appointed.

SEC. 77. There shall be appointed by the President, by and w the advice and consent of the Senate, a survey general for the States and Territories herein nam embracing, respectively, one surveying distri namely: Louisiana, Florida, Minnesota, Kans California, Nevada, Oregon, Nebraska and Iowa, Dakota, Colora New Mexico, Idaho, Washington, Montana, Utah, Wyoming, Arizo (R. S., 2207.)

Residence of surveyor general.

SEC. 83. Every surveyor general, while in the discharge of th duties of his office, shall reside in the district f which he is appointed. (R. S. 2214.)

Bond of surveyor general.

SEC. 84. Every surveyor general shall, before entering on t duties of his office, execute and deliver to t Secretary of the Interior a bond, with good a sufficient security, for the penal sum of thirt thousand dollars, conditioned for the faithful disbursement, ac cording to law, of all public money placed in his hands, and fo the faithful performance of the duties of his office; and the President has discretionary authority to require a new bond and additiona security, under the direction of the Secretary of the Interior, for th lawful disbursement of public moneys. (R. S., 2215, 2216.)

Duration of office.

SEC. 85. The commission of each surveyor general shall cease an expire in four years from the date thereof, unle sooner vacated by death, resignation, or remov from office. (R. S., 2217.)

Continuance of duties and bond after expiration of commission.

SEC. 86. Every surveyor general, except where the President se cause otherwise to determine, is authorized to co tinue in the uninterrupted discharge of his regul official duties after the day of expiration of h commission and until a new commission is issued him for the same office, or until the day when a successor enters up the duties of such office; and the existing official bond of any offic so acting shall be deemed good and sufficient and in force until t date of the approval of the new bond to be given by him, if recom missioned, or otherwise, for the additional time he may so contin ficially to act, pursuant to the authority of this section. (R. S., 22.)

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 receive them, all the field notes, maps, records, and other papers pertaining to land titles within the same; and the office of surveyor neral in every such district shall thereafter cease and be disconnued. (R. S., 2218.)

Transfer of papers d discontinuance office in case of mpleted surveys.

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 e General Land Office. (R. S., 2219.)

Devolution of wers upon Comissioner in case of continuance.

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 such public records shall be made to the authorities of any State ntil such State has provided by law for the reception and safeeping of such public records, and for the allowance of free access ereto by the authorities of the United States. (R. S., 2220, 2221.)

Free access to blic records deered to States, d condition of ch delivery.

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 rm townships of six miles square, unless where the line of an Inan reservation, or of tracts of land heretofore surveyed or patted, or the course of navigable rivers, may render this impractible; and in that case this rule must be departed from no further an such particular circumstances require.

Rules of survey.

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

Third. The township shall be subdivided into sections, contai as nearly as may be, six hundred and forty acres each, by runı through the same, each way, parallel lines at the end of every miles[1]; and by making a corner on each of such lines at the en every mile. The sections shall be numbered, respectively, be ning with the number one in the northeast section, and procee west and east alternately through the township with progres numbers till the thirty-six be completed.

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

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

Sixth. All lines shall be plainly marked upon trees, and measu with chains, containing two perches of sixteen and one-half f each, subdivided into twenty-five equal links; and the chain shall adjusted to a standard to be kept for that purpose.[2]

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

Eighth. These field books shall be returned to the surveyor g eral, who shall cause therefrom a description of the whole lands

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

[2] The superior results obtained by the use of modern steel ribbon tapes, in c trast with the obsolete link chain, have led to the abandonment of the lat except that the "chain unit," which is peculiarly adapted to land surveying, l always been employed.

veyed 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.)

Boundaries and contents of public lands, how ascertained.

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

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

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.)

Extension of public surveys over mineral lands.

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.)

Surveyors general to survey private land claims when confirmed, etc.

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.)

Penalty for interrupting surveys.

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.)

Protection of surveyor by marshal of district.

9. More recent legislation has brought about (*a*) provision for the appointment of a United States Surveyor General for the District of Alaska; (*b*) authority for the purchase of durable monuments, to be employed in place of native material to mark public land corners; (*c*) penalty for the destruction of monuments of the public land surveys; (*d*) authority for necessary resurveys; and (*e*) change of survey system from contract to direct with authority for the employment of a permanent corps of United States surveyors; all as indicated by the following quotations from the United States Statutes:

The act of Congress approved May 17, 1884, providing a civil government for Alaska, provides "That the said District of Alaska is hereby created a land district, * * * and the marshal provided for by this act shall be ex officio surveyor general of said district." (23 Stat., 24, sec. 8.) The act of Congress approved July 24, 1897, amends the act approved May 17, 1884, and provides "That there shall be appointed by the President, by and with the advice and consent of the Senate, a surveyor general for the District of Alaska, embracing one surveying district." (30 Stat., 215, sec. 2.)

Surveyor general for the District of Alaska.

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 approved July 1, 1918, provided, under "Surveying the Public Lands," as follows:

Purchase of metal monuments.

"That the sum of not exceeding 10 per centum of the amount hereby appropriated may be expended by the Commissioner of the General Land Office, with the approval of the Secretary of the Interior, for the purchase of metal or other equally durable monuments to be used for public land survey corners wherever practicable: * * *." (40 Stat., 668.)

Penalty for the destruction of survey monuments.

The act of Congress approved March 4, 1909, entitled "An act to codify, revise, and amend the penal laws of the United States," provides punishment for offenses against the operation of the surveying service of the Government, 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., 1088, sec. 57.)

Resurvey of public lands.

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, and 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 townships 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.)

Selection of surveyors.

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 contract system which had theretofore be adhered to since the beginning of the public land surveys, a the authority for the employment of a permanent corps of Unit States surveyors has been continued from year to year to the pr ent time. The following comprises that part of the act of Congr approved July 1, 1918, under "Surveying the Public Lands," r lating directly to the administrative control of the surveying servic

"For surveys and resurveys of public lands, under the supervisi of the Commissioner of the General Land Office and direction of t Secretary of the Interior, * * *. The surveys and resurve provided for in this appropriation to be made by such compete surveyors as the Secretary of the Interior may select, * * *. (40 Stat., 668.)

GENERAL RULES.

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

First. That the boundaries of the public lands established a returned by the duly appointed surveyors, when approved by t surveyors general and accepted by the Commissioner of the Gener Land Office, are unchangeable.

Second. That the original township, section, and quarter-sectio corners established by the surveyors must stand as the true corne which they were intended to represent, whether in the place show by the field notes or not.

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

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

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

ixth. That lost or obliterated corners of the approved surveys
st be restored to their original locations whenever it is possible to
so. Actions or decisions by surveyors which may result in
nges of boundaries of patented lands and disturb questions of
ership in connection therewith are subject to review by the
rts.

THE MANUAL.

1. Various regions of the United States have been surveyed
ler different sets of instructions issued at periods ranging from
5 to the present time. The earliest rules were given to surveyors
manuscript or in printed circulars. Regulations more in detail,
proving the system for greater accuracy, permanency and uni-
nity, were issued in book form in editions of 1855, 1881, 1890,
4 and 1902.

'he Manual of Surveying Instructions has been again revised with
iew to harmonizing the printed instructions furnished to the sur-
rors with recent legislation and current surveying practice. The
of iron-post corner monuments adds much to the permanency
he evidence of the surveys, but this calls for little change in rules
ept to outline the standard practice. A growing necessity for
urveys to identify and restore original surveys actually made, but
orly monumented, or to supersede grossly erroneous or fraudulent
ginal surveys—"to properly mark the boundaries of the public
d remaining undisposed of"—has demanded a full discussion of
subject in this revision of the Manual. The change from the
tract system to the present system under which the public-land
veys are executed by a permanent corps of surveyors employed
the General Land Office has involved changes in the administra-
e control without departing from previous technical procedure,
l hereafter throughout the Manual all reference to administrative
estions will be found to be stated in general terms in order to avoid
nfusing that matter with the purely technical subjects. Modern
veying practice has been introduced into the public-land surveys
far as legally consistent and efficient, which has prompted a rather
l instructive treatment of the subjects of measurements with long
el tapes, stadia method and triangulations, and field observations
the determination of time, latitude and azimuth, to afford
satility on the part of the surveyor in adopting methods best
ted to the ever-changing conditions under which his work must
accomplished.

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

THE STANDARD FIELD TABLES.

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

1. Units of linear measure, units of area, expansion of steel t and conversion tables; chains to feet and feet to chains.
2. Reduction in latitude to south boundary of township, and rections 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 lo tude.
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 tim 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 OF POLARIS.

18. 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 surveyors 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 adopted 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.

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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 surveyor 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 entrusted 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

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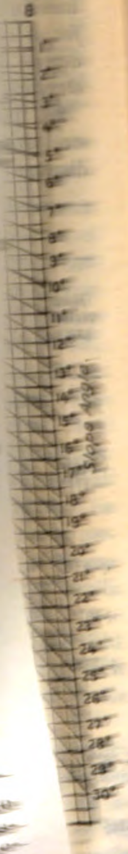
Fieldnotes.

Distance on slope.	True horizontal distance.	[illegible]
Chains.	Chains.	Chains.
4.50	4.398	
2.20	2.098	
6.70	6.496	3.80
8.00	7.917	
14.70	14.413	
6.20	5.835	
20.90	20.248	
3.30	3.270	
24.20	23.518	0.00
		1.20
		1.90
8.00	7.949	
32.20	31.467	1.15
3.70	3.641	
35.90	35.108	
5.00	4.851	
40.90	39.959	
.04	.04	
40.94	40.00	
40.00	40.00	



. A simplification [illegible] e is obtained by [illegible] ments on the ion paper, as f[illegible] ted on cross- ing [illegible] tical lines repre- ain[illegible] the slope to [illegible] ting [illegible] izontal lines repre- the [illegible] from the measurement dr[illegible] distance; slanting lines [illegible] ope scaled to the proper

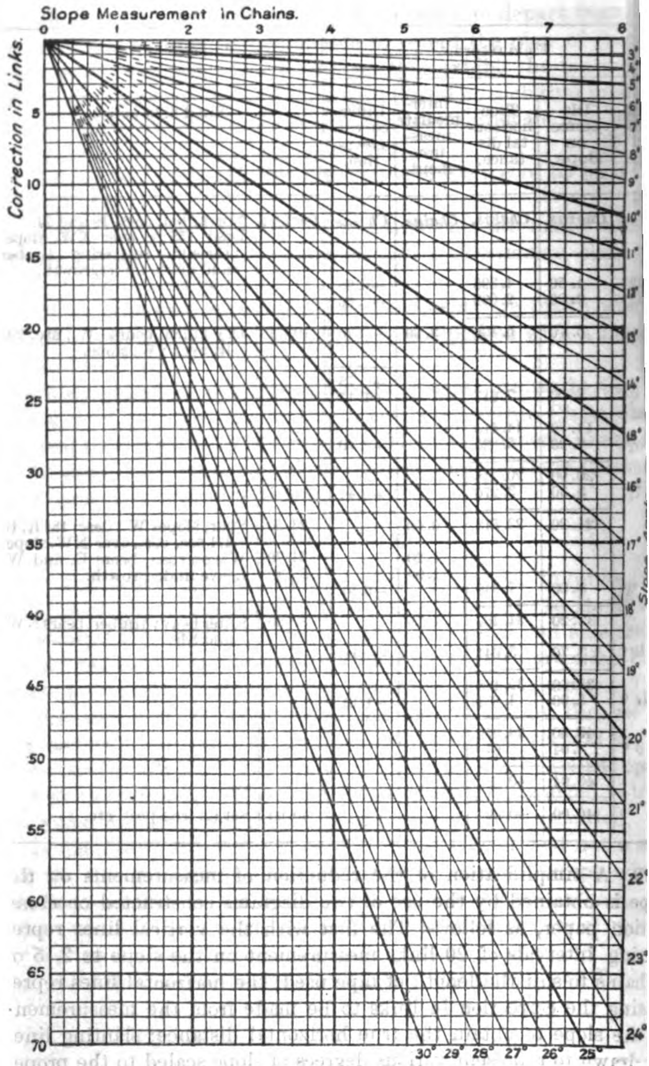


Fig. I.

Reduction from the slope to the horizontal.

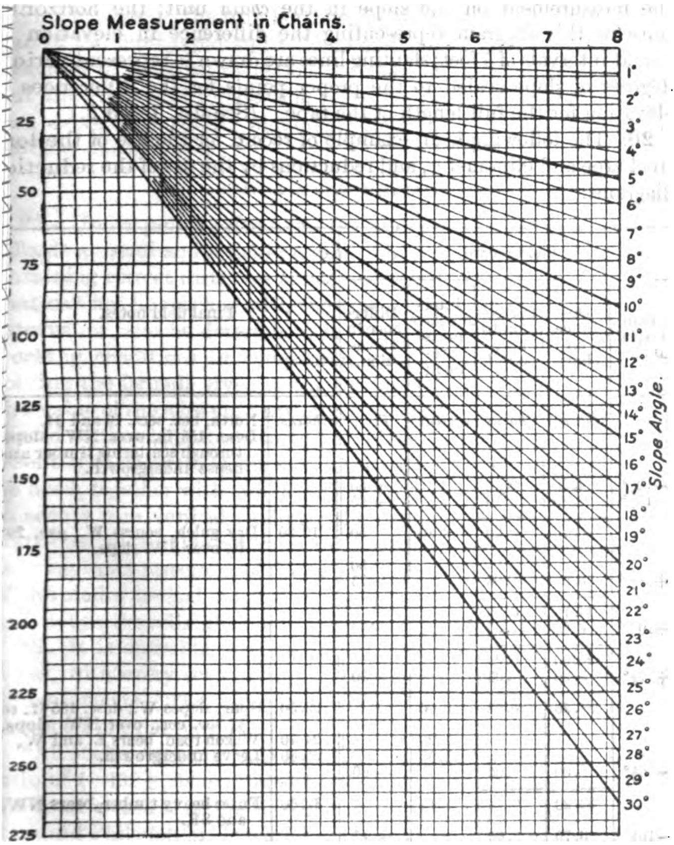


Fig. 2.

Reduction for difference of elevation.

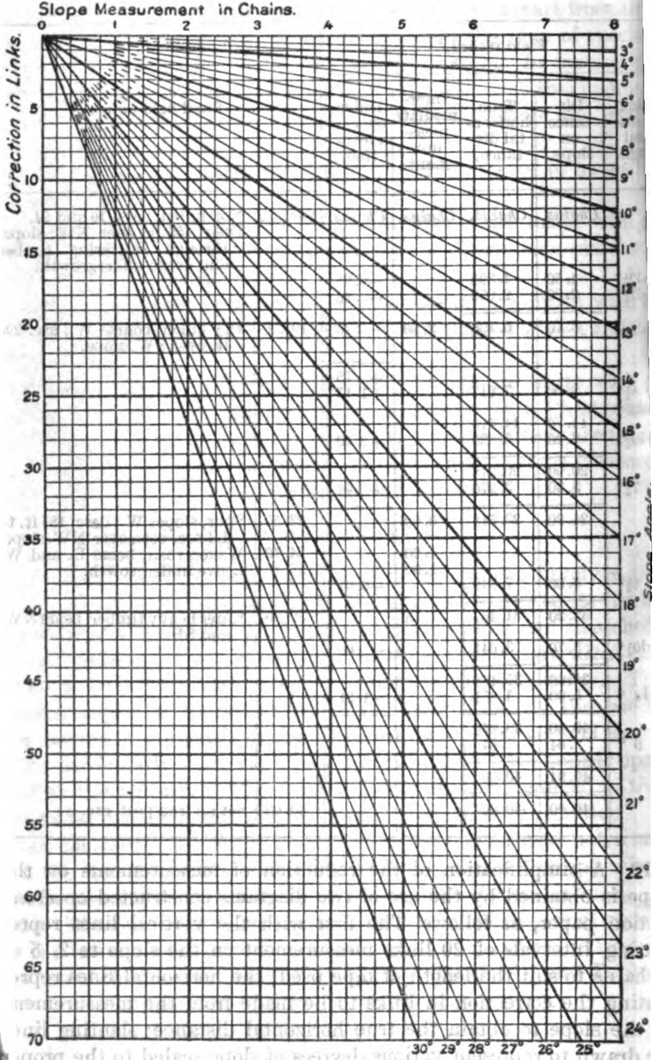


Fig. I.

Reduction from the slope to the horizontal.

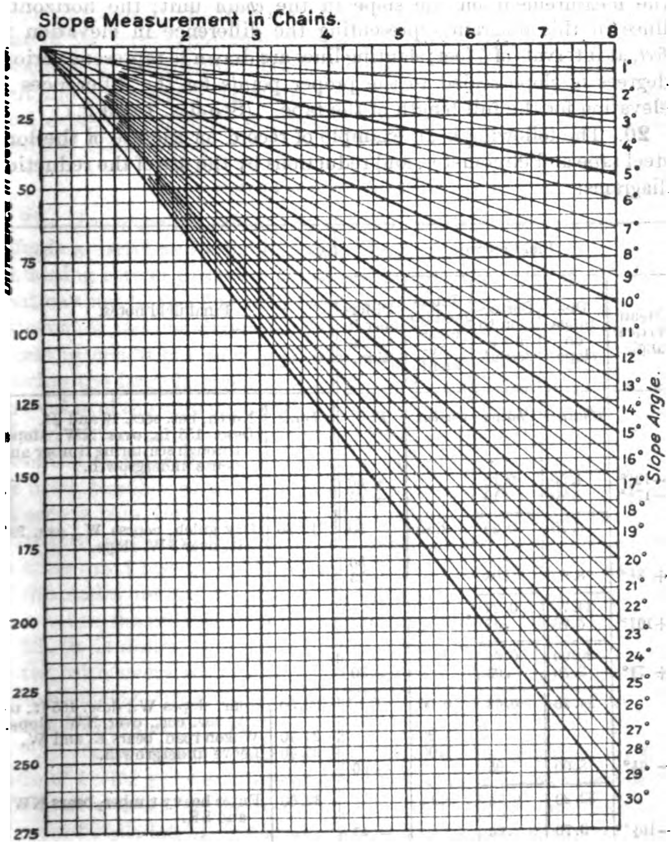


Fig. 2.

Reduction for difference of elevation.

points for the correction for the full length of the tape. The seco diagram is constructed with the vertical lines representing simila the measurement on the slope in the *chain* unit; the horizon lines in this diagram representing the difference in elevation *feet*, at intervals of 5 feet; slanting lines are drawn to represent vari degrees of slope scaled to the proper points for the differences 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 lo steel tape and clinometer, and reductions by the use of the reducti diagrams:

Field record.					Final field notes.	
Mean vertical angle.	Distance on slope.	Correction to horizontal.	Intermediate measurement.	Difference in elevation.		
	Chains.	*Chains.*	*Chains.*	*Feet.*	*Chains.*	North, bet. secs. 19 and 24. Desc. 155 ft. over NW. slo through scattering timber a dense undergrowth.
$-12\frac{1}{4}^\circ$	4.50	0.10		− 60		
$-17\frac{1}{2}^\circ$	2.20	.10		− 45		
	6.70	0.20	3.80	− 50	10.30	Dry gulch, course W.; asc. ft. over SW. slope.
				+ 50		
$+8\frac{1}{4}^\circ$	8.00	.08		+ 75		
	14.70	0.28				
$+19\frac{3}{4}^\circ$	6.20	.37		+ 140		
	20.90	0.65				
$+7\frac{3}{4}^\circ$	3.30	.03		+ 30		
	24.20	0.68	0.00		23.50	Spur, slopes W.; desc. 185 ft. ¼ sec. cor., over NW. slo
			1.20		24.70	Wagon road, bears E. and W.
			1.90		25.40	Leave undergrowth.
$-6\frac{1}{2}^\circ$	8.00	.05		− 60		
	32.20	0.73	1.15		32.60	Enter heavy timber, bears N and SE.
$-10\frac{1}{4}^\circ$	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 a 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 surveyor 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 surveyor.

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±, 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±, 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 strument to the rod.

Diff. elev.: The true vertical distance from the height of the ins ment to the center point between the two target 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 ob glass.

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

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

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

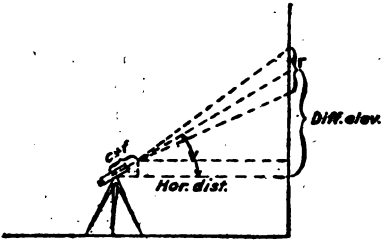


Fig. 3

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

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

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

Field record.				Final field notes.
Measurement of base by steel tape and clinometer.			Vertical rod reading.	
fean rtical ngle.	Distance on slope.	True horizontal distance.		
	Chains.	*Chains.*	*Feet.*	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 of test = −0° 40′ K = 132.551 Reduced error in 10 chs. = 4.1 lks. All corrections to be added to the distances given by the stadia.
−4½°	3.90	3.888	6.992	
−1¼°	8.00	7.998	6.998	
+7¾°	2.20	2.180	7.002	
			6.995	
ıtal base		= 14.066	7.003	
ıcal constant		= .012	7.004	
			6.997	
ıdia base		= 14.054 chs.	6.995	
" "		= 927.564 ft.	7.001	
			6.998	
ıan rod reading		=	6.9965	
efficient for 0° 40′		= 0.9999;		
001×6.9985		=	.0007	
$r \cos^2 r$		=	6.9978	
$= \frac{927.564}{6.9978} = 132.551$				
asurod base			= 14.066 chs.	
9985 } 9985 } = mean rod reading.				
997 = equivalent 1:66.				
997 × 0.9999 = 13.996 } $(c+f)$ = .012 }			14.008 chs.	
ʼor in 14.008 chs. by stadia			= 0.058 chs.	
ʼor in 10.00 chs. by stadia			= 0.041 chs.	

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

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

29. The following example of record, with reductions added, is ıpted to the instrument showing the above test of the wire interval, ratio 1:132 with an error of 4.1 links in 10 chains, and focal constant 1.2 links.

Field record.	Final field notes.	
	Chains.	N. 0° 02′ W., bet. secs. 15 and 16. Descend gradually over mountainous land.
	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′.
3.194 3.212 6.406×0.7976=5.109 Error + .021 $(c+f)$ cos v + .011 12.60 +5.14 chs.	=17.74	Left bank of creek, 62 lks. wide, course NW.
6.406×0.4018=2.574 chs. Diff. elev. =170 ft. 3.448 3.432 6.880×0.8324=5.727 Error + .024 $(c+f)$ cos v + .011 12.60 +5.76 chs.	=18.36	Right bank of creek; precipitous ascent of 225 ft. to rim of canon.
5.14 chs. Width of creek =0.62 chs. 4.914 4.895 9.809×0.9925=9.735 Error + .040 $(c+f)$ cos v .012 12.60 +9.79 chs.	=22.39	Rim of canon, bears NW. and SE., asc. gradually.
9.809×0.0863=0.847 chs. =56 ft. +170 ft. Diff. elev. =226 ft.		

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

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

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

82. Example of test of stadia wire interval, the approximate ratio eing 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.		
	Chains.	*Chains.*	*Feet.*	
− 3¼°	6.40	6.386 chs.	9.515	July 7, 1915, I made the following test of the stadia wire interval:
− 4¼°	2.70	2.692	9.518	Horizontal length of base = 14.160 chs.
+12¼°	5.20	5.082	9.522	Mean of ten rod readings = 9.5200 ft.
			9.519	Vertical angle of test = +1°54′
Total base		= 14.160	9.527	K = 98.193
			9.513	log $\frac{K}{66}$, rod in feet and horizontal distance in chains = 0.172537
$+f)$		= .012	9.521	
			9.524	
tadia base		= 14.148 chs.	9.521	
" "		= 933.768 ft.	9.520	
ean rod reading =			9.5200	
oefficient for 1°54′ = 0.9989; 0.0011×9.5200 =			.0105	
$r \cos^2 v$ =			9.5095	
$K = \frac{933.768}{9.5095} = 98.193$				
g K = 1.992081				
66 = 1.819544				
$\frac{K}{66}$ = 0.172537				

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

Field record.	Final field notes.	
	Chains.	North, bet. secs. 31 and 36. Over level land.
	14.20	Commence gradual ascent of 40 ft. 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. E.; ascend 190 ft. to top.
$\log \frac{K}{66} = 0.172537$ " $8.472 = 0.927986$ " $\cos^2 16° 40' = \begin{cases} 9.981361 \\ 9.981361 \end{cases}$ 1.063245		
nat $\frac{K}{66} r \cos^2 v = 11.568$		
$(c+f) \cos v = \quad .012$		
14.20 + 11.58 chs.	25.78	Top of cliff; thence over level mesa.
$\log K = 1.992081$ " $8.472 = 0.927986$ " $0.2748 = 9.439017$ 2.359084		
Diff. elev. = 228 ft. To bluff = 40 Cliff = 188 "		

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

85. In making all triangulations for the purpose of obtaining measurements across water or over precipitous slopes, the surveyor 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.

86. 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° 32′; this gives a value of 24° 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 error and finally takes a mean of the resulting four readings, which is di vided by the proper factor. It is occasionally necessary in public land surveying to repeat angles by the latter method, but the fo mer method is of more general use and will be found dependabl and quickly executed.

87. The base lines for triangulations are to be carefully measure even to tenths of links if necessary, and the sum of the angles shoul be balanced to 180°, or redetermined if the disagreement is found t exceed 1′ of arc.

88. The following examples, with the reductions added, are de signed to illustrate the form of record of triangulations best suite for the official field notes:

(*a*) Field record.

Angles.

50° 35′
93 20
36 05
180° 00′

Hor. meas. of base by one chain tape = 12.80 chs.

$$\text{Dist.} = 12.80\ \frac{\sin 36°\ 05'}{\sin 50°\ 35'}$$

log 12.80	= 1.107210
" sin 36° 05′	= 9.770087
	0.877297
" sin 50° 35′	= 9.887926
" 9.76	= 0.989371
Dist. by tri.	= 9.76 chs.
log hor. dist.	= 0.989371
" 66	= 1.819544
" tan 32° 47′	= 9.808916
" 415	= 2.617831
Diff. elev. = 415 ft.	

Final field notes.

Chains.	
	S. 89° 56′ W., on random line bet. sec 19 and 30.
40.00	Set temp. ¼ sec. cor.
72.20	Top of precipitous bluff; vertical ang to flag on random line = −32° 47 auxiliary flag bears S. 39° 21′ W from flag on random line the auxiliar flag bears S. 3° 16′ W., 12.80 chs. dist all bearings checked by direct rea ing of the solar, and all angles checke by deflection:
	
	Dist. on random line = 72.20 ch
	Dist. by triangulation = 9.76
	81.96
	Dist. by return meas. = 2.84
	79.12
79.12	Intersect W. bdy. of Tp., 14 lks. S. the cor. of secs. 19, 24, 25 and 30. Thence
	S. 89° 58′ E., on a true line bet. sec 19 and 30.
	Ascend gradually in valley.
1.75	Base of bad-land bluff, bears N. and S precipitous ascent of about 400 ft.
6.92	Top of bad-land bluff, bears N. and S thence over level prairie.

3) Field record.

NOTE.—Stadia wire ratio, 1:132.551; $(c+f)$=1.2 lks.

$$\begin{array}{r} 9.827 \\ 9.839 \\ \hline 19.666 \\ \text{Error}=+.082 \\ (c+f)=+.012 \\ \hline \text{Base}=19.76 \end{array}$$

Angles.

$$\begin{array}{r} 79^\circ\ 11' \\ 33\ \ 03 \\ 67\ \ 46 \\ \hline 180^\circ\ 00' \end{array}$$

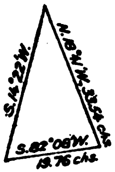
ist.=19.76 $\dfrac{\sin 67^\circ 46'}{\sin 33^\circ 03'}$

g 19.76	= 1.295787
sin 67° 46′	= 9.966447
	1.262234
sin 33° 03′	= 9.736692
33.54	= 1.525542
ist. by tri.	=33.54 chs.

Final field notes.

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:

Length of base =19.76 chs.
From meander cor. to island=33.54 chs.



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

Set a limestone, 28 x 10 x 6 ins., 21 ins. in the ground, for auxiliary meander cor. in sec. 8, mkd. A M C on S. face; from which

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.

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.

Field record.

Final field notes.

Chains.

5th Guide Meridian West, through T. 14 N., between Rs. 20 and 21 W.

North, bet. secs. 13 and 18.

Descend 225 ft. over NW. slope, through heavy timber and dense undergrowth.

Difference between measurement of 27.80 chs., by two sets of chainmen, is 4 lks.; position of middle point
by 1st set=27.78 chs.,
by 2d " =27.82 ",
the mean of which is

(*c*) **Field record, con.**

At $A = \frac{54^\circ\ 29'}{3} = 18^\circ\ 09'40''(-02'')$

" $B = \frac{245^\circ\ 13'}{3} = 81^\circ\ 44'20''(-09'')$

" $C = \frac{240^\circ\ 19'}{3} = 80^\circ\ 06'20''(-09'')$

$180^\circ\ 00'20''(-20'')$

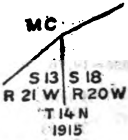
Dist. $= 16.427 \frac{\sin 80^\circ\ 06'\ 11''}{\sin 18^\circ\ 09'\ 38''}$

log 16.427	=1.215558
" sin 80° 06′ 11″	=9.993488
	1.209046
" " 18° 09′ 38″	=9.493710
" 51.92	=1.715336
+27.80	
79.72	

Final field notes, con.

27.80 The south shore of Grand Lake, bea[rs] N. 62° E. and S. 48° W.

Set an iron post, 3 ft. long, 1 in. diam[.], 28 ins. in the ground, for meand[er] cor. of frac. secs. 13 and 18, with bra[ss] cap mkd.



from which

A pine, 8 ins. diam., bears N. 84¾° E[.], 105 lks. dist., mkd. T 14 N R 20 W 18 M C B T.

A pine, 10 ins. diam., bears S. 26¼° W[.], 49 lks. dist., mkd. T 14 N R 21 W 13 M C B T.

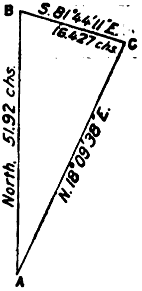
To make a triangulation across the la[ke] I designate the above meander co[r.] point *A* and set a flag *B* at point f[or] meander cor. on north shore of la[ke]; also a flag *C* on the north shore whi[ch] from point *A* bears N. 18° 09′ 38″ E[.]; the base *B C* bears S. 81° 44′ 11″ E[.], 16.427 chs. dist., the mean by t[wo] sets of chainmen,

by 1st set=16.425 chs.,

by 2d " =16.429 ";

longer base impracticable; the ang[le] subtended at point *C*=80° 06′ 11″; all angles by three repetitions wi[th] 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.

89. In practical field work triangulations are made only to over-
me physical difficulties of measurement, and under the conditions
nerally presented a right-angled triangle is likely to be less desir-
le than an oblique triangle as the latter may be selected to fit the
st topography for the base line. A stadia base may likewise be
perior to a measured base as, for example, in extremely rough
untainous regions where possibly no obstruction would interfere
th a good stadia determination even though a steel tape measure-
ent of the same base might be almost impossible, or involve
eat delay and expense. Under some conditions a double triangu-
ion by independent bases may be highly desirable, one result
a check upon the other, whereby the mean of the two would be
etter value than either result alone. True efficiency demands a
oice of the best methods to suit the peculiar conditions encoun-
ed in each circumstance, and this must be left to the judgment
the surveyor.

The subject of measurements is incomplete without a suggestion
at each surveyor should devise a system of signals by means of
ich numbers and directions may be readily communicated from
e member of a party to another; such signals will be found espe-
lly useful in long steel tape and stadia measurements and
angulations.

STRUMENTS AND REQUIREMENTS AS TO THEIR ADJUSTMENT.

40. The direction of all lines of the public land surveys will be
termined with reference to the true meridian as defined by the
is of the earth's rotation. No departure from this rule is authorized.
ginning with the Manual of 1890 the use of the magnetic needle
s prohibited except in subdividing and meandering, and then
ly in localities free from local attraction and with the use of
tably constructed needle instruments. The Manual of 1894
quired that all surveys of the public lands of the United States,
bracing all classes of lines, be made with reference to the true
ridian, independently of the magnetic needle, and this pro-
ition against the use of the magnetic needle was even more
nounced in the Manual of 1902. In the modern instruments the
gth of the needle and other details relating to its construction are
rificed in favor of the vastly more important details of design of
transit and solar attachment, and it is not presumed that the
edle of the modern solar transit will give results even as reliable

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

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

"Survey commenced August 1, 1915, and executed with a Bu 'Rocky Mountain Favorite' solar transit No. 9936, 1915 mode with U-shaped standards, 4½-inch horizontal circle, 4-inch ve tical circle, and improved Smith solar attachment; all azimu determinations are accomplished with the solar attachment exce the special observations upon Polaris and the sun for meridian up 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 equipped with a full vertical circle and the Smith solar attachmen unless otherwise specified all azimuth determinations are acco plished with the solar attachment."

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

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

43. The record of the field test of the instrument should embrac a comprehensive statement of fact as to date, locality, and cond n of the instrumental adjustments. The data relative to the lependent observations for meridian should be included in the ›ord, and the functions of apparent time, latitude and sun's ›clination will always be given in connection with the meridional ts of solar instruments. Various forms of record will be found connection with the examples of observations and reductions 'en on the following pages.

ŀ4. When a transit without solar attachment is employed, Polaris servations, or direct altitude observations upon the sun, necessary execute the work in accordance with existing law and the require›nts of these instructions will be insisted upon. Observations on Polaris, or direct altitude observations upon the sun, at freent intervals, will be necessary to secure accuracy in the pro›tion of transit reference lines, when solar apparatus is not used. ıe method of transferring the azimuth determined by the meri›nal observations to the surveyed lines will distinctly appear in the ld notes.

ŀ5. Surveyors using instruments with solar apparatus will be reired to make azimuth observations on Polaris, or direct altitude servations upon the sun, at the beginning of every survey, to test e accuracy of the solar apparatus, and subsequent tests will be quired at least at the beginning of the subdivision of every township.

ŀ6. A test at the conclusion of a survey is necessary in order to ove the continued proper projection of transit lines or the conued satisfactory adjustment of the solar apparatus during the rvey. A book of field notes of the survey of standard lines, or township exteriors, will therefore show preliminary and final aziuth observations for the projection of transit lines, or preliminary d final observations and tests for the adjustment of the solar appatus, and intermediate tests to comply with the requirements of e preceding paragraphs. The satisfactory condition of the solar paratus at the conclusion of the subdivision of a township exeted with the solar apparatus may, if so desired, be shown by spefic reference to the next succeeding test preliminary to commencg the subdivision of another township included in the same series books of subdivisional notes. A careful surveyor will make a fficient number of tests to satisfy himself at all times of the accucy of his alinement, but it is not intended to burden the surveyor the field notes with superfluous evidence in this particular atter.

GENERAL STATEMENT, TIME, LATITUDE AND AZIMUTH.

47. When considering the following treatment of field method determination of time, latitude and azimuth, the surveyor sho bear in mind that a small error, either in assumed latitude or a muth, produces only a slight effect in time, and when all are u known the order of sequence in their determination should be th of time, latitude and azimuth. Time may be readily determin by the surveyor with an error not to exceed 10 seconds, while la tude and azimuth are readily determined with an error not to exce 1′ 00″; the stated limits of error are not unreasonable where an the methods herein described and authorized are employed; sm errors in assumed longitude may be neglected in the determinati of time, latitude and azimuth.

The following methods are limited to observations upon the s and the north star, Polaris, and are arranged to facilitate the su veyor's work under all conditions encountered in the field, witho involving more than an elementary understanding of astronomic technology. The tables and formulas published in the Standa Field Tables, and the complete daily ephemeris of the sun a Polaris and the tables of azimuths of Polaris, published in t "Ephemeris," are designed primarily for the convenience of t public-land surveyors in the field, thus encouraging a general u of approved modern methods, consistent at all times with the su veyor's clear understanding of underlying principles involved.

All reference to tables and formulas, or to the daily functions the sun or Polaris, that follow herein, relate to the above suppl ments to the Manual, and when necessary to use conventional no tion in the demonstrations that follow, the same agrees with th shown in detail in the Standard Field Tables.

With relation to the subject of records of observations as the sa should appear in the official field notes of a survey, it must b granted that it is absolutely necessary to state all of the special ba functions of an observation, but it is quite unnecessary to inclu the process of reduction, except in unusual cases; thus the fie notes should be complete in every respect, and it is the purpose insist upon this requirement without involving that which is une sential to the record. In general also, no attempt is warranted b which the surveyor may endeavor to make his results by analytic reduction appear to be more accurate than justified by the refin ments of the observation upon which a determination is based; bu good practice not to discard the various small elements, fractions ecimal parts of the record value of a function until the result is rtained, whereupon the insignificant figures may be disposed of.

ANALYTICAL NOTATION, DECLINATION AND REFRACTION.

. ≠: The symbol for approximation; this symbol signifies inlity, but it is used in a relation representing an inequality h approaches equality.

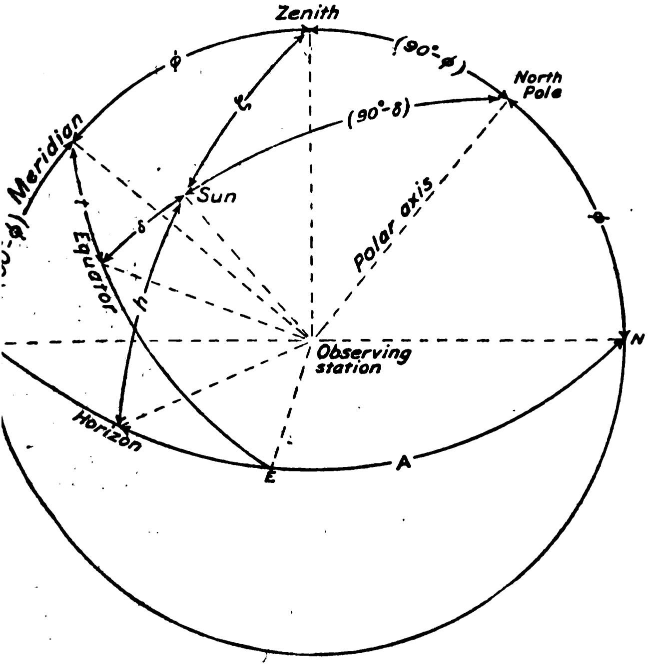


Fig. 4.

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

9. v: Observed vertical angle; in altitude observations on the sun, reductions to the sun's center both vertically and horizontally, vell as instrumental errors, are eliminated by taking direct and ersed observations on the opposite limbs of the sun, and the mean erved vertical angle to the sun's center will be designated v in the ation. 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: $h=v-$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.					Final field notes.
Tele-scope.	Watch time.	Horizontal angle.	Vertical angle.	Sun's limbs.	
Dir.	3h56m58s	65° 0′ 0″	25° 20′ 0″		Mar. 18, 1910, I mal an altitude obs vation upon the su for time and az muth, making tw observations, o each with the tel scope in direct an reversed position observing opposit limbs of the sun. Mean watch time o observation, 3h 57 53s p. m. Mean horizontal a gle from flag S. sun SW., 64° 52′ 30 Mean observed vert cal angle 25° 25′ 30
Rev.	3 58 48	64 45 0	25 31 0		
Mean	3h57m53s	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.		**Final field notes.**
Sun's lower limb	**=25° 20′ 0″**	**Mar. 18, 1910, I mal an altitude obs vation upon the su for time, observi the sun's lower lim only; failing to o serve the sun's u per limb in the r versal of the trans on account of cloud Watch time of obse vation, 3h 58m 5 p. m. Observed vertical a gle to sun's lowe limb, 25° 20′ 0″, co rected to the sun center=25° 36′ 6″.**
Reduction to sun's center	**= +16′ 6″**	
Sun's center, v	**=25° 36′ 6″**	
v	**=25° 36′ 6″**	
Refraction	**= − 2′ 0″**	
Parallax	**= + 0′ 8″**	
h	**=25° 34′ 14″**	
ζ	**=64° 25′ 46″**	
	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 he Ephemeris for the date of observation; the declination of the un is to be corrected in hourly difference to the longitude of the tation and to the time of observation; north declinations are treated s positive and south declinations as negative; a northerly hourly notion is treated as positive and a southerly hourly motion is treated s negative; in the use of the solar attachment the declination of he sun is to be corrected for refraction in polar distance, always orth.

Examples of computation of the sun's declination.

(*a*) It is desired to compute the value of the sun's declination for he above altitude observation upon the sun for time and azimuth. ongitude of the station of observation, 5^h 8^m W.; apparent time of bservation, 3^h 42^m p. m.:

)eclination of the sun at Greenwich apparent noon
Mar. 18, 1910 $=1°\ 11'\ 3''$ S.

)ifference in time from Greenwich apparent noon
to apparent time of observation:
For longitude $=\ 5^h\ 8^m$
For time, p. m. $= +3\ \ 42$

$8.83^h = \ 8^h\ 50^m$

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

)ifference in declination from Greenwich apparent
noon to apparent time of observation:
$8.83 \times 59.28 = 523''$ $=\ \ 8'\ 43''$ N.

Crue declination of the sun $1°\ \ 2'\ 20''$ S.

(*b*) It is desired to prepare, by computation, a table of hourly leclinations of the sun, corrected for refraction in polar distance, or use with the solar attachment, for a date March 14, 1912, and for station in latitude 33° 10′ N., and longitude 7^h 47^m W.

2° 33′ 28″.6 S. =Declination of the sun at Greenwich appare
noon, Mar. 14, 1912.

Difference in time from Greenwich apparent noo
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 appare
noon to 7 a. m., local apparent time: 2.78×59.2=
164″.5.

2° 30′ 44″.1 S. =True declination of the sun, 7 a. m., local appare
time.

Local apparent time.	True declination.	Refraction.	Declination setting.
7 a. m.	2° 30′ 44″ S.	2′ 41″ N.	2° 28′ 3″
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 23	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 hou declinations of the sun, corrected for refraction in polar distance, f use with the solar attachment, for a date August 12, 1912, and for station in latitude 47° 10′ N., and longitude $7^h\ 24^m$ W.

15° 1′ 6″ N.=Declination of the sun at Greenwich apparent noo
Aug. 12, 1912.

Difference in time from Greenwich apparent noon t
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 appare
noon to 6 a. m., local apparent time: 1.4×45.1=63″

15° 0′ 3″ N.=True declination of the sun, 6 a. m., local appare
time.

Local apparent time.	True declination.	Refraction.	Declination setting.
m.	15° 0′ 3″ N.	3′ 29″ N.	15° 3′ 32″ N
	14 59 40	2 22	15 2 2
	14 59 18	1 46	15 1 4
	14 58 33	1 9	14 59 42
	14 57 48	0 52	14 58 40
	14 57 3	0 42	14 57 45
m	14 56 18	0 39	14 56 57
n.	14 55 33	0 37	14 56 10
m.	14 54 48	0 39	14 55 27
	14 54 3	0 42	14 54 45
	14 53 18	0 52	14 54 10
	14 52 33	1 9	14 53 42
	14 51 48	1 46	14 53 34
	14 51 26	2 22	14 53 48
m.	14 51 3	3 29	14 54 32

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

'he horizontal lines may be used to represent each hour of the day, the vertical lines may represent intervals of 1′ in declination. It onvenient to use the right-hand side of the sheet to represent N., the left-hand side of the sheet to represent S., or to have N. linations increase numerically to the right-hand side of the sheet, S. declinations increase numerically to the left-hand side of sheet. The vertical lines are numbered to suit the range of lination of the sun for the date. Two points are marked on the gram to agree with the true declination of the sun; the first point narked with the argument of declination agreeing with the lination of the sun taken from the Ephemeris for Greenwich ıarent noon and with the argument of time agreeing with the local ıarent time corresponding to Greenwich noon; the second point is ·ked agreeing with the proper declination and time 10 hours later; straight line determined by the two points agrees with the sun's declination for the date for the local apparent time. The proper actions in polar distance are then scaled from the straight line he N. for each tabulated refraction, a. m. and p. m., taken from ıle 23, Standard Field Tables, appropriate to the latitude of ervation and declination of the sun; the locus of the latter nts is a smooth curve representing graphically the declinations he sun, corrected for refraction in polar distance, for use with the ır attachment. The scale of the refractions must equal the scale he intervals of 1′ in declination, and the refractions are laid off ıg or parallel to the horizontal lines and *not* normal to the line of true declination. At any time throughout the day the pro declination for use with the solar attachment is obtained by refere to the curve at the point corresponding to the time of observati To obtain any true value of the sun's declination for use in t reduction of *altitude observations* reference may be made to the strai line of true declination at the point corresponding to the time observation.

The advantage of the diagram method is found in the practi elimination of errors of computation, and the ease with which i checked, together with the fact that in the use of the diagram act values are obtained at any time without any process of interpolati

The following diagrams have been prepared to illustrate method:

DIAGRAM OF THE SUN'S DECLINATIONS.

Date, Mar. 20, 1912.
Station: Lat.=37° 30′ N.
Long.=7^h 30^m W.

Declination.

Greenwich noon=0° 11′ 14″ S.=4^h 30^m a. m.
Diff. 10^h, +593″= 09 53 N.
0° 01′ 21″ S.=2^h 30^m p. m.

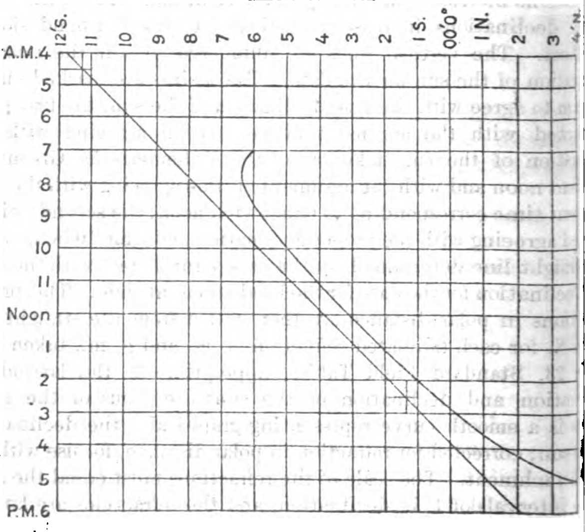


Fig. 5.

DIAGRAM OF THE SUN'S DECLINATIONS.

Date, Sept. 23, 1913.
Station: Lat. = 47° 30′ N.
Long. = $6^h\ 18^m$ W.
Greenwich noon = 0° 03′ 55″ N. = $5^h\ 42^m$ a. m.
Diff. 10^h, −585″ = 9 45 S.
0° 05′ 50″ S. = $3^h\ 42^m$ p. m.

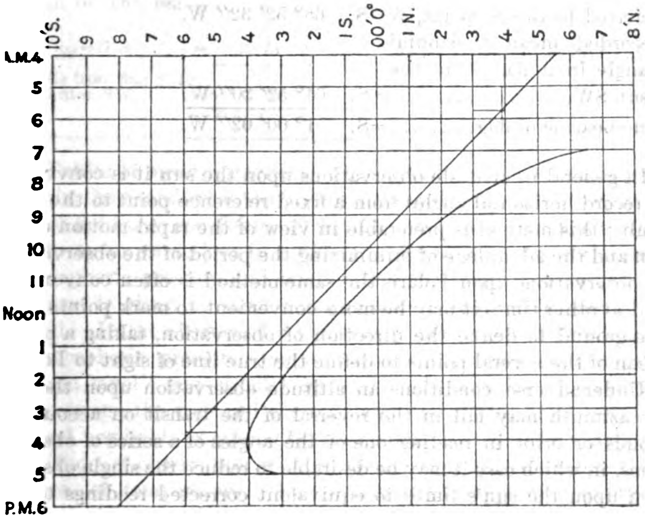


Fig. 6.

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, and ζ, is shown the record of certain observed horizontal angl from a fixed reference point to the sun's limbs, and now for the pu pose of clearly stating the use of the notation A, the final reductio of that observation is here anticipated, in which the following resu is obtained:

Sun's azimuth.

Referred to the N. point,	A=N.	114° 07′ 28″ W.
Referred to the S. point,	A=S.	65° 52′ 32″ W.
Recorded mean horizontal angle from flag S. to the sun SW..................	=S.	64° 52′ 30″ W.
True bearing of flag.........	=S.	1° 00′ 02″ W.

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

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

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

Field record.		Final field notes.
Vertical angle to sun's lower limb	=25° 20′ 00″	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:
's semi-diameter for reaction to center	= + 16′ 06″	Apparent time of observation, 3h 42m p. m.
's center, v	=25° 36′ 06″	Observed vertical angle to sun's lower limb, 25° 20′ 00″, corrected to the sun's center=25° 36′ 06″.
angle from flag S. to n's right limb, SW.	=65° 00′ 00″	Observed horizontal angle to sun's right limb from flag S. to sun SW., 65° 00′ 00″, corrected to the sun's center=64° 42′ 06″.
action to sun's center, $\frac{16'.1}{\cos 25° 36'}=17'.9$	= 17′ 54″	
angle from flag S. to n's center, SW.	=64° 42′ 06″	

6. Tables of mean refractions both in zenith and polar distance ear in the Standard Field Tables, arranged to meet the requirents of field use; see Tables 20 and 23. A table of coefficients to ly to mean refractions in zenith or polar distance for variations atmospheric pressure and temperature to obtain true values of actions is given to meet occasional necessity for its use, see le 21. In the absence of a barometric instrument to determine atmospheric pressure, the argument "approximate elevation ve sea level" may usually be safely substituted. The differes between the true and the tabulated refractions are generally ll and negligible excepting for the combined effect of low appar- altitude of observation with great elevation above sea level or remes of temperature. The following example of reduction strates the method to be employed in all reductions from the ulated refractions:

abulated refraction =6′ 45″=6′.75; elevation above sea level 0,000 feet, for which elevation the coefficient is 0.70; temperae at the time of observation =82° F., for which temperature the fficient is 0.94; true refraction =0.70×0.94×6′.75=4′.44=4′26″.

TIME.

7. The element of time enters into all azimuth determinations such an extent that the surveyor should be able to arrive at the ct apparent time of all observations upon the sun and the exact al mean time of all observations upon Polaris. The sun's declinan varies with the apparent time and the longitude west from

Greenwich, and enters directly into all observations upon the for azimuth; thus the apparent time and longitude should be kno to a degree of accuracy commensurate with the refinement neces in computing the sun's declination. The azimuth of Polaris va with the local mean time of observation, which must be known degree of accuracy consistent with the result wanted in the de mination of the true meridian. In observations upon Polaris elongation precision in local mean time is unnecessary, but in h angle observations upon Polaris it will be noted that at uppe lower culmination, in latitude 40° for example, Polaris varies 1' azimuth in about 2.5 minutes of time; this interval of time slo increases toward elongation and in the latter position more t 30 minutes of time are required for a change of 1′ in azimuth.

58. Conversion of standard time into local mean time: watch re ing ± watch error in standard time by comparison ± correction longitude; the correction for longitude is additive east and s tractive west of the standard meridian of the time belt; the c version table "degrees to time" (Table 18, Standard Field Tab is convenient in this reduction.

Example of conversion of standard time into local mean ti longitude 77° 01′ 37″.5 W.:

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

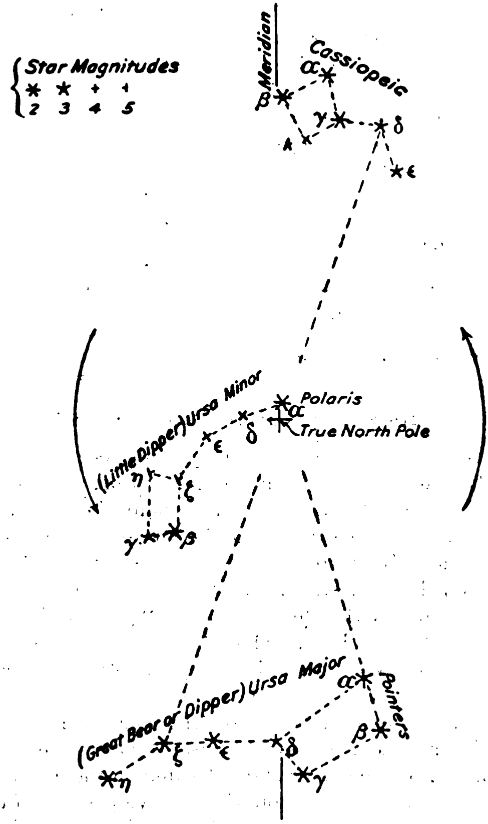
59. Conversion of apparent time into local mean time: appar time of observation ± the equation of time; the equation of tim to be taken from the Ephemeris for the date of observation and c rected for the longitude and time of observation, convenien interpolated as the interval from Greenwich noon to the time observation; the watch error in local mean time is then found taking the difference between the watch reading at the epoch of observation and the reduced local mean time of observation.

Example of conversion of apparent time into local mean ti longitude 77° 01′ 37″.5 W.:

ır. 18, 1910, apparent time of altitude observation upon sun		$=3^h\ 42^m\ 11^s$ p. m.
ıuation of time, Greenwich apparent noon	$+8^m\ 23.4^s$	
terpolation 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	$= -6.5^s$	
ıuation of time	$+8^m\ 16.9^s$	$+8^m\ 17^s$
ıcal mean time of observation		$=3^h\ 50^m\ 28^s$
atch time of observation		$=3^h\ 57^m\ 53^s$
atch 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 the northern heavens a little more than 1° from a line defined by e axis of the earth's rotation, and on account of its brightness and oximity to the polar axis it ranks to the surveyor as the most useful rcumpolar star. It will be assumed that the surveyor has learned w to identify the north star among its associates in the clear starlit avens, especially with reference to the "pointers" in the con-ıllation of the "Great Bear," which is popularly called the "Dip-ır." Polaris (α Ursæ Minoris) is nearly on a line (or great circle) termined by the pole and the star "δ Cassiopeiæ," and both stars e located in the same direction from the pole. The same line (or eat circle) passes near the star "ζ Ursæ Majoris" (another star of e "Dipper"), but the latter star is located on the *opposite* side of e pole. The surveyor may note the relative position of the three ars aforementioned, if it is a clear night, and this will give an im-ediate indication of the approximate position of Polaris in its di-nal circle at such time of observation. The novice should secure ıld demonstration in these details from an experienced observer. he three stars named are all of about the same brightness. In-ructions will follow (sec. 99) regarding the positive identification Polaris by instrumental methods during the twilight period, be-re 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.

nployed for verification of night observations, if there should ny doubt as in case the neighboring constellations are obscured louds.

skillful surveyor can readily observe Polaris at sunset or sunrise out artificial illumination, and with a very clear atmosphere perform the observation when the sun is as much as 20 or 30 ites above the horizon. At any time that Polaris is visible any of the various methods of Polaris observation for meridian, erly followed, is superior to any form of observation upon the for the same purpose. In general, in public-land surveying, est of all practices is found in the proper use of a solar instru- adjusted to the true meridian as established by Polaris obser- n.

laris has a diurnal circle about the earth's polar axis similar to iurnal circle of other stars, though Polaris has the smallest circle y naked-eye star. The daily circuit of Polaris is covered in one eal day of 24 sidereal hours, or an equivalent of 23 hours 56 ites 4.09 seconds of mean solar time. In its diurnal circle Polaris es the meridian twice, once at upper culmination, or above the axis, and once at lower culmination, or below the polar axis. e direction of the apparent motion of Polaris is suggested by the ving diagram:

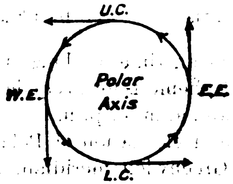


Fig. 7.

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

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

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

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

Example of reduction from the Greenwich mean time of upp culmination of Polaris to the local mean time of upper culminati of Polaris, longitude 111° 15′ W.:

Aug. 12, 1910, Gr. U. C. of Polaris	$=4^h\ 08.3^m$ a. m.
Red. to long. 111° 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, latitu 40°, is tabulated in the Ephemeris for every day in the year, arrang for the ordinary civil date, a. m. or p. m.

64. Local mean time of elongation of Polaris: the mean time elongation of Polaris, Greenwich meridian, latitude 40°, is to l taken from the Ephemeris for the date of observation: the amou to be subtracted from the mean time of elongation of Polaris, Gree wich meridian, latitude 40°, to obtain the mean time of elongati of Polaris, local meridian, latitude 40°, in which the argument is t longitude west from Greenwich, is obtained from the table of sid real conversions (Table 19, Standard Field Tables) without comp tation. The amount to apply to the local mean time of elongati of Polaris latitude 40° to obtain the local mean time of elongation Polaris at the *latitude of observation* is tabulated in the Epheme in connection with the table of azimuths of Polaris at elongation.

Examples of reduction from the Greenwich mean time of elong tion of Polaris, latitude 40°, to the local mean time of elongation Polaris, latitude 64° 30′ N., and longitude 146° 30′ W.:

EASTERN ELONGATION.

ept. 9, 1910, Gr. E. E. of Polaris, Lat. 40°	$=8^h$ 19.6^m p. m.
ed. to long. 146° 30′ W., 1^m 36^s	$= -$ 1.6
ed. to lat. 64° 30′ N.	$= +$ 5.8
. M. T. of E. E. of Polaris	8^h 23.8^m p. m.

WESTERN ELONGATION, SAME STATION.

ct. 16, 1910, Gr. W.E. of Polaris, lat. 40°	$=5^h$ 48.5^m a. m.
ed. to long. 146° 30′ W., 1^m 36^s	$=$ $-$ 1.6
ed. to lat. 64° 30′ N.	$=$ $-$ 5.8
. M. T. of W. E. of Polaris	$=5^h$ 41.1^m a. m.

65. Conversion of a mean time interval into a sidereal time inter-l, or vice versa: The amount to apply to one time interval to obtain e 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 me interval:

ean time hour angle of Polaris for an assumed observation in Alaska $= 7^h$ 32.6^m	$=$ 7^h 32^m 36^s
nversion into equivalent sidereal hour angle	$=$ $+$ 1 14
dereal hour angle	$=$ 7^h 33^s $50''$

7^h $=105°$
$33^m=$ 8° 15′
$50^s =$ 12′ 30″

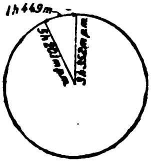
$=113°$ 27′ 30″

66. Hour angles of Polaris: a mean time hour angle of Polaris *st* of the meridian is the mean time interval *from* the local mean ne of the last preceding upper culmination *to* the local mean time observation of Polaris; a mean time hour angle of Polaris *east* of the eridian is the mean time interval *from* the local mean time of ob-rvation *to* the local mean time of the next succeeding upper cul-ination of Polaris.

The above application of the term "hour angle" is a departure m conventional usage, which has been employed in order to simplify the text. By this means one confusing step in the prob relating to hour angles for positions of Polaris east of the meridia avoided. Polaris crosses the meridian at lower culmination a hour angle of $11^h\ 58^m\ 02^s$, and in the arrangement of the vari examples, the observations west of the meridian have been refer to the last preceding upper culmination, and those east of the me ian have been referred to the next succeeding upper culminati thus avoiding the introduction of any hour angles exceeding 11^h 02^s.

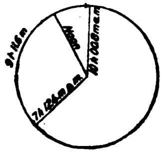
Examples of computing hour angles of Polaris; all taken ou longitude 117° 15′ W.:

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



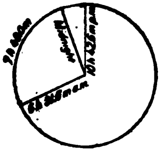
L. M. T. of obsn., Feb. 18, 1911		$=5^h\ 20.1^m$ p
Gr. U. C. same date	$=3^h\ \ 36.5^m$ p. m.	
Red. to long. 117° 15′ W.=	$-\ 1.3$	$=3\ \ 35.2$ p
Hour angle of Polaris, west		$=1^h\ 44.9^m$

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



L. M. T. of obsn., May 14, 1911		$=\left\{\begin{matrix}+12 \\ \quad 7^h\ 12.4^m\end{matrix}\right.$ p.
Gr. U. C. same date	$=10^h\ 02.1^m$ a. m.	
Red. to long. 117° 15′ W.=	-1.3	$=\ \ 10\ \ \ 0.8$ a
Hour angle of Polaris, west		$=\ \ 9^h\ 11.6^m$

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



$\left\{\begin{array}{l}+12 \\ = 6^h\ 31.6^m \text{ a. m.}\end{array}\right.$

M. T. of obsn., Nov. 3, 1911

U. C., Nov. 2 $=10^h\ 43.9^m$ p. m.

l. to long. 117° 15′ W. -1.3 $=10\ \ 42.6$ p. m.

ur angle of Polaris, west $= 7^h\ 49.0^m$

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

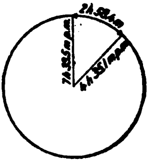
M. T. of obsn., Aug. 11, 1911 $= 5^h\ 05.9^m$ a. m.

U. C., same date $=4^h\ 13.6^m$ a. m.

l. to long. 117° 15′ W. -1.3 $= 4\ \ 12.3$ a. m.

ur angle of Polaris, west $= 0^h\ 53.6^m$

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



U. C., Dec. 20, 1911 $= 7^h\ 34.8^m$ p. m.

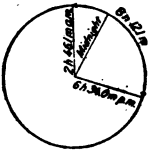
l. to long. 117° 15′ W. $= \ -1.3$

M. T. of U. C., Dec. 20 $= 7\ \ 33.5$ p. m.

M. T. of obsn., same date $= 4\ \ 35.1$ p. m.

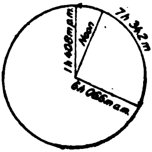
ur angle of Polaris, east $= 2^h\ 58.4^m$

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



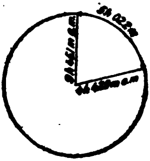
Gr. U. C., Sept. 2, 1911	$= 2^h\ 47.4^m$ a.
Red. to long. 117° 15′ W.	$= \quad -1.3$
L. M. T. of U. C., Sept. 2	$\begin{cases} = 2\ \ 46.1 & \text{a.} \\ +12 & \end{cases}$
L. M. T. of obsn., Sept. 1	$= 6\ \ 34.0$ p.
Hour angle of Polaris, east	$8^h\ 12.1^m$

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



Gr. U. C., Mar. 19, 1911	$= 1^h\ 42.1^m$ p.
Red. to long. 117° 15′ W.	$= \quad -1.3$
L. M. T. of U. C., Mar. 19	$\begin{cases} = 1\ \ 40.8 & \text{p.} \\ +12 & \end{cases}$
L. M. T. of obsn., same date	$= 6\ \ 06.6$ a.
Hour angle of Polaris, east	$= 7^h\ 34.2^m$

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



Gr. U. C., May 18, 1911	$= 9^h\ 46.4^m$ a. m.
Red. to long. 117° 15′ W.	$= \quad -1.3$
L. M. T. of U. C., May 18	$= 9\ \ 45.1$ a. m.
L. M. T. of obsn.	$= 4\ \ 42.9$ a. m.
Hour angle of Polaris, east	$= 5^h\ 02.2^m$

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.

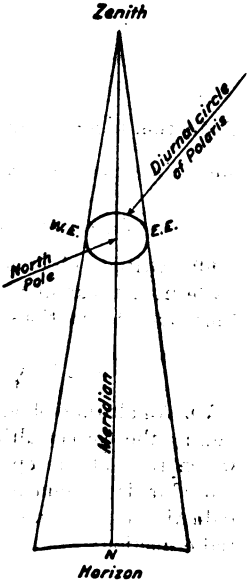


FIG. 8.—The meridian and vertical planes tangent to the diurnal circle of Polaris as viewed from inside of the celestial sphere.

At the equator, if Polaris could be observed, the hour angle of Polaris at elongation would be 90° 0′ 0″ = $6^h\ 0^m\ 0^s$ sidereal hour angle = $5^h\ 59^m\ 1.02^s$ 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.

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:

$$\text{Cos } t = \text{cotan } \delta \tan \phi$$

Example of computing the mean time hour angle of Polaris a elongation, April 3, 1915, in latitude 65° 0′ N., on which date th declination of Polaris=88° 51′ 20″ N.:

ϕ=65° 0′;	log tan ϕ	= 0.331327
δ=88° 51′ 20″;	" cotan δ	= 8.300530
	" cos t	= 8.631857
Sidereal hour angle		=87° 32′ 41″
		87°=5^h 48^m
		32′= 2^m 08^s
		41″= 3^s
		=5^h 50^m 11^s
Reduction to mean time hour angle		= -0^m 57^s
Mean time hour angle at elongation		=5^h 49^m 14^s

ALTITUDE OBSERVATION OF THE SUN FOR APPARENT TIME.

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

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

70. An altitude observation of the sun for time is made by dete mining the correct altitude of the sun's center and recording th watch time at the epoch of observation. The following order procedure is recommended for the elimination of instrumental erro reduction to the sun's center, and practical elimination of differe tial refraction:

A. M. OBSERVATION.

Thoroughly level the transit.

Observe the sun's upper limb, recording the watch time of observa tion 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° 16′ 50″ N., and longitude 102° 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 $=19° 39' 30''$
Mean watch time of observation $=$ $4^h 56^m 04^s$ p. m.
Watch slow of local mean time $=$ $0^m 56^s$

Field record.

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

True vertical angle $=h=19°37'$
Zenith distance $=\zeta=70°23'$
Sun's declination $=\delta=11°05'$N.

$\zeta=70°23'$			$\zeta=70°23'$
$\phi=37\ 17$			$\phi=37\ 17$
$(\zeta+\phi)=107°40'$			$(\zeta-\phi)=33°06'$
$\delta=11°05'\ (+)$			$\delta=11°05'$ (
	$\frac{1}{2}$ values=		
$(\zeta+\phi+\delta)=118°45'$	$59°22'30''$	$22°05'30''$	$(\zeta-\phi+\delta)=44°11'$
$(\zeta+\phi)=107°40'$			$(\zeta-\phi)=33°06'$
$\delta=11\ 05\ (+)$			$\delta=11\ 05$ (
$(\zeta+\phi-\delta)=96°35'$	$48°17'30''$	$11°00'30''$	$(\zeta-\phi-\delta)=22°01'$

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	$73° = 4^h52^m$
" $\tan^2 \frac{1}{2}t$ =		9.749338	$41' =\ 2^m$
" $\tan \frac{1}{2}t$ =		9.874669	$24''=$

$\frac{1}{2}t=36°50'42''$ $t=73°41'24''$ $t=4^h54^m$

Apparent time of observation $=4^h54^m46^s$ p. m.
Equation of time $+2\ 14$

Local mean time of observation $=4^h57^m00^s$ p. m.
Watch time of observation $=4\ 56\ 04$ p. m.

Watch slow of local mean time $=0^m56^s$

MERIDIAN OBSERVATION OF THE SUN FOR APPARENT NOON.

71. *Meridian observation of the sun for apparent noon.*—With t telescope in the meridian elevated to the sun's altitude, the wa times of transit of the sun's west and east limbs are noted, the me of which is the watch time of apparent noon; if the observation fo for either limb the reduction to the sun's center is accomplished adding or subtracting 68 seconds; a refinement in the amount of time is had by referring to the Ephemeris for the time of the su

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

$$v \neq 90° - \phi \pm \delta$$

OBSERVING PROGRAM.

etermine the meridian by the best means at hand and compute ltitude setting for the sun.

vel the transit, place the instrument in the meridian, and ele- the telescope to the altitude of the sun's center.

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

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

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

ample of meridian observation of the sun for apparent noon:

Final field notes.

igust 14, 1909, in latitude 37° 16′ N., and longitude 102° 16′ W., the telescope in the meridian and elevated to the sun's altitude, serve the sun's transit for time, noting the watch time of transit ch limb:

ean watch time of apparent noon $= 12^h\ 00^m\ 27^s$
atch slow of local mean time $=\ 4^m\ 06^s$

Field record.

Setting:		90° 00′
	$\phi \neq$	(−) 37° 16′ N.
	$\delta \neq$	(+) 14° 25′ N.
	$v \neq$	67° 09′

Watch time of transit, W. limb	$= 11^h\ 59^m\ 22^s$
Watch time of transit, E. limb	$= 12\ \ 01\ \ 32$
Watch time of apparent noon	$= 12^h\ 00^m\ 27^s$
Apparent noon $= 12^h\ 00^m\ 00^s$	
Equation of time $= +\ 4\ \ 33$	
Local mean time of apparent noon	$= 12\ \ 04\ \ 33$
Watch slow of local mean time	$=\ 4^m\ 06^s$

ae above form of meridian observation of the sun for apparent a 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, incl principally the Smith solar attachment and the Burt solar com have a graduated arc or circle mounted normal to the polar a indicate the apparent time of observation. The reading of the arc is most conveniently checked by comparison with the form of meridian observation of the sun for apparent noon error in the reading of the time arc or hour circle may be co by adjusting the circle, or allowed for as an index error. The r of the hour circle may then be safely accepted as giving c apparent time for use in computing or taking out required d tions of the sun for the various forms of solar observations. A reading of the hour circle may be safely accepted to indicate ap time at which moment the watch reading may be noted, a watch error *local mean time* determined as shown in the pre example of conversion of apparent time into local mean time; result derived for the *watch error local mean time* may then be u used in observations on Polaris at *elongation*, but for observat upon Polaris by the *hour angle method* the time should be determi by one of the more refined methods already given.

LATITUDE.

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

MERIDIAN ALTITUDE OBSERVATION OF THE SUN FOR LATITUD

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

$$\phi = 90° + \delta - h$$

The following observing program is recommended:

Thoroughly level the transit and place the telescope in the merid-ian 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° 20′ N., and longitude 8° 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	$=47°\ 59'\ 45''$
Reduced latitude	$=37°\ 19'.3$ N.

Field record.

Setting:		90° 00′
	$\phi \neq (-)$	37° 20′ N.
	$\delta \neq (-)$	4° 42′ S.
	$v \neq$	47° 58′
Lower limb		47° 42′
Upper limb		48° 14′

$\underline{\odot}$ Observed alt., lower limb, tel. dir.	$=47°\ 43'\ 00''$
$\overline{\odot}$ Observed alt., upper limb, tel. rev.	$=48°\ 16'\ 30''$
Mean observed altitude, v	$=47°\ 59'\ 45''$
Refraction	$-\ 0\ \ 52$
Parallax	$+\ 0\ \ 06$
	$h=47°\ 58'\ 59''$
	$\delta=\ 4\ \ 41\ \ 42$ S.
$\phi=37°\ 19'.3$ N. $=90°-\delta-h$	$=37\ \ 19\ \ 19$
	$90°\ 00'\ 00''$

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

$$v \neq 90° - \phi \pm \delta \mp 16'$$

Example of meridian observation of the sun for time and lati

Final field notes.

June 8, 1910, in approximate latitude 38° 54′ N., and long 77° 01′.6 W., I make a meridian observation of the sun for tim latitude, observing simultaneously the altitude of the sun's l limb and the transit of the sun's west limb, reversing the tele and observing simultaneously the altitude of the sun's upper and the transit of the sun's east limb:

Mean observed altitude	=73° 55′ 30″
Reduced latitude	=38° 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° 00′
	$\phi \neq$	(−) 38° 54′ N.
	$\delta =$	(+) 22° 49′ N.
	$v \neq$	73° 55′
Lower limb		73° 39′
Upper limb		74° 11′

Position of telescope.	Position of sun.	Watch time transit.	Observ tical a
Direct		12^h 05^m 37^s	73°
Reversed		12 07 42	74
Mean		12^h 06^m 40^s	73°
Refraction			−
Parallax			+
h			= 73°
δ=22° 49′ 00″; 90°+δ			=112
ϕ=38° 53′.7 N.=90°+δ−h			= 38°

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

The known latitude of the above station is 38° 53′ 40″, but it can t be assumed that any one altitude observation of the sun will ways give a result so close to the true latitude. In general a better termination of the latitude by this method is possible only by king a series of observations on successive days, or by combining e result with Polaris observations for latitude.

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

75th meridian time of comparison.=	12^h	00^m	00^s
Correction for longitude 77° 1.6′...=		-08	06
Local mean time of comparison...=	11^h	51^m	54^s
Watch time of comparison........=	11	59	56
Watch fast of local mean time.....=		8^m	02^s

ALTITUDE OBSERVATION OF POLARIS FOR LATITUDE.

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

$$\phi=h+\delta-90°$$

Altitude observation of Polaris at lower culmination for latitude: e mean time hour angle of Polaris at lower culmination is 11 urs 58 minutes 2 seconds:

$$\phi=h+90°-\delta$$

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

$$v\neq\phi\pm(90°-\delta)$$

The following program is recommended in altitude observations 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 laris 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 reve position.

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

Take the mean observed altitude to use in the reduction.

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

Final field notes.

June 19, 1910, in approximate latitude 38° 54′ N., and longi 77° 01′.6 W., I make an altitude observation on Polaris at l culmination for latitude, making four observations, two each 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
Mean observed vertical angle	=	37° 44′ 00″
Reduced latitude	=	38° 53′.4 N.

Field record.

Setting: 90° 00′

$\delta \neq 88° \ 49'$

$90° - \delta \neq 1° \ 11'$

$\phi \neq 38° \ 54'$

$v \neq 37° \ 43' = \phi - (90° - \delta)$

Gr. U. C. of Polaris, June 19, 1910	=	$7^h\ 39.7^m$ a
Reduction to longitude 77° 1.6′ W.	=	−0.8
Reduction to lower culmination	=+	11 58.0
		$7^h\ 36.9^m$ p
L. M. T. of L. C. of Polaris, June 19	=	$7^h\ 36^m\ 54^s$ p
Watch fast of 75th meridian standard time by comparison with a Western Union telegraph clock	=+	0 24
Correction for longitude 77° 01′.6 W.	=+	8 06
Computed watch time of lower culmination	=	$7^h\ 45^m\ 24^s$ p

Telescope.	Watch time.	Vertical angle.
...t	7h 40m 14s	37° 42′ 30″
...rsed	7 42 45	37 44 30
...rsed	7 46 39	37 45 30
...t	7 48 50	37 43 30
Mean	7h 44m 37s	37° 44′ 00″
...ction		−1 15
		h=37° 42′ 45″
...° 49′ 20″; 90°−δ		= 1 10 40
...° 53′.4 N.=h+(90°−δ)		=38° 53′ 25″

AZIMUTH.

THE SOLAR ATTACHMENT.

... The solar attachment to the engineer's transit has been ...gned for instrumentally setting off the sides of the "pole-zenith-..." triangle in agreement with their angular values at the station ...time of observation. The sun's image may be brought into the ... of collimation of an auxiliary telescope by orientation of the ...sit to the position where the instrumental parts are made parallel ...e respective sides of the celestial triangle, whereupon the verti... plane of the "pole-zenith" arc of the solar attachment will ...cide with the true meridian. Skillfully handled, the solar at...ment will give at once close approximations to the true meridian ...paring favorably for accuracy with direct observations. The ...ntage in the proper use of the solar attachment is found in its ...l and close determinations of the meridian in heavy timber, ...e undergrowth, and strong wind, in low swamp or on high ...ntain ascents, and under nearly all other difficult physical ...tions encountered in the field, avoiding in its proper use accumu...e errors incident to the prolongation and deflection of transit ..., and deviations in the azimuth of latitudinal lines. Several ...nious instruments have been devised for this purpose, but the ...th solar attachment, invented by Benjamin H. Smith, of Colo..., in 1880, has given the most general satisfaction of any solar ...rument in meeting the special requirements of the surveying ...ice of the General Land Office wherein it has been developed ... state of efficiency which has fully warranted the adoption of ... model as a standard instrument for use in the public-land ...eys.

Owing to the different details in the design of the Smith sol attachment as constructed by various instrument makers it impossible to discuss fully the test and adjustment of each witho giving a complete description of the several models, and this wou lead away from the purpose of the Manual. The standard mode embracing the most recent improvements, is therefore selected f description, and discussion of the theory, adjustment and use of th Smith solar attachment. The supervising officers will furnish th surveyors with suitable instructions relative to the test and adjus ment of any other special instruments supplied to them, publish in circular form as deemed expedient.

DESCRIPTION.

78. The working parts of the Smith solar attachment consi five fundamental features, each performing its own distincti function. The principles involved have been adapted to vari types of construction, and the efficiency of the different designs related directly to the perfection which may be attained in maki a proper adjustment in the field, the stability of the adjustme when made, and the compactness of the design, considering prot tion to the working parts and proper distribution of weight. T five fundamental working parts consist of:

1. An auxiliary telescope whose line of collimation is the po axis of the solar attachment; the telescope may be revolved in c lar bearings which are securely mounted on a vertical limb.

2. The vertical limb is mounted on a horizontal axis and ha graduated latitude arc in its vertical plane.

3. A plane mirror at the objective end of the auxiliary telesco with an axis normal to the line of collimation, and an arm lead to a graduated declination arc.

4. An hour circle on the auxiliary telescope mounted normal 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 auxiliary telescope is mounted in a vertical plane parallel to transit telescope. Thus, if the instrument is in proper adjustm and oriented to the true meridian, the polar axis of the solar atta ment may be made parallel to the earth's polar axis by setting the true latitude of the station. The sun's rays are brought into t auxiliary telescope by means of the mirror, due allowance bei

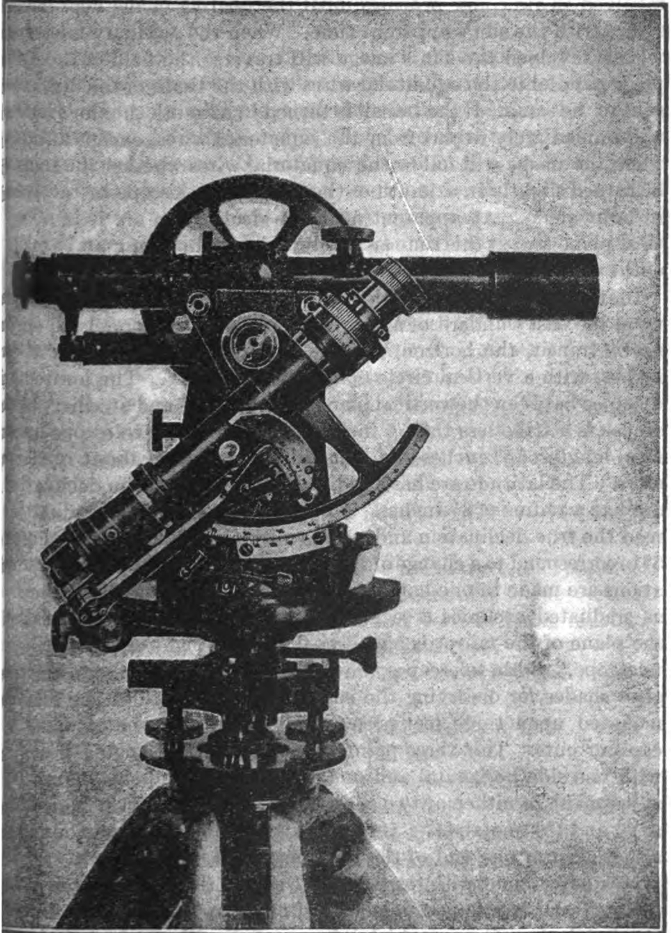


FIG. 9.—The solar transit as it appears in use.

made for the sun's declination north or south of the equator, but t bring the sun's image into the auxiliary telescope the latter must b revolved in its collar bearings until the reading of the hour circ agrees with the sun's apparent time. When the auxiliary telescop is thus revolved the sun's image will traverse the field of the ey piece parallel to the equatorial wires with the limbs of the disk ta gent to the same. If the transit is turned in azimuth the sun's ima will immediately depart from the equatorial wires, except at no when the image will follow the equatorial wires whether the tran be turned slightly in azimuth or the auxiliary telescope be revolv in hour angle. At apparent noon the declination arc is in a ve tical plane and at this time an absolute determination may be ma of the correctness of the reading of this arc.

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

Good solar work must depend first of all upon the proper adju ment of the transit upon which it is mounted, with great care in kee ing every working part cleaned, suitably oiled to work smoothly, a otected from adverse weather and injury. The same precautions e due the solar attachment. It will give very efficient meridional rformance if properly adjusted and operated; nothing less can be nceded.

Before starting in with the adjustments it should be determined at the auxiliary telescope revolves smoothly in its collar bearings, ither too tight nor too loose; that there is free and smooth motion the latitude and declination arcs; that the clamps are positive and e tangent motions smooth and free in either direction; that the e-piece is carefully focused upon the cross wires; and that the jective is carefully focused upon any quite distant object, then cured in this position. The eye-piece turns freely and has a pin-ich travels in a guide slot; this pin is not a clamp. The objective ay be moved by first loosening, then pushing the screw, which will found to travel in a guide slot near the lower (or left hand) collar aring.

ADJUSTMENT.

79. The field adjustments of the solar attachment should be con-lered in the following order:

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

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

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

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

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

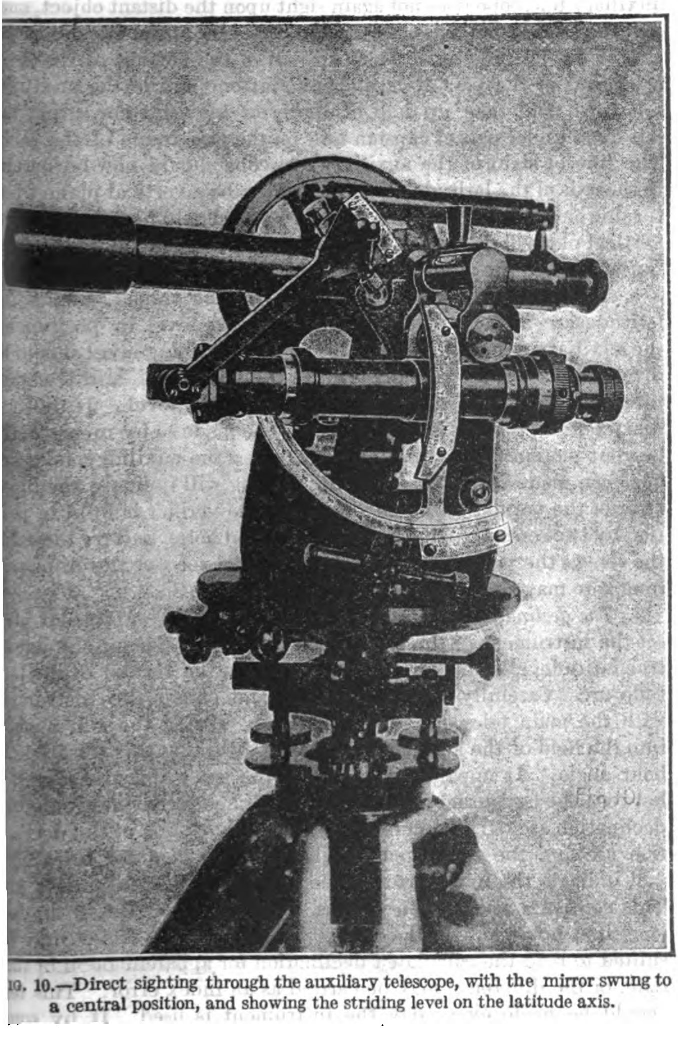
6. The hour circle should read the sun's apparent time.

There are two or more methods of testing each and every adjust-nt, but those stated below are without doubt the simplest, and st rapid and reliable of all field methods. The true meridian ould be established by Polaris or other independent observation, on which to test the solar, but otherwise it plays only a small part the adjustments of the solar attachment. The true latitude of the ation 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 a must be utilized due allowance may be made for the horizontal tance between the vertical planes of the transit and auxiliary scopes.

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

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

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



IG. 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 th auxiliary telescope does not again sight upon the distant object, on half the error is due to its line of sight not being at right angles to th axis of the latitude arc. Take up half of the amount of the err by means of the pair of capstan nuts at one end of the auxiliar telescope, and take up half of the error by again correcting th left-hand upper pair of capstan nuts on the base frame of the sola The line of sight of the auxiliary telescope should now be norm to the axis of the latitude arc, should describe a vertical plane wh turning on said axis, and said vertical plane should be parallel to th vertical plane of the transit telescope. The tests should be careful repeated until the adjustments are perfected.

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

5. *The declination vernier.*—A few minutes before apparent no set the instrument in the established meridian. Set off the know true latitude, allowing for any index error in the vernier of the la tude arc. Carefully level the transit and clamp the instrume with the main telescope in the meridian. Bring the sun's ima into the field of the auxiliary telescope by turning this telescope i hour angle. At apparent noon bring the sun's image accurate between the equatorial wires by means of the tangent motion of th declination arc. The difference between the reading of the declin tion arc and the calculated declination (corrected for refractio will indicate the index error of the vernier of the declination ar This vernier is also held in position by two screws passing throu elongated holes, and by loosening the screws the vernier may b shifted to read the calculated declination for apparent noon of th date, or the difference may be carried as an index error. This te should be made every day the instrument is used. If by som

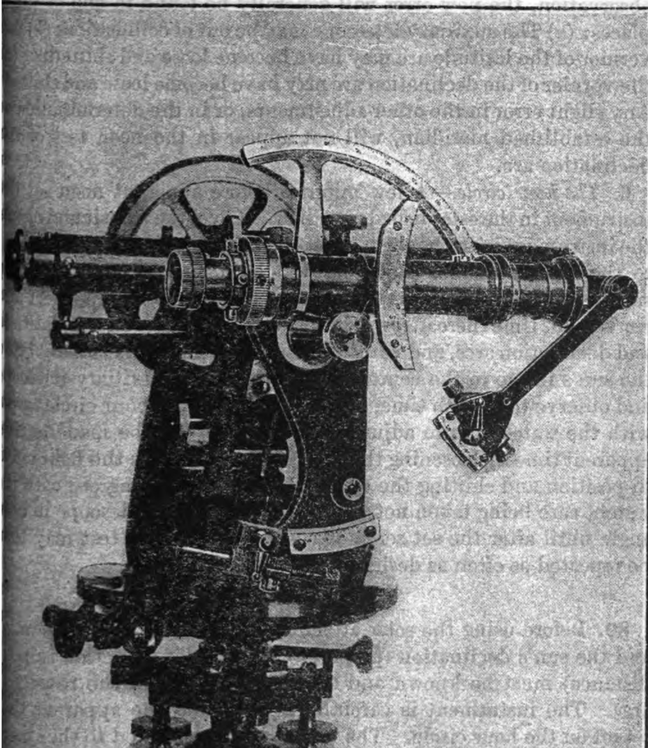


FIG. 11.—The auxiliary telescope in reversed position.

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

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

USE.

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

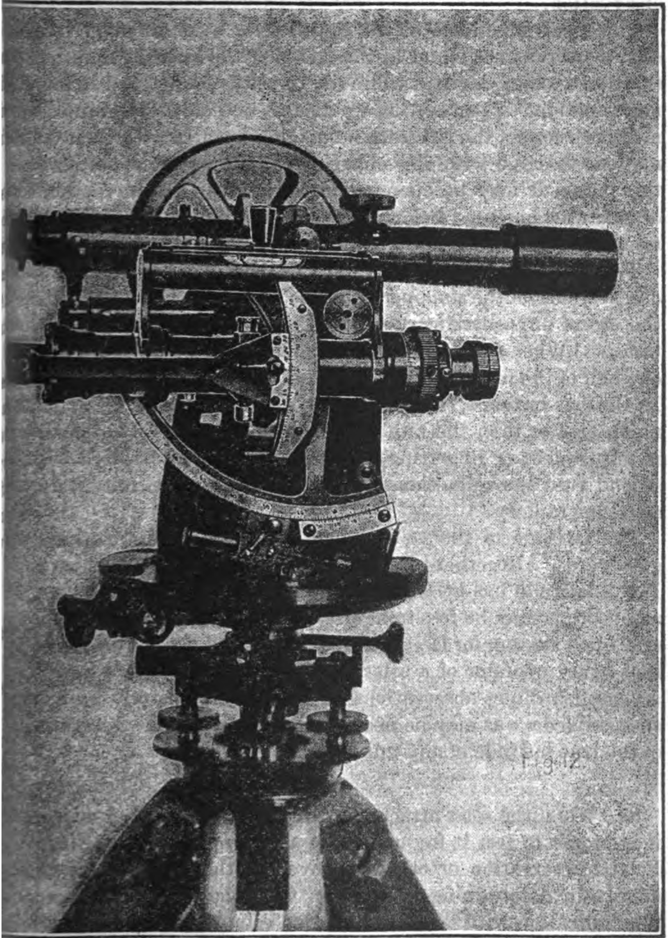


FIG. 12.—The striding level on the auxiliary telescope.

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

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

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

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

TEST.

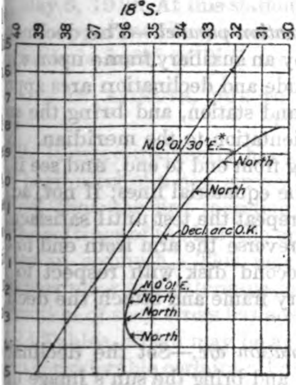
81. When the solar attachment has been put in good adjust it is proper to test it frequently on a true meridian establishe Polaris observation or other approved method. The test co merely in determining a meridian with the solar and comp this indication with the true meridian established by other reli method. The test should be repeated in a. m. and p. m. hou equent intervals, and the noon observation should most certainly e taken every day that the solar is used.

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

Field record.

Solar Transit No. 8028.
's declination at Greenwich noon
58m a. m., local app. t. =18° 32′ 04″ S.
. 10^h, −382″ = 6 22 S.

58m p. m. =18° 38′ 26″ S.



just auxiliary telescope for collimation.

Final field notes.

Nov. 16, 1911, at my station in Sec. 35, T. 11 N., R. 6 E., 5th Prin. Mer., Arkansas, in latitude 35°·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° 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 $9^h 20^m$ a. m., app. t., I set off 35° 33′ N., on the lat. arc; 18° 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° 34′.5 S., which agrees with the computed declination of the sun.

At $3^h 0^m$ p. m., app. t., with the lat. arc unchanged, I set off 18° 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.

THE SOLAR COMPASS.

82. The Burt solar compass, invented by William A. Burt, of ichigan, in 1836, was the first solar instrument, and since its intro-

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

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

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

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

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

xample of noon observation with the Burt solar compass, in lati- ə 38° 53′ 40″ N., and longtitude 77° 01. 6′ W.:

May 6, 1910: At this station I set off 16° 26′ N., on the decl. arc; , at apparent noon, observe the sun on the meridian; the resultlatitude is 38° 54′ N."

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

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

'or example, at $9^h 40^m$ a. m., app. t., at a station in latitude assumed e 46° 20′ N., a test was made with a solar transit whereby the trial ication was found to fall 0° 05′ west of the true meridian. Subsequent determinations of the true latitude of the station and of correctness of the vernier of the declination arc showed that actual latitude of the station was 46° 21′.5 N., and that the ver of the declination arc had an index error which gave read 0° 00′.5 S. of the calculated declination (i. e. reading 15° 19′.5 for a calculated declination of 15° 20′ N.). Thus in the test latitude arc was set 1′.5 S. of the correct latitude of the station, the declination arc was actually set 0′.5 N. of the value that wo have been set had the index error been known.

Table 22 is entered to obtain the correction coefficients:

Latitude.	Hours from noon. 2h 0m.	2h 20m.	3h 0m.	
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	2.69	2.31	1.56	

The corrections are then applied as follows:

Indication of solar in test	=S. 0°	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°	00′.5 W.

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

In the above connection it should be explained that it is deemed desirable to burden the official record with evidence correction for index errors found in the verniers of the latitude declination arcs, other than to state, when such are determined, t the same are forthwith removed or are allowed for in subsequ observations.

POLARIS AT ELONGATION.

84. The surveyor having thoroughly considered the theory a se of the solar instrument in its relation to the public-land surve

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

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

imuth of Polaris at elongation:

$$\text{Sin } A = \frac{\cos \delta}{\cos \phi}$$

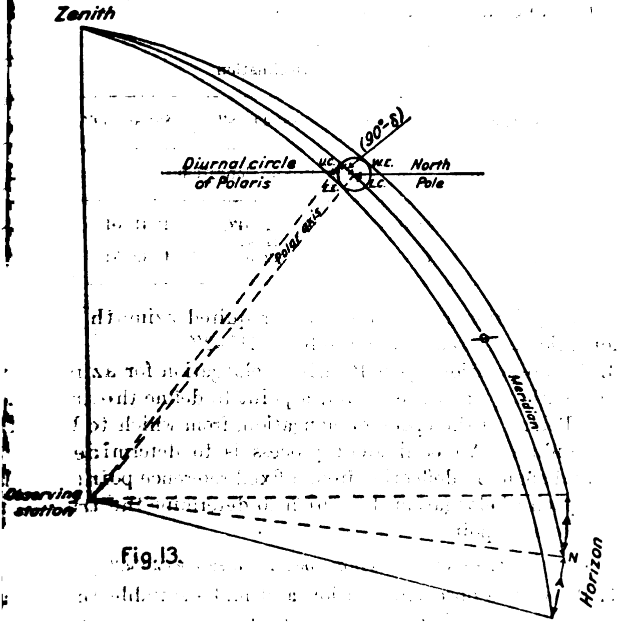


Fig. 13.

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, (ber 20, 1910, in latitude 46° 20′ N., on which date the declinati Polaris=88° 49′ 48″ N.:

$$\log \cos \delta = 8.310033$$
$$\text{''} \quad \cos \phi = 9.839140$$
$$\text{''} \quad \sin A = 8.470893$$

A=Azimuth of Polaris at elongation=1° 41′ 41″.

85. A table of azimuths of Polaris at elongation for latitudes 25° to 70° N., appears in the Ephemeris, arguments: declinati Polaris, and latitude of station.

Example in the use of the table of azimuths of Polaris at elong same date and station as above, showing the method of interpol

Latitude.	Declination.		
	88° 49′ 40″	88° 49′ 48″	88° 49′ 50″.
	Azimuths at elongation.		
46° 00′	1° 41′ 15″	1° 41′ 04″	1° 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 P at elongation is therefore found to be 1° 41′ 42″.

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

POLARIS AT ELONGATION, OBSERVING PROGRAM "*a*."

87. Select the observing station and make suitable provisi mark the line defining the direction of Polaris at elongation flag point should be from 5 to 10 chains N. of the transit point should be cleared of all obstruction before dark. Determin local mean and watch time of elongation of Polaris, provide sui umination for both the transit and flag point, and have every-ing in readiness as much as 15 minutes before the time of elonga-n.

Thoroughly level the transit.

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

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

Again level the transit.

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

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

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

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

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

xample of observation of Polaris at elongation, observing pro-n "a:"

Field record.

Sept. 10, 1911, Gr. E. E. of Polaris, lat. 40°	$=8^h 17.0^m$ p. m.
Red. to long. 111° 45′ W.	$= -1.2$
Red. to lat. 43° 22′ 30″ N.	$= +0.5$
L. M. T. of E. E. of Polaris	$=8^h 16.3^m$ p. m.
Watch slow of l. m. t.	$= -1.7$
Watch time of E. E.	$=8^h 14.6^m$ 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° 49′ 54″ N.

Latitude.	Declination.		
	88° 49′ 50″	88° 49′ 54″	88° 49′ 60″
	Azimuth.		
43° 00′ 00″	1° 35′ 57″	1° 35′ 51″	1° 35′ 43″
43 22 30		1 36 27	
44 00 00	1 37 33	1 37 27	1 37 19

Final field notes.

Sept. 10, 1911, in camp at t standard cor. of Tps. 1 N Rs. 39 and 40 E., Boise Me in latitude 43° 22′ 30″ N., a longitude 111° 45′ W., 8^h 16.3^m p. m., l. m. t., observe Polaris at easte elongation, making four servations, two each w the telescope in direct a reversed positions, and m the mean point in the l thus determined, on a p driven firmly in the grou 5 chs. N.

Azimuth of Polaris at easte elongation=1° 36′ 27″.

Sept. 11: I lay off the azimuth Polaris, 1° 36′ 30″, to the we and mark the meridian th determined, by a tack in a p driven firmly in the grou 5 chs. N.

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

POLARIS AT ELONGATION, OBSERVING PROGRAM "b."

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

› the local mean and watch time of elongation of Polaris, pro- suitable illumination for both the transit and flag point, and › everything in readiness as much as 10 minutes before the time ›ngation.

ıoroughly level the transit.

›out 6 minutes before elongation with the transit in direct ion, read and note the deflection angle from the reference point ›laris, noting also the watch time of observation.

›verse the transit and read and note the deflection angle from eference point to Polaris, noting also the watch time of observa-

ain level the transit.

ith the transit in the reverse position again read and note the ction angle from the reference point to Polaris and note the h time of observation.

›verse the transit to the direct position and again read and note leflection angle from the reference point to Polaris, and note vatch time of observation.

the position of Polaris remains within about 0° 00′ 01″ of true gation for a period of about five or six minutes either side of the of exact elongation, the observation may be considered satis- ry if all of the watch readings fall within the stated period.

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

reference point in any direction may be used in the above ıod; the direction of the deflection from the reference point to ris should always be clearly stated. The insignificant figures e final result may be discarded if the value of the bearing angle not enter into another determination that demands great pre- n. In the example below the true meridian may be laid off by rately measuring a distance from the reference point, at right es to the line of sight, found by multiplying the distance from instrument to the reference point (660 ft.) by the tangent of the ing angle (nat tan 0° 00′ 44″=0.00021) which gives 0.14 ft. r laying off the true meridian the angle from the reference point be checked by the method of repetitions.

Example of observation of Polaris at elongation, observing pr gram "*b*":

Field record.

Apr. 1, 1911, Gr. W. E. of Polaris, lat. 40°	$=6^h\ 46.1^m$ p. m.
Red. to long. 104° 39′ W.	$= -\ 1.1$
" " lat. 46° 13′ N.	$= -\ 1.0$
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° 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° 40′ 30″

Declination of Polaris=88° 49′ 58″ N.

Latitude.	Declination.		
	88° 49′ 50″	88° 49′ 58″	88° 49′ 60″
	Azimuth.		
46° 00′	1° 41′ 01″	1° 40′ 50″	1° 40′ 47″
46 13		1 41 14	
47 00	1 42 54	1 42 42	1 42 39

Final field notes.

April 1, 1911, in camp at the c of Tps. 5 and 6 N., Rs. 56 a 57 E., Prin. Mer., Monta in latitude 46° 13′ N., and lo tude 104° 39′ W., at 6^h 44 p. m., l. m. t., I observe Pol is at western elongation, m ing four observations, two e with the telescope in di and reversed positions, read the deflection angle from a t in a peg driven firmly in t ground, 10 chs. N., west Polaris:

Azimuth of Polaris at western elongation	=	1° 41′ 14″
Mean deflection angle	=	1 40 30
True bearing of mark	=	N. 0° 00′ 44″

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

ero motion in azimuth, is taking place, when the surveyor marks direction of sight thus defined.

he rate of horizontal motion for the hour preceding elongation dly diminishes, the change in azimuth being to the west for tern elongation, or to the east for eastern elongation, when Polaris follow the vertical cross-wire, after which the motion is reversed n accelerating rate. This suggests a third, but less refined, obing program.

POLARIS AT ELONGATION, OBSERVING PROGRAM "c."

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

oroughly level the transit.

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

verse and level the transit.

in bisect Polaris and mark the direction of sight upon the d.

ify the position of Polaris in its diurnal circle by again bisect-e star and without changing the tangent motion note the move-of Polaris; the motion should still be nearly vertical, with a ly discernible movement in the opposite horizontal direction. daylight determine the mean of the sights, and establish the ian by properly laying off the correct azimuth as described erving program "*a*."

AZIMUTH OF POLARIS AT ANY HOUR ANGLE.

While no more reliable method is at the command of the sur-for the establishment of the true meridian than the observa-pon Polaris at elongation, yet the epoch of elongation may at a very inconvenient time and should Polaris be obscured uds at the time of elongation the observation must fail. The angle" method admits of observation upon Polaris for azi at any time that the star is visible; the precise watch ean time must be known, but if this has been determ the hour angle method becomes at once the most convenient. possible accuracy of the result compares favorably in every with the refinement to be obtained in an observation at elongat

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

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

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

Example of computing the azimuth of Polaris, February 23, 1 at a mean time hour angle of $2^h\,37.4^m$, in latitude 33° 20′ N which date the declination of Polaris=88° 50′ 08″ N.:

Mean time hour angle	$=2^h37.4^m$		
	$=2^h37^m24^s$	2^h	$=30°$
		37^m	$=9°\,15'$
Red. to sidereal hour angle=	$+26^s$	50^s	$=\quad 12'\,30''$
Sidereal hour angle	$=2^h37^m50^s$		$=39°\,27'\,30''$

log cos ϕ	= 9.921940	log sin ϕ	=9.739975
" tan δ	= 1.691944	" cos t	=9.887666
" cos ϕ tan δ=	1.613884	" sin ϕ cos t=	9.627641
nat cos ϕ tan δ=	41.104	nat sin ϕ cos t=	0.424
nat sin ϕ cos t=	0.424 (−)		
		log sin t	=9.803127
Algebraic sum=	40.680	" 40.680	=1.609381
		" tan A	=8.193746

Azimuth of Polaris at above hour angle, $A=0°\,53'\,42''$

3. A table of azimuths of Polaris at all hour angles, for latitudes m 30° to 50° N., appears in the Ephemeris, arguments: declinan of Polaris, mean time hour angle, and latitude of station. For er than the latitudes given in the table the surveyor will be uired to solve the above equation.

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

Declination.			Latitude.		
88° 50′ 0″	88° 50′ 08″	88° 50′ 10″	32° 00′	33° 20′	34° 00′
Mean time hour angles.			Azimuths of Polaris.		
2^h 34.7^m	2^h 35.1^m 37.4	2^h 35.2^m	52′.2	53′.1 53.7	53′.5
41.1	41.5	41.6	54.0	54.9	55.3

y interpolation in the table the required azimuth of Polaris is refore found to be 0° 53′.7=0° 53′ 42″.

4. Example of computing the azimuth of Polaris, Sept. 11, 1911, mean time hour angle of 7^h 25.1^m, in latitude 42° 54′ N., on which e the declination of Polaris=88° 49′ 54″ N.:

n time hour angle..............	$=7^h$ 25.1^m	7^h	=105°
	$=7^h$ 25^m 06^s	26^m=	6°30′
luction to sidereal hour angle....	= $+1^m$ 13^s	19^s =	4′ 45″
ereal hour angle.................	$=7^h$ 26^m 19^s		=111° 34′ 45″

cos ϕ	=9.864833	log sin ϕ	=9.832969
tan δ	=1.690496	" cos t	=9.565596
cos ϕ tan δ	=1.555329	" sin ϕ cos t	=9.398565
cos ϕ tan δ	=35.919	nat sin ϕ cos t	= .250
sin ϕ cos δ	= .250(+)	log sin t	=9.968441
ebraic sum	=36.169	" 36.169	=1.558337
		" tan A	=8.410104
muth of Polaris at above hour angle, A			=1°28′22″

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

Declination.			Latitude.		
88° 49′ 50″	88° 49′ 54″	88° 49′ 60″	42° 00′	42° 54′	44° [illegible]
Mean time hour angles.			Azimuths of Polaris.		
7^h 15.7^m 29.3	7^h 15.1^m 25.1 28.8	7^h 14.2^m 28.0	88′.6 86. 6	89′.9 88. 4 87. 8	91′.5 89. 4

By interpolation in the table the required azimuth of Polaris therefore found to be 88′.4=1° 28′ 24″.

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

HOUR ANGLE OBSERVATION OF POLARIS, OBSERVING PROGRAM "*a*."

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

Thoroughly level the transit.

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

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

Again level the transit.

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

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

By daylight determine the mean (*a*) of the first and fourth sight and (*b*) of the second and third sights; then take the mean ints "*a*" and "*b*" to define the true direction of Polaris at the och of the average of the watch times of observation.

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

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

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

Field record.	Final field notes.
idian observation of the sun for apparent noon: $\phi=37°\ 18'$ N. — 90° 00′ $\delta=\ 4\ \ 36$ S. — 41 54 $\phi+\delta=41°\ 54'$ — $v=48°\ 06'$ *Watch time.* 's W. limb — $=12^h\ 00^m\ 18^s$ E. " — $=12\ \ 02\ \ 26$ tch time of app. noon — $=12^h\ 01^m\ 22^s$. noon $=12^h\ 00^m\ 00^s$ ation of time $=\ -11\ \ 25$ I. T. of apparent noon — $=11\ \ 48\ \ 35$ tch fast of l. m. t. — $12^m\ 47^s$	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° 17′.6 N., and longitude 102° 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. $=12^m\ 47^s$.
r angle observation of Polaris:	
Telescope. — **Watch time.**	
ect — $5^h\ 48^m\ 40^s$ p. m. ersed — 5 49 49 ersed — 5 51 36 ect — 5 52 54 Mean — $5^h\ 50^m\ 45^s$ p. m. tch fast of l. m. t. — $-\ 12\ \ 47$ 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.

Gr. U. C. of Polaris, Oct. 6, 1910	$= 0^h\ 32.7^m$ a. m.
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.	

Declination.			Latitude.		
+88° 49′			36° 00′	37° 18′	38° 00′
40″	42″	50″			
Mean time hour angles.			**Azimuth of Polaris.**		
$6^h 51.6^m$	$6^h\ 51.2^m$ 53.6	$6^h 49.5^m$	84′.3	85′.7 85. 5	86′.5
61.5	61.1	59.6	83. 3	84. 8	85. 6

Final field notes, con.

Watch time of obsn., mea[n] four readings = $5^h\ 50^m\ 45^s$ p[.]

Oct. 6, I lay off the azim[uth] Polaris, 1° 25′ 30″, to the w[est] and mark the meridian determined, by a tack in driven firmly in the gr[ound] 8 chs. N.

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

98. Select the observing station and choose a suitable refere[nce] mark in any direction. The reference point should be at leas[t] chains distant.

Thoroughly level the transit.

With the telescope in the direct position, read and note the ho[ri]zontal angle from the reference point to Polaris, noting the wa[tch] time at the moment Polaris is properly bisected.

Reverse the transit and read and note the horizontal angle fr[om] the reference point to Polaris, noting the watch time at the mom[ent] 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 ag[ain] read and note the horizontal angle from the reference point to Polar[is,] noting the watch time at the moment Polaris is properly bisected.

Treat the reduction as one observation, applying the watch er[ror] to the average watch time of observation to obtain the correct lo[cal] mean time of observation.

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

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

Field record.	Final field notes.

Field record.

ur angle observation on Polaris:

elescope.	Horizontal angle from flag to Polaris.	Watch time.
ect........	177° 34′ 30″	6h 22m 37s p. m.
versed......	177 34 30	6 25 29
versed......	177 34 00	6 28 17
ect........	177 34 00	6 30 17
Mean...	177° 34′ 15″	6h 26m 40s p. m.

tch slow of 75th mer. stand-rd time	+ 1 22
rection for longitude.........	− 8 6
M. T. of obsn. Mar. 21, 1910=	6h 19m 56s
	6h 19. 9m p. m.
U. C. of Polaris, same date..... =1h 33.0m p. m.	
l. to long. 77° 1.6′ W......= − 0.9 =	1 32.1 p.m.
r angle of Polaris west of e meridian	=4h 47.8m
lination of Polaris	=88° 49′ 41″ N.

Declination.			Latitude.		
88° 49′			38° 00′	38° 54′	40° 00′
40″	41″	50″			
an time hour angles.			Azimuths of Polaris.		
3. 5m	33. 7m	35. 0m	83′.6	84′.7	86′.0
	47. 8			86 . 4	
9.0	49. 2	50. 8	85 .5	86 . 6	88 . 0

Final field notes.

March 21, 1910, at a transit point in Washington, D. C., in latitude 38° 53′ 40″ N., and longitude 77° 1′.6 W., I find by comparison with a Western Union telegraph clock that my watch is 1m 22s slow of 75th meridian standard time.

At the same station at 6h 19.9m 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.=6h 26m 40s p. m.

Mean horizontal angle from Polaris to flag	=177° 34′ 15″ N-W-S
Azimuth of Polaris=	1 26 24 W.
True bearing of flag	= N. 179° 00′ 39″ W.
	= S. 0° 59′ 21″ W.

POLARIS AT SUNSET OR SUNRISE.

99. Polaris is conveniently observed for azimuth by the h angle method at sunset or sunrise without artificial illuminati The preparation for the observation consists in computing in adva the approximate settings in azimuth and altitude in order to f Polaris, and the plan contemplates an approximate refere meridian: With the time of sunset or sunrise assumed as the tim observation, the hour angle "t" and azimuth "A" are ascertai in order to find the position of Polaris in azimuth; the position altitude is found by the following approximation, the positive being used for hour angles less than 6 hours and the negative for hour angles exceeding 6 hours:

$$v \neq \phi \pm 70' \cos t$$

Example of computation of the position of Polaris at sunset, 6, 1911, at a station in latitude 47° 20′ N., and longitude 102° 40′

From the Ephemeris the declination of the sun is found to 16° 18′ N., and by entering Table 17, of the Standard Field Tab 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.
Gr. U. C. of Polaris, May 6	= $10^h\ 33.5^m$ a. m.		+12
Red. to long. 102° 40′ W.	−1.1	=	10 32.4 a.
Assumed hour angle of Polaris west of the meridian		=	$8^h\ 42.6^m$
Hour angle, angular measure		=	130° 39′
Azimuth of Polaris, W.		≠	1° 17′
Latitude of station	=47° 20′		
70′ cos t=70 cos 130° 39′	= 46(−)		
	$v \neq 46° 34'$		

Example of computation of the position of Polaris at sunset, N 6, 1911, at a station in latitude 47° 20′ N., and longitude 102° 40′ W

From the Ephemeris the declination of the sun is found to 15° 44′ S., and by entering Table 17, of the Standard Field Tab

apparent time of sunrise is found to be 7^h 12^m a. m., or of sunset
8^m p. m.

U. C. of Polaris, Nov. 6, 1911		=	10^h 28.2^m p. m.
ı. to long. 102° 40′ W.		=	−1.1
ſ. T. of U. C. of Polaris		=	10^h 27.1^m p. m.
ımed time of observation		=	4 48 p. m.
ımed hour angle of Polaris east of the meridian		=	5^h 39.1^m
r angle, angular measure		=	84° 46′
nuth of Polaris, E.		≠	1° 43′
tude of station	=47° 20′		
'os t=70 cos 84° 46′	= 06 (+)		
	v≠47° 26′		

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

med time of obsn., Nov. 7, 1911		=	7^h 12^m a. m. +12
. T. of U. C. of Polaris, Nov. 6		=	10 27.1 p. m.
med hour angle of Polaris west of the meridian		=	8^h 44.9^m
· angle, angular measure		=	131° 14′
ıuth of Polaris, W.		≠	1° 16′
ıude of station	=47°20′		
os t=70 cos 131°14′=	46(−)		
	v≠46°34′		

us at the above station in latitude 47° 20′ N., and longitude 40′ W., to observe Polaris by the daylight method an approxi- meridian should be established with the solar before sunset, to *find* Polaris the following angles are set off:

	Horizontal angle.	Vertical angle.
t May 6, 1911	1°17′ W.	46° 34′
Nov. 6, 1911	1°43′ E.	47° 26′
e Nov. 7, 1911	1°16′ W.	46° 34′

The above "settings" are merely approximations, but sufficien close, however, to bring Polaris reasonably near the center of field of the telescope where the star will be found in plain vi the telescope should be focused upon a distant object, otherw though Polaris may be practically at the center of the field, it mi be out of focus and therefore not observable during daylight. W Polaris has been found the above settings have answered t purpose and the observation may proceed in accordance with ei observing program "*a*" or "*b*" of the hour angle method, the f reductions to be based upon the precise details of the observat During the reversals of the transit the settings should be made time. The daylight hour angle method is particularly desirabl cause the observation, including all instrumental work, markin points upon the ground, etc., is accomplished without artificial i mination, and sunset is usually a convenient time to devote to field duty.

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

Time: By meridian observation of the sun for apparent noo

Latitude: By meridian altitude observation of the sun.

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

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

ALTITUDE OBSERVATION OF THE SUN FOR AZIMUTH.

100. While the methods of observation upon Polaris for azim are unquestionably the most desirable in their relation to the the and practice of public-land surveying, yet a very efficient alterna is found in direct altitude observations upon the sun for azim with a number of equations at the disposal of the surveyor to suit convenience. During the shorter days of the year and even qu often at any season the surveyor finds himself at a loss for time suitable daylight hours in which to make the required tests of solar attachment; conditions obtain making the required t impossible if limited to a Polaris meridian in camp, without inv ing unreasonable delay. It is in such cases that a direct altit observation upon the sun for azimuth, on the actual line of survey, finds its most useful application. Presuming the surve ork with a standard instrument with solar attachment, the racy of its adjustments can, by this method, be readily tested ork on line at any suitable morning or afternoon hour, without eciable loss of time. Under working conditions any line deterd with the solar attachment may be used for reference pur-, while vertical and horizontal angles are recorded to the sun tain the necessary data for computing the true bearing of the lished solar line. A series of three altitude observations upon un, each with the telescope in direct and reversed positions, equired to guard against error; these are readily made in 10 minutes, while the reductions may be made in the evening out loss of time from the line work.

her difficulties in the nature of temporary disability of the solar hment, and cloudy nights preventing Polaris observations, her adverse conditions may sometimes obtain, during which ds, even for a few days, if the surveyor is familiar with the od of direct altitude observation upon the sun for meridian, n thus establish his lines and possibly realize a saving of the e time of his party until the trouble is removed. To the surrs who have used this method little more needs to be said in its , but to those unfamiliar with it the suggestion is made to ice the observations and reductions until proficiency is attained, n its application the reward will come many times during an ge season's work.

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

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

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

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

The spherical angles "ζ", "ϕ", and "δ" appear in this equ combined as in the formula for the reduction of an altitude ob tion of the sun for apparent time, and when it is desired to r for both time and azimuth, the above equation for azimuth is preferred to any that follow.

103. *Altitude observation of the sun for azimuth.*—For south d ations the function "sin δ" becomes negative by virtue of th of a negative angle being treated as negative in analytical r tions: If the algebraic sign of the result is positive the azimuth is referred to the north point, but if negative, the azimuth " referred to the south point:

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

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

104. *Altitude observation of the sun for azimuth.*—To man veyors the following equation is familiarly expressed direc terms of the spherical triangle "pole-zenith-sun:" Reverse th of "δ" for south declinations:

Pole to zenith $=90°-\phi=$ colat.;
Pole to sun $=90°-\delta=$ codecl.;
Zenith to sun $=90°-h=$ coalt.;
$S=\frac{1}{2}$ sum of the three sides:

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

OBSERVING PROGRAM, MORNING.

105. Thoroughly level the transit.

With the telescope in direct position observe and record th zontal deflection angle from a fixed reference point to the sun's limb, and the vertical angle to the sun's upper limb; these ob tions must be simultaneous, at the epoch of which the sun will a as indicated; note the watch time at the epoch of the observatio

Reverse the transit.

)bserve and record the horizontal deflection angle from the fixed
rence point to the sun's left limb, and the vertical angle to the
's lower limb; these observations must be simultaneous, at the
ch of which the sun will appear as indicated; note the watch
e at the epoch of the observation:

'he mean observed vertical and horizontal angles, and the mean
ch time are to be used in the reduction; this program constitutes
complete altitude observation, which is repeated until a series
hree complete direct and reversed observations are made.

OBSERVING PROGRAM, AFTERNOON.

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

irst observation, telescope direct, observe the sun's right and
er limbs:

econd observation, telescope reversed, observe the sun's left and
er limbs:

)7. By the above observing programs the horizontal and ver-
l angles in the direct positions of the telescope will be found of
it the same numerical values as in the reversed position of the
scope, by reason of the sun passing in a direction that will carry
ross the field of the telescope during the time taken in the re-
al and second setting. Differential refraction is therefore prac-
lly eliminated, and it is desirable that the corresponding angles
he direct and reversed positions of the telescope be about the
e rather than as far apart as would result in any other observing
ram.

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

108. Example of direct altitude observation of the sun for azi-muth, sun north declination, and both north and south of an eas 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° 17′.5 N., and longitude 102° 18′.6 W., at 7h 30m. a. m., app. t., I set off 37° 17′ 30″ N., on the lat arc; 17° 52′ N., on the decl. arc; and determine a meridian with th solar, whence I turn 90° to the east and set a flag, about 20 ch dist.; then to test this indication of the solar I make a series of thre altitude observations of the sun for azimuth, each with the telescop in direct and reversed positions, observing opposite limbs of the su and reading the horizontal deflection angles from the flag to the su

Obser-vation.	Telescope.	Sun.	Watch time.	Vertical angle.	Horizontal an from flag to su
1st	Direct		7h 36m 54s	30° 05′	0° 08′ 30″ to
"	Reversed ...		7 38 15	29 48	0 33 00 "
	Mean..	....	....	29° 56′ 30″	0° 20′ 45″ to
2nd	Direct		7h 41m 20s	30° 58′ 00″	0° 32′ 00″ to
"	Reversed ...		7 43 00	30 46 30	0 12 30 "
	Mean..	....	....	30° 52′ 15″	0° 22′ 15″ to
3rd	Direct		7h 52m 00s	33° 05′ 00″	2° 11′ 00 to
"	Reversed ...		7 53 48	32 53 30	1 50 00 "
	Mean..	....	7h 52m 54s	32° 59′ 15″	2° 00′ 30″ to

By 1st obsn. flag bears N. 89° 58′ 57″ E.
By 2nd obsn. flag bears N. 89 58 26 E.
By 3rd obsn. flag bears N. 89 58 38 E.

Mean true bearing of flag N. 89° 58′ 40″ E.
Indicated error of solar attachment 1′ 20″

Field record.

The declination of the sun for the mean period of the three obser-vations=17° 51′ 04″ N.

e decl
ns=17° 5

e following reductions are made to obtain the true vertical s of the above observations:

	1st obsn.	2nd obsn.	3rd obsn.
v	$=29°\ 56'\ 30''$	$30°\ 52'\ 15''$	$32°\ 59'\ 15''$
Refraction =	$-1\ \ 40$	$-1\ \ 36$	$-1\ \ 28$
Parallax =	$+\ \ 8$	$+\ \ 8$	$+\ \ 8$
h	$=29°\ 54'\ 58''$	$30°\ 50'\ 47''$	$32°\ 57'\ 55''$

e following examples of reduction are all by the equation:

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

os ϕ=9.900674 log sin δ=9.486493(+) log tan ϕ=9.881708
os h=9.937897 " tan h=9.759970

9.838571 9.838571 log 9.641678

log 9.647922 nat(−) .43821
nat (+) .44455
(−) .43821

cos A=(+) .00634
A=True bearing of sun =N. 89° 38′ 12″ E.
Angle from sun to flag =(+) 0 20 45

True bearing of flag =N. 89° 58′ 57″ E.

os ϕ=9.900674 log sin δ=9.486493(+) log tan ϕ=9.881708
os h=9.933763 " tan h=9.776132

9.834437 9.834437 log 9.657840

log 9.652056 nat(−) .45482
nat(+) .44880 (+) .44880

cos A=(−) .00602
A=True bearing of sun =S. 89° 39′ 19″ E.
Angle from sun to flag =(+) 0 22 15

True bearing of flag =S. 90° 01′ 34″ E.
=N. 89° 58′ 26″ E.

log cos ϕ=9.900674		log sin δ=9.486493(+)		log tan ϕ=9.88170	
" cos h=9.923762				" tan h=9.8119	
9.824436		9.824436		log	9.6936
	log	9.662057		nat (−)	.4939
	nat (+)	.45926		(+)	.4592
				cos A=(−)	.0346

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:

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

$90° - \phi = 90° - 37° 17' 30''$	=52° 42′ 30″	=colat.
$90° - \delta = 90° - 17° 51' 04''(+)$	=72 08 56	=codecl.
$90° - h = 90° - 32° 57' 55''$	=57 02 05	=coalt.
$2S$=	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
" cos² ½A	=	9.683651
" cos ½A	=	9.841825
½A	=	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 reduction by the equation:

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

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

$$\begin{array}{rlcrl}
\zeta = & 57^\circ\ 02'\ 05'' & \qquad & \zeta = & 57^\circ\ 02'\ 05'' \\
\phi = & 37\ \ 17\ \ 30 & & \phi = & 37\ \ 17\ \ 30 \\
\hline
\zeta+\phi = & 94^\circ\ 19'\ 35'' & & \zeta-\phi = & 19^\circ\ 44'\ 35'' \\
\delta = & 17\ \ 51\ \ 04\ (+) & & \delta = & 17\ \ 51\ \ 04\ (+) \\
\hline
\zeta+\phi+\delta = & 112^\circ\ 10'\ 39'' & & \zeta-\phi+\delta = & 37^\circ\ 35'\ 39'' \\
\frac{1}{2}(\zeta+\phi+\delta) = & 56^\circ\ 05'\ 20'' & & \frac{1}{2}(\zeta-\phi+\delta) = & 18^\circ\ 47'\ 50'' \\
\hline\hline
\zeta+\phi = & 94^\circ\ 19'\ 35'' & & \zeta-\phi = & 19^\circ\ 44'\ 35'' \\
\delta = & 17\ \ 51\ \ 04\ (+) & & \delta = & 17\ \ 51\ \ 04\ (+) \\
\hline
\zeta+\phi-\delta = & 76^\circ\ 28'\ 31'' & & \zeta-\phi-\delta = & 1^\circ\ 53'\ 31'' \\
\frac{1}{2}(\zeta+\phi-\delta) = & 38^\circ\ 14'\ 15'' & & \frac{1}{2}(\zeta-\phi-\delta) = & 0^\circ\ 56'\ 45'' \\
\hline\hline
\end{array}$$

$$\begin{array}{lrr}
\log \cos \frac{1}{2}(\zeta+\phi+\delta) = & & 9.746561 \\
\text{“}\ \sin \frac{1}{2}(\zeta+\phi-\delta) = & & 9.791636 \\
\hline
 & & 9.538197 \\
\text{“}\ \cos \frac{1}{2}(\zeta-\phi-\delta) = 9.999941 & & \\
\text{“}\ \sin \frac{1}{2}(\zeta-\phi+\delta) = 9.508152 & & \\
\hline
 & 9.508093 & 9.508093 \\
\hline\hline
\log \tan^2 \frac{1}{2}A = & & 0.030104 \\
\text{“}\ \tan \frac{1}{2}A = & & 0.015052 \\
\hline\hline
\frac{1}{2}A = & & 45^\circ\ 59'\ 34''
\end{array}$$

A = True bearing of sun = N. 91° 59′ 08″ E.

Angle from sun to flag = (−)2 00 30

True bearing of flag = N. 89° 58′ 38″ E.

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

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

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

$$\begin{array}{llll}
\log \sin \frac{1}{2}(\zeta+\phi-\delta) = & & & 9.791636 \\
\text{"}\ \ \sin \frac{1}{2}(\zeta-\phi+\delta) = & & & 9.508152 \\
\hline
 & & & 9.299788 \\
\text{"}\ \ \cos \frac{1}{2}(\zeta+\phi+\delta) = & 9.746561 & & \\
\text{"}\ \ \cos \frac{1}{2}(\zeta-\phi-\delta) = & 9.999941 & & \\
\hline
 & 9.746502 & & 9.746502 \\
\hline
\text{"}\ \ \tan^2 \frac{1}{2}\, t & = & & 9.553286 \\
\text{"}\ \ \tan \frac{1}{2}\, t & = & & 9.776643 \\
\frac{1}{2}\, t & = 30^\circ\, 52'\, 34'' & & \\
t & = 61^\circ\, 45'\, 08'' & = 4^h\, 07^m\, 01^s &
\end{array}$$

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 azimu sun south declination:

Final field notes.

March 18, 1910, at a transit point in Washington, D. C., in latitu 38° 53′ 40″ N., and longitude 77° 01′.6 W., at $3^h\,42^m$ p. m., app. t., make a series of three altitude observations upon the sun for azimut each with the telescope in direct and reversed positions, observi opposite limbs of the sun, and reading the horizontal deflecti angle from a flag pole about 20 chs. to the S., SW. to the sun:

…r- …n.	Telescope.	Sun.	Watch time.	Vertical angle.	Horizontal angle flag to sun.
…	Direct.......		3h 56m 58s	25° 20′	65° 00′ to SW.
…	Reversed....		3 58 48	25 31	64 45 " "
	Mean .	....	3h 57m 53s	25° 25′ 30″	64° 52′ 30″ " "
…	Direct.......		4h 01m 48s	24° 28′	65° 56′ " "
…	Reversed....		4 03 10	24 44	65 36 " "
	Mean .	....	....	24° 36′ 00″	65° 46′ 00″ " "
…	Direct.......		4h 05m 58s	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.

e declination of the sun for the mean period of the three obser-ns=1° 02′ 16″ S.

e following reductions are made to obtain the true vertical es 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=	25° 23′ 38″	24° 34′ 02″	23° 48′ 28″

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

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

$h = 25° \ 23' \ 38''$

$\zeta = 64° \ 36' \ 22''$	$\zeta = 64° \ 36' \ 22''$
$\phi = 38 \ \ 53 \ \ 40$	$\phi = 38 \ \ 53 \ \ 40$
$\zeta+\phi = 103° \ 30' \ 02''$	$\zeta-\phi = 25° \ 42' \ 42''$
$\delta = 1 \ \ 02 \ \ 16 \ (-)$	$\delta = 1 \ \ 02 \ \ 16 \ ($+
$\zeta+\phi+\delta = 102° \ 27' \ 46''$	$\zeta-\phi+\delta = 24° \ 40' \ 26''$
$\frac{1}{2}(\zeta+\phi+\delta) = 51° \ 13' \ 53''$	$\frac{1}{2}(\zeta-\phi+\delta) = 12° \ 20' \ 13''$
$\zeta+\phi = 103° \ 30' \ 02''$	$\zeta-\phi = 25° \ 42' \ 42''$
$\delta = 1 \ \ 02 \ \ 16 \ (-)$	$\delta = 1 \ \ 02 \ \ 16 \ ($+
$\zeta+\phi-\delta = 104° \ 32' \ 18''$	$\zeta-\phi-\delta = 26° \ 44' \ 58''$
$\frac{1}{2}(\zeta+\phi-\delta) = 52° \ 16' \ 09''$	$\frac{1}{2}(\zeta-\phi-\delta) = 13° \ 22' \ 29''$

$\log \cos \frac{1}{2}(\zeta+\phi+\delta) =$		9.796697
" $\sin \frac{1}{2}(\zeta+\phi-\delta) =$		9.898118
		9.694815
" $\cos \frac{1}{2}(\zeta-\phi-\delta) = 9.988058$		
" $\sin \frac{1}{2}(\zeta-\phi+\delta) = 9.329724$		
	9.317782	9.317782
$\log \tan^2 \frac{1}{2} A$	=	0.377033
" $\tan \frac{1}{2} A$	=	0.188516

$\frac{1}{2} A = 57° \ 03' \ 44''$

A = True bearing of sun = N. 114° 07′ 28″ W.
Angle from sun to flag = (+)64 52 30

True bearing of flag = N. 178° 59′ 58″ W.
= S. 1° 00′ 02″ W.

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

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

$\log \sin \frac{1}{2}(\zeta+\phi-\delta)=$		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
$\frac{1}{2} t=27^\circ\ 46'\ 29''$		
$t=55^\circ\ 32'\ 58''=3^h\ 42^m\ 12^s$		

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.	$=\ \ 7^m\ 24^s$

ṡth 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 xample of reduction by the equation:

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

og $\cos \phi=9.891149$	$\log \sin \delta=8.257958$ (−)	$\log \tan \phi=9.906733$	
" $\cos h=9.958790$		" $\tan h=9.660053$	
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 example of reduction by the equation:

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

$90°-\phi=90°-38°\ 53'\ 40''$	$=$	$51°\ 06'\ 20''$	$=$ colat.
$90°-\delta=90°-\ \ 1\ \ 02\ \ 16\ (-)$	$=$	$91\ \ 02\ \ 16$	$=$ codecl.
$90°-h=90°-23\ \ 48\ \ 28$	$=$	$66\ \ 11\ \ 32$	$=$ coalt.
	2 S	$=208°\ 20'\ 08''$	
	S	$=104°\ 10'\ 04''$	
codecl. $=90°-\delta$	$=$	$91\ \ 02\ \ 16$	
$S-$codecl.	$=$	$13°\ 07'\ 48''$	

log sin S	$=$		9.986585
" sin ($S-$codecl.)	$=$		9.356334
			9.342919
" sin colat.	$=$	9.891149	
" sin coalt.	$=$	9.961376	
		9.852525	9.852525
log $\cos^2 \tfrac{1}{2}A$	$=$		9.490394
" $\cos \tfrac{1}{2}A$	$=$		9.745197
$\tfrac{1}{2}A$	$=$		$56°\ 12'\ 35''$
$A=$True bearing of sun	$=$		N. $112°\ 25'\ 10''$ W.
Angle from sun to flag	$=$		$(+)\ 66\ \ 35\ \ 00$
True bearing of flag	$=$		N. $179°\ 00'\ 10''$ W.
	$=$		S. $\ \ 0°\ 59'\ 50''$ W.

EQUAL ALTITUDE OBSERVATIONS OF THE SUN FOR MERIDIAN.

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

The fixation of the true meridian by this method depends up the theory that the sun's center at equal altitudes occupies sy metrical positions in azimuth east and west of the meridian the morning and in the afternoon except for the correction nec to be applied due to the change in the sun's declination in nterval between the a. m. and p. m. observations:

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

δ": Change in declination of the sun from the a. m. to the p. m. vation, expressed in minutes of angular measure.

$_1+t_2)$": The sum of the hour angles from apparent noon, or the watch time from the a. m. to the p. m. observation, expressed gular measure.

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

e symmetry of the equal altitude observation is maintained bserving opposite limbs in azimuth in the a. m. and p. m. vations, in connection with the same limb in vertical angle th observations.

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

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

EQUAL ALTITUDE OBSERVATIONS OF THE SUN, OBSERVING PROGRAM.

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

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

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

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

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

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

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

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

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

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

The equal altitude observation may be modified by taking a p observation one day followed by an a. m. observation the nex which case the functions "$\frac{1}{2}d\delta$" and "$\frac{1}{2}(t_1+t_2)$" are to be comp for the period from the p. m. to the a. m. observation; and the di ntial azimuth correction, "$d\ A_\delta$", is then applied in the *opposite* irection.

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° ′ 40″ N., and longitude 77° 1′.6 W., at 9^h27^m a. m. and 2^h33^m p. m., p. t., I make a series of three equal altitude observations upon the n for azimuth, reading the horizontal deflection angle from a flag-le about 20 chs. to the S., SE. in the a. m. to the sun's right limb, d SW. in the p. m. to the sun's left limb; equal vertical angles ing taken to the sun's lower limb.

Observation.	Sun.	Watch time.	Vertical angle.	Horizontal angle flag to sun.	
. m.		$9^h29^m25^s$	48°28′00″	67°20′00″	to SE.
. m.		2 41 40		65 28 30	to SW.
				1°51′30″ (Diff.)	
. m.		$9^h32^m50^s$	49°05′00″	66°29′30″	to SE.
. m.		2 38 15		64 38 00	to SW.
of hour angles...	....	$5^h05^m25^s$			
n hour angle......	....	$2^h32^m42^s$		1°51′30″ (Diff.)	
. m.		$9^h36^m30^s$	49°43′00″	65°34′30″	to SE.
. m.		2 34 45		63 45 30	to SW.
				1°49′00″ (Diff.)	

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

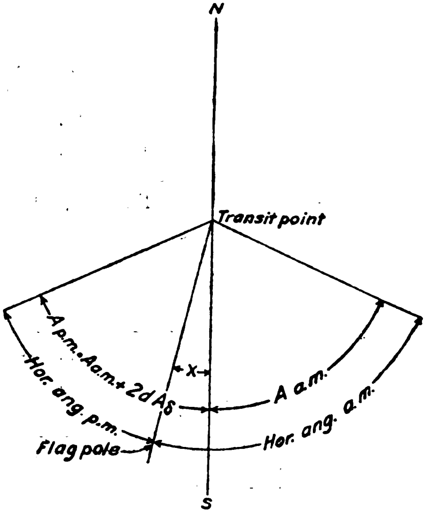
By 1st obsn. = S. 0° 55′ 45″ W.
" 2d " = S. 0 55 45 W.
" 3d " = S. 0 54 30 W.

Mean = S. 0° 55′ 20″ W.
ifferential azimuth correction = (+) 3′ 53″

ean true bearing of flag = S. 0° 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 differe azimuth correction for the above series:

$\frac{1}{2}\,d\delta=\frac{1}{2}\times5.08\times44.3=112''$; $\log\frac{1}{2}d\delta=2.049218$
$\phi=38°\ 53'\ 40''$ N.; $\log\cos\phi\quad=9.891149$
$\frac{1}{2}(t_1+t_2)=2^h\ 32^m\ 42^s$
$=38°\ 10'\ 30''$
$\log\sin\frac{1}{2}(t_1+t_2)\quad=9.791034$

9.682183   9.682183

$\log d\,A_\delta=2.367035$
$d\,A_\delta$=Differential azimuth correction$=233''$
$=3'\ 53''$

. The following reduction to obtain the value of the differ- azimuth correction for the above series is made with the use le 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′ 38 54 40 00	2.44 2.61	2.05 2.16 2.19	1.73 1.85

Declination coefficient $=2.16$

$d\ A_\delta=2.16\times\frac{1}{2}\ d\delta=2.16\times112''$ $=242''$

$d\ A_\delta$=differential azimuth correction=4′ 02″

small difference (09″) in the computation of "$d\ A_\delta$" in the ocesses of reduction is due to the error in adopting a coefficient ed by linear interpolation in Table 22 of the Standard Field , the tabular interval of which is large. Ordinarily the equal le method would be used when the latitude of the station is tain, and the slight error in using the declination coefficient by linear interpolation from Table 22 is small enough to be ible.

. The second a. m. and p. m. observations of the above series lected for an example of reduction to the sun's center and computation of the sun's azimuth, and true bearing of the y the equation:

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

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° 34′ 37″

Diff. in time to a. m. obsn.:

For longitude = 5^h08^m

For time, a. m. = $-2\ 33$

2.58^h = 2^h35^m

Diff. in declination to app. t. of a. m. obsn.:

$2.58 \times 44''.3 = 114''$ = 1′ 54″

Sun's decl. a. m. obsn. = 15° 36′ 31″

Diff. to p. m. obsn., already computed $(2 \times 112'' = 224'')$ = 3′ 44″

Sun's decl. p. m. obsn. = 15° 40′ 15″

		a. m. obsn.		p. m. obsn.
log cos ϕ=9.891149	log sin δ=	9.429856(+)	log sin δ=	9.43154
" cos h=9.813992				
9.705141		9.705141		9.70514
" tan ϕ =9.906733	log	9.724715	log	9.7264
" tan h =0.065991	nat (+)	.53054	nat (+)	.5326
log 9.972724				
nat (−) .93913	(−)	.93913	(−)	.93913
cos A =	(−)	.40859	(−)	.40653
A=true bearing of sun	=	S. 65° 53′ 02″ E.		S. 66° 00′ 47″

		a. m. obsn.	p. m. obsn.
Horizontal angle from flag to sun's right and left limbs	=	66° 29′ 30″ to SE.	64° 38′ 00″ to
Reduction to sun's center $= \dfrac{15.9'}{\cos 49° 20'}$	=	(+) 24′ 24″	(+) 24′ 24″
Hor. ang. to sun's center	=	66° 53′ 54″ to SE.	65° 02′ 24″ to
Sun's azimuth as computed above	=	S. 65° 53′ 02″ E.	S. 66° 00′ 47″ W.
True bearing of flag	=	S. 1° 00′ 52″ W.	S. 0° 58′ 23″ W.
Mean true bearing of flag	=	S. 0° 59′ 37″ W.	

The discrepancy between the a. m. and p. m. results sugges systematic instrumental error ordinarily eliminated by taking di d reversed observations, which in this instance is of opposite effect a. m. and p. m. hours and apparently eliminated in the mean ult.

123. One additional fact should be noted relative to the several luctions of the above equal altitude observations:

$$
\begin{aligned}
\text{By above direct computation, } A \text{ p. m.} &= 66^\circ\ 00'\ 47'' \\
A \text{ a. m.} &= 65^\circ\ 53'\ 02'' \\
\hline
\text{Difference} = 2dA_\delta &= \quad 7'\ 45'' \\
dA_\delta &= \quad 3'\ 53''
\end{aligned}
$$

his value for $dA\delta$ (3′ 53″) agrees with same function as first puted.

24. Upon concluding the subject of azimuth determinations it l be of interest to note that the weighted mean of a large number bservations gives a value of S. 0° 59′ 25″ W. for the azimuth of line from the Washington, D. C., transit point to the flag pole herere described. A comparison of the methods and results of the vas observations as given on the preceding pages suggests that the yor should seldom be without means by which accurately to rmine time, latitude and azimuth at any place in the field, ever remote, and should doubt arise as to his results a "check" independent method is nearly always available and a certain de as to the accuracy of the determinations. It might be added t a careful surveyor will not fail to surround his methods with quate verification to insure the accuracy required in the execution he public-land surveys.

THE TRUE PARALLEL OF LATITUDE.

125. The base lines and standard parallels of the rectangular tem are established on the true parallel of latitude; the random tudinal township boundary lines are also projected on the same ve; this curve is defined by a plane at right angles to the earth's r axis cutting the earth's surface on a small circle. At every nt on the true parallel the curve bears due east and west, the ection of the line being at right angles to the meridian at every nt along the line. Two points at a distance of 20 chains apart on same parallel of latitude may be said to define the direction of curve at either point, without appreciable error, but the projecn of a line so defined in either direction, easterly or westerly,

would describe a great circle of the earth gradually departing so erly from the true parallel. The great circle tangent to the par at any origin or reference point along the parallel is known as "tangent to the parallel," and it is coincident with the true lati curve only at the point of origin. The rate of the change of azimuth of the tangent is a function of the latitude on the ear surface. The azimuth of the tangent varies directly as the dist from the origin, and the offset distance from the tangent to parallel varies as the square of the distance from the point of gency. A great circle connecting two distant points on the s latitude curve has the same angle with the meridian at both p and the azimuth of such a line at the two points of intersection function of one-half the distance between the points.

There are three general methods of establishing a true parall latitude which may be employed independently to arrive at same result: (1) The solar method; (2) the tangent method; (3) the secant method.

SOLAR METHOD.

126. The solar instruments are capable of following the parallel of latitude without substantial offsets. If such an in ment, in good adjustment, is employed, the true meridian ma determined by observation with the solar at each transit point turn of 90° in either direction then defines the true parallel, an sights are taken not longer than from 20 to 40 chains distant, the so established does not appreciably differ from the theore parallel of latitude. The locus of the resulting line is a succe of points each one at right angles to the true meridian at the vious station. However, during a period each day the solar is available, and during this time, also whenever the sun may obscured by clouds, or on account of a disturbance of the adj ments of the solar attachment, and whenever an instrument wit solar attachment is employed, reference must be made to a t line from which to establish the true latitude curve by one o following methods.

TANGENT METHOD.

127. The tangent method of determination of the true lat curve consists in establishing the true meridian at the poi beginning, from which a horizontal deflection angle of 90° is t to the east or west, as may be required, and the projection of the thus determined is called the tangent. The tangent is project

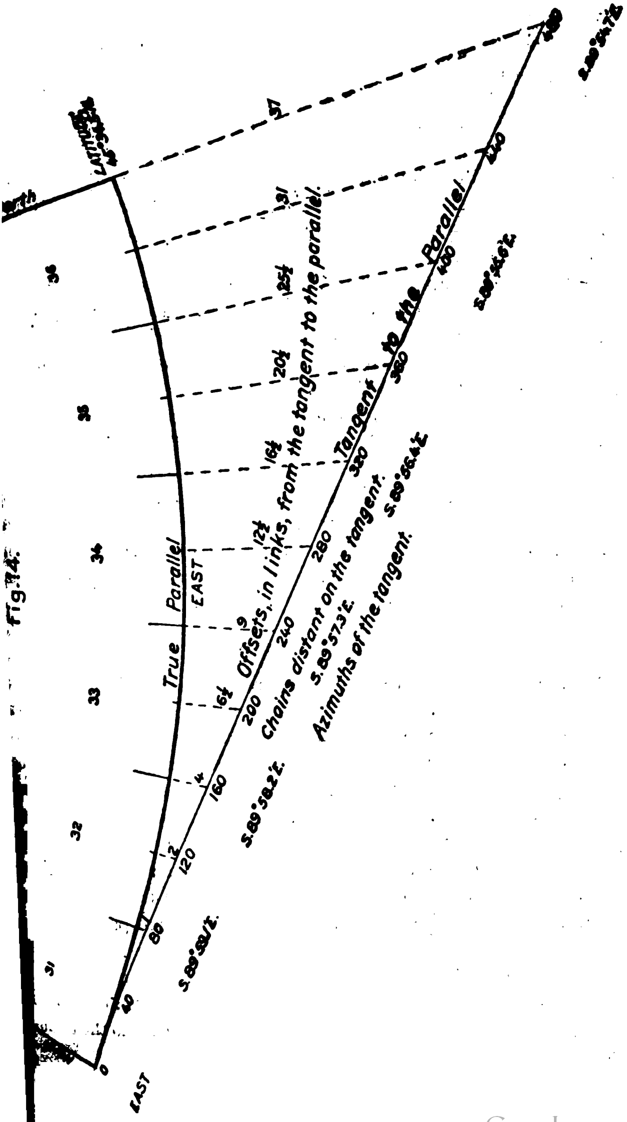

True Parallel
EAST
Offsets, in links, from the tangent to the parallel.
Tangent to the Parallel
Chains distant on the tangent.
Azimuths of the tangent.
S.89°58.2'E.
S.89°57.3'E.
S.89°56.4'E.
31
32
33
34
35
36
0
40
80
120
160
200
240
280
320
360
400
440
2
4
16¼
9
12¼
16¼
20¼
25¼
31
37

Fig. 14.

miles in a straight line, and as the measurements are completed f each corner point, proper offsets are measured north from the tange to the parallel, upon which line the corners are established.

In Table 12, Standard Field Tables, are given the bearing angl or azimuths of the tangent to the parallel, referred to the true point, tabulated for any degree of latitude from 25° to 70° N., for t end of each mile from 1 to 6 miles. At the point of beginning t tangent bears east or west, but as the projection of the tangent continued the deviation to the south increases in accordance wi rules already stated.

In Table 13, Standard Field Tables, are shown the various offs from the tangent north to the parallel, tabulated for any degree latitude from 25° to 70° N., for each half mile from ½ to 6 miles.

The accompanying diagram illustrates the establishment o standard parallel in latitude 45° 34′.5 N., by the tangent meth (See Fig. 14.) The form of record is shown in the specimen field not

Objection to the use of the tangent method in a timbered coun is found owing to the requirement that all blazing is to be made the true surveyed lines. Also, all measurements to items of top raphy entered in the field notes are to be referred to the true est lished lines. These objections to the tangent method, on accoun the increasing distance from the tangent to the parallel, are larg removed in the secant method.

SECANT METHOD.

128. The designated secant is a great circle which cuts any t parallel of latitude at the first and fifth mile corners, and is tangent an imaginary latitude curve at the third mile point. From t point of beginning to the third mile corner the secant has a nor easterly or northwesterly bearing; at the third mile corner the sec bears east or west; and from the third to the sixth mile corners t secant has a southeasterly or southwesterly bearing, respective depending upon the direction of projection, east or west. From t point of beginning to the first mile corner and from the fifth to t sixth mile corners the secant lies south of the true parallel, and fr the first to the fifth mile corners the secant lies north of the t parallel. It will thus be seen that the secant method is a m modification of the tangent method, so arranged that the minim offsets can be made from the projected transit line to the establish true parallel of latitude.

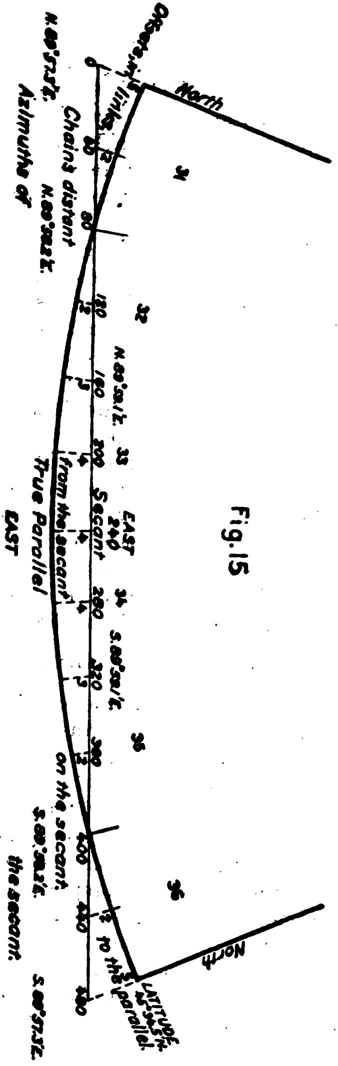

North
Offsets in links
Chains distant
from the secant
True Parallel
on the secant
to the parallel
Secant
EAST
Azimuths of
the secant
North

Fig. 15

The secant method of determination of the true latitude curve c
sists in establishing the true meridian at a point south of the beg
ning corner a measured distance taken from the table, from whi
meridian the proper horizontal deflection angle, as taken from t
table, is turned to the northeast or northwest to define the seca
The secant is projected 6 miles in a straight line, and as the meas
ments are completed for each corner point, proper offsets are m
ured, north or south, from the secant to the parallel, upon w
parallel the corners are established.

In Table 14, Standard Field Tables, are given the bearing angl
azimuths of the secant, referred to the true N. point for the fi
miles, and the same symmetrical bearing angles or azimuths refe
to the true S. point for the last 3 miles, tabulated for any degr
latitude from 25° to 70° N., for the end of each mile from 0 t
miles.

In Table 15, Standard Field Tables, are shown the various of
from the secant to the parallel, tabulated for any degree of lati
from 25° to 70° N., for each half mile from 0 to 6 miles.

The accompanying diagram illustrates the establishment o
standard parallel in latitude 45° 34'.5 N. by the secant met
(See Fig. 15.) The form of record is shown in the specimen field n

The secant method is recommended for its simplicity of execu
and proximity to the true latitude curve, as all measurements
cutting by this method are substantially on the true parallel.

CONVERGENCY OF MERIDIANS.

129. The linear amount of the convergency of two meridians i
function of their distance apart, of the length of the meridian betw
two reference parallels, of the latitude, and of the spheroidal fi
of the earth's surface.

The following equation is convenient for the analytical com
tation of the linear amount of the convergency on the paralle
two meridians any distance apart, and any length. The correct
for convergency in any closed figure is proportional to the area, t
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° 20′:

nat 1	=	1. 0000000
log e	=8. 915 2515	
" "	=8. 915 2515	
" sin 43° 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° 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° 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 lin amounts of the convergency of meridians, 6 miles long and 6 mil apart, for each degree of latitude from 25° to 70° N., together wi the angle of convergency of the same meridians. These amounts linear convergency are at once the proper corrections to apply the north boundary of a regular township in the computation of t closing error around a township, or other computation by which theoretical length of a north or south boundary of a township is co pared with the length of the opposite boundary; the tabulated lin amounts of convergency are equal to double the amounts of the off from a tangent to the parallel at 6 miles for the same latitu Simple interpolation may be made for any intermediate latitu and the amount of the convergency for a fractional township or ot figure may be taken in proportion to the tabulated convergency the fractional area is to 36 square miles.

The tabulated angle of convergency represents at once the dev tion in azimuth of the tangent from the parallel at 6 miles; and $\frac{1}{3}$, $\frac{1}{2}$, $\frac{2}{3}$, and $\frac{5}{6}$ of the tabulated angles of convergency repres at once the amounts of the correction in the bearing of meridio section lines to compensate for convergency within a township.

In the same table are given the differences of longitude for 6 mi in both angular and time measure, also the differences of latitu for 1 or 6 miles, in angular measure, in the various tabulated latitud

181. In the plan of subdivision of townships the meridional secti lines are established parallel to the east boundary or other governi line; this necessitates a slight correction on account of the angul convergency of meridians. Meridional section lines west of t governing line are deflected to the left of the bearing of the governi line the amount shown in the second part of Table 2, Standard Fi Tables, which is entered under two arguments: (1) Latitude, and (distance from the governing line. Meridional section lines east o governing boundary are given the same amount of correction i 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 given measurement along a meridian or the converse calculation, other computations involving a difference of longitude for a give measurement along a parallel or a similar converse calculation, a readily accomplished by the use of the values given in Table 1 Standard Field Tables; this table gives the lengths in miles a nal part of a mile of one degree of longitude measured on the lel, and the lengths in miles of one degree of latitude measured ıe meridian, for any latitude from 25° to 70° N.

e above tabulated values may be reduced to miles and chains, chains or feet, as convenient. In taking out lengths of degrees ıgitude measured on the parallel an exact linear interpolation be made, and in taking out lengths of degrees of latitude meas- on the meridian the value should be taken out for the mean ion in latitude of that portion of the meridian whose length it ired to compute.

3. The first part of Table 2, Standard Field Tables, has been ged for the reference of the latitude of any point within a town- to the south boundary, the only argument being the miles and s distant from the south boundary. Thus with the use of this all observations for latitude within a township may be reduced e south boundary; and conversely, given the latitude of the boundary of a township, the latitude of any station within the ship may readily be obtained by applying the difference given e table for the known distance north.

CHAPTER III.

SYSTEM OF RECTANGULAR SURVEYS.

GENERAL SCHEME.

4. In the preceding chapters there has been outlined the sys-
of nomenclature and procedure relating, in general terms, to the
ey of the public domain. It is confidently assumed that the
ed States surveyor has become impressed with the purpose of
ısk and the stability and dignity which should be attached to a
so great and important, commensurate with its broad founda-
in law and science.

r the purpose of disposal of the public domain the law provides,
neral terms, for its description, subdivision and identification
nformity with the following general scheme:

. The township, 6 miles square, containing 36 sections, each 1
square.

. The numbering of the townships meridionally into a range and
ıdinally into a tier, from which the necessity at once appears
ıe selection of independent initial points, each to serve as an
ı for the extension of surveys synchronously needed in somewhat
ly separated localities, to provide for which, principal or gov-
g meridians and base lines have been established, to which
t be related the surveys executed in each of such localities.

. The establishment of guide meridians and correction lines or
lard parallels at intervals sufficiently near each other to main-
a practical workable adherence to the legal definition of the
ary unit, the township 6 miles square, and at the same time to
ce to a minimum the number of corners required.

ı. The placing of fractional sections on the north and west bound-
of the township.

ı. The subdivision of the townships into 36 sections by running
lel lines through the township from south to north and from
o west at distances of 1 mile.

ı. The inflexible declaration of the integrity of the corners marked
ıe public surveys as the proper legal corners of the sections
the subdivisions of the sections which they were intended to

designate, together with the equally important provisions (*a*) the boundary lines actually run and marked shall be and re the proper boundary lines of the sections or subdivisions for w they were intended; (*b*) that the length of such lines as retu by the surveyors shall be held as the true length thereof; an that the sections shall be subdivided by running straight from the established quarter-section corners to the opposite e lished quarter-section corners.

135. The townships will be numbered to the north or south mencing with number 1 at the base line, and with range numb the east or west beginning with number 1 at the principal meri

The 36 sections into which a township is subdivided are numl commencing with number 1 in the northeast section of the town proceeding thence west to section 6, thence south to section 7, th east to section 12, and so on, alternately, to number 36 in the s east section. In the case of fractional townships, the section bear the same numbers they would have had if the townships full, that is to say the section numbers should be employed w are the proper section numbers relating to the sides which ar governing boundaries, leaving any deficiency to fall on the op sides.

136. The specimen field notes will serve to illustrate the me of running lines to form quadrangles 24 miles square; the me of running the exterior lines of townships; and the method of dividing regular townships. The methods here presented designed to insure a full compliance with every practicable req ment, meaning and intent of the surveying laws.

137. By the terms of the original law and by general pra section lines are surveyed from south to north and from east to in order uniformly to place excess or deficiency of measureme the north and west sides of the townships. For convenience exterior lines on which subdivisions are based are called the go ing boundaries. In unusual cases the north and west bound may be employed to govern the subdivision of a township, an extreme cases an irregular township may be without even a si governing boundary.

INITIAL POINTS.

138. Initial points from which the lines of the public survey to be extended will be established whenever necessary, under special instructions as may be prescribed in each case by the (

ioner of the General Land Office. The initial points are to be ted with a view to their control of extensive agricultural areas in reasonable geographical limitations. Upon the establish- t of an initial point, the position of the point in latitude and longi- is to be determined by accurate field astronomical methods.

uring the period since the organization of the system of rectan- surveys numbered and locally named principal meridians and lines have been established as shown by the accompanying ar exhibit. These bases and meridians may be found by iining the large wall map of the United States published by the ral Land Office; they are also shown upon the various official maps, and upon a special map entitled "United States, Showing ipal Meridians, Base Lines and Areas Governed Thereby."

9. The latitudes and longitudes given in the following table are l upon the best obtainable information, but in some cases the s shown are only approximately correct owing to the fact that of the initial points were fixed in position and the surveys from largely completed before the same importance was at- d to the matter of accurate latitudes and longitudes as at the nt time. It may also be noted, by way of explanation, that nt-day facilities for accurate field astronomical determinations not available to the early surveyors. It is not expected that alues of the latitudes given in the table will be used as the of the calculation of the latitude of an unknown station, in lieu field determination thereof, except as an approximate value satisfy all requirements. The coördinates of the earliest sur- in Ohio can not be conveniently tabulated, but they are shown the maps as stated above.

PRINCIPAL MERIDIAN.

0. This line shall conform to the true meridian and will be ided from the initial monument, either north or south, or in directions, as the conditions may require; regular quarter- on and section corners will be established alternately at inter- of 40 chains, and regular township corners at intervals of 480 s; meander corners will be established at the intersection of ine with all meanderable bodies of water.

1. In the survey of the principal meridian and the other lard lines (base lines, standard parallels and guide meridians), nafter described, two independent sets of measurements will

MERIDIANS AND BASE LINES OF THE UNITED STATES RECTANGU
SURVEYS.

Meridians.	Governing surveys (wholly or in part) in States of—	Longitude of principal meridians west from Greenwich.			Latit of ba lin north Equ
		°	′	″	°
Black Hills	South Dakota	104	03	00	44
Boise	Idaho	116	24	15	43
Chickasaw	Mississippi	89	15	00	34
Choctaw	do	90	14	45	31
Cimarron	Oklahoma	103	00	00	36
Copper River	Alaska	145	18	42	61
Fairbanks	Alaska	147	38	33	64
Fifth Principal	Arkansas, Iowa, Minnesota, Missouri, North Dakota, and South Dakota.	91	03	42	34
First Principal	Ohio	84	48	50	41
Fourth Principal	Illinois	90	28	45	40
Do.	Minnesota and Wisconsin	90	28	45	42
Gila and Salt River	Arizona	112	18	24	33
Humboldt	California	124	07	11	40
Huntsville	Alabama	86	34	45	35
Indian	Oklahoma	97	14	30	34
Louisiana	Louisiana	92	24	15	31
Michigan	Michigan	84	22	24	42
Mount Diablo	California and Nevada	121	54	48	37
Navajo	Arizona and New Mexico	108	32	45	35
New Mexico Principal	Colorado and New Mexico	106	53	40	34
Principal	Montana	111	38	50	45
Salt Lake	Utah	111	54	00	40
San Bernardino	California	116	56	15	34
Second Principal	Illinois and Indiana	86	28	00	38
Seward	Alaska	149	21	53	60
Sixth Principal	Colorado, Kansas, Nebraska, South Dakota, and Wyoming.	97	23	00	40
St. Helena	Louisiana	91	09	15	31
St. Stephens	Alabama and Mississippi	88	02	00	31
Tallahassee	Florida	84	16	42	30
Third Principal	Illinois	89	10	15	38
Uintah	Utah	109	57	30	40
Ute	Colorado	108	33	20	39
Washington	Mississippi	91	09	15	31
Willamette	Oregon and Washington	122	44	20	45
Wind River	Wyoming	108	48	40	43

employed, unless subdivisional closings thereon are provided in same assignment with the standard line, in which case the clos- will furnish a satisfactory verification of the length of the lines surveyed. Where such closings are not to be made during the gress of the same survey, the proper supervising officer will pro- le suitable instructions for the employment of a second set of inmen, or for the duplication of the measurement by the one set chainmen. In either case, where two independent sets of measure- nts are employed, the distance to the mean point, and the differ- e between the measurements to each corner established, will be wn in the field notes; a form of record is given in the specimen notes.

12. Should the difference between the two sets of measurements ny standard line, as above provided, exceed 20 links per 80 chains, required that the line be remeasured to reduce the difference, final measurement of the line only to be shown in the field notes. uld the successive independent tests of the alinement of any dard line, or the average tests of the solar attachment employed he projection thereof, indicate that the line has deflected from true cardinal course to exceed 3′ 00″, the necessary corrections be made to reduce the deviation in azimuth, the field notes of true line only being shown. Every reasonable effort will be cised to insure the accuracy of both the alinement and the meas- ment of the standard lines, and the stated discrepancies are the imum that will be allowed in new surveys; corrective steps will required where the differences are beyond the maximum.

BASE LINE.

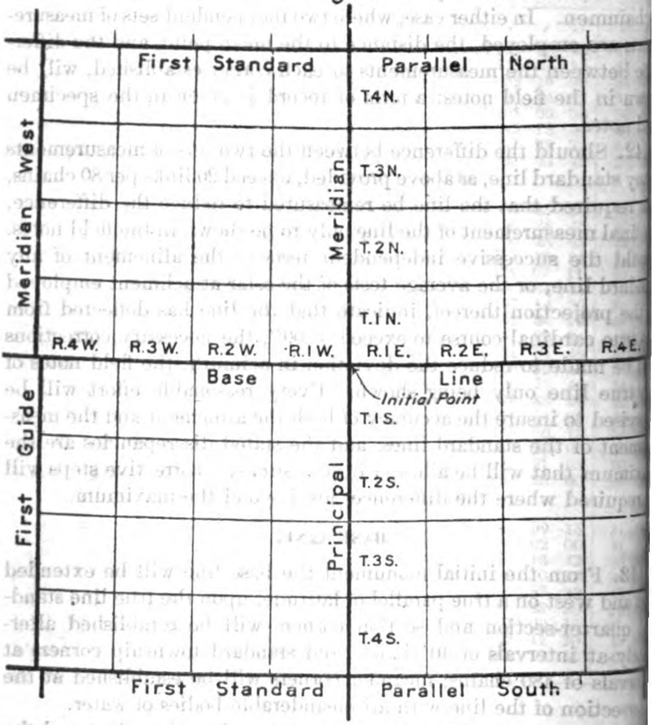
13. From the initial monument the base line will be extended and west on a true parallel of latitude; upon the true line stand- quarter-section and section corners will be established alter- ely at intervals of 40 chains, and standard township corners at ervals of 480 chains; meander corners will be established at the ersection of the line with all meanderable bodies of water.

The manner of making the measurement of the base line and the uracy of both the alinement and measurement will be the same required in the survey of the principal meridian. Any one of the thods heretofore set forth for the determination of the alinement the true latitude curve may be used as existing conditions may uire and the detailed process will be fully stated in the field notes.

STANDARD PARALLELS.

144. Standard parallels, which are also called correction lin[es] are extended east and west from the principal meridian, at interv[als] of 24 miles north and south of the base line, in the manner prescrib[ed] for the survey of the base line.

Fig. 16.



Illustrating the survey of quadrangles each embracing 16 townships boun[ded] by standard lines, and showing the coördinate system of numbering the towns[hips].

145. Where standard parallels have been placed at interv[als] of 30 or 36 miles, under practice then permissible, and present co[n]ditions require additional standard lines from which to initiate ne[w] or upon which to close the extension of old surveys, an intermedi[ate] ection line should be established to which a local name may be ɪn, e. g., "Fifth Auxiliary Standard Parallel North," or "Cedar ɜk Correction Line," etc., and the same will be run, in all respects, a regular standard parallel.

GUIDE MERIDIANS.

ɫ6. Guide meridians are extended north from the base line, tandard parallels, at intervals of 24 miles east and west from principal meridian, in the manner prescribed for running the ɪcipal meridian. Under all conditions the guide meridians be terminated at the points of their intersections with the stand- parallels; the guide meridian is to be projected on the true meri- ɪ and the fractional measurement is to be placed in the last half ɜ. At the true point of intersection of the guide meridian with standard parallel a closing township corner is to be established; parallel will be retraced between the first standard corners east west of the point for the closing corner, in order to determine exact alinement of the line closed upon, and the distance will measured and recorded to the nearest corner on said standard ɪllel.

ɫ7. When existing conditions require that such guide meridians ɪl be run south from the base or correction lines, they will be ini- ɜd at the theoretical point for the closing corner of the guide idian, which will be calculated on the basis of the survey of the from south to north initiated at the proper standard township ɪer. At the theoretical point of intersection a closing township ɪer will be established.

ɫ8. Where guide meridians have been placed at intervals ex- ling the distance of 24 miles, and new governing lines are re- ɜd in order to limit the errors of the old or to control new sur- s, a new guide meridian will be established, and a local name be assigned to the same, e. g., "Twelfth Auxiliary Guide Merid- West," or "Grass Valley Guide Meridian," etc. These auxiliary le meridians will be surveyed in all respects like regular guide idians.

ɫ9. The above scheme covers the controlling lines contemplated ɪer the rectangular system, and results regularly in the survey of drangles bounded on the north and south by true parallels of tude, and on the east and west by true meridians, 24 miles apart. ɜ exception may now be noted which will be found to de-

from former practice, that is, where a guide meridian is ca
forward at a time when uncertainty exists as to how the exterio
subdivisional surveys to the east may close upon it, the corners
the same will be marked only for the surveys to the west.

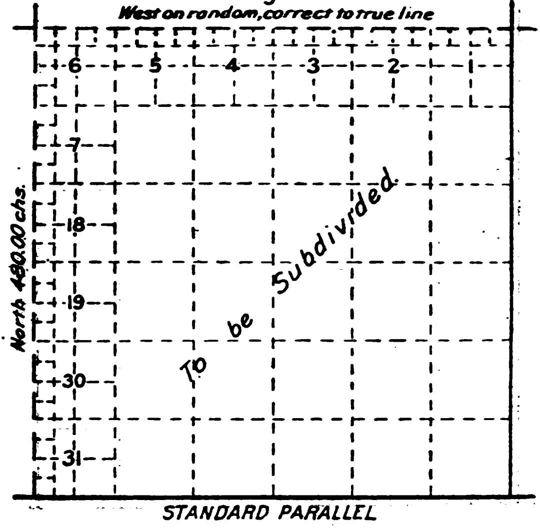
TOWNSHIP EXTERIORS.

REGULAR ORDER.

150. The controlling factors to be recognized in the establish of new township boundary lines are found in the relation of lines to the new subdivisional surveys which are to be exec The south and east boundaries are normally the governing lin the subdivisional surveys. Defective conditions which ma found in previously established exteriors can not be elimin where subdivisional lines have been initiated from or closed an old boundary, but the errors of the former surveys are not incorporated into the new, and where the previously establi south and east boundaries can not on that account be used to go the subdivision of the adjoining township, other controlling known as the sectional correction line and the sectional g meridian, hereinafter described, will be employed as expedient new meridional township exterior is normally the governing bou ary of the township to the west, and a new latitudinal town exterior is normally the governing boundary of the township to north; any new boundary should therefore be established with consideration for its control upon the subdivisional surveys th after to be executed.

151. Whenever practicable the township exteriors will be veyed successively through a quadrangle in ranges of townsh beginning with the townships on the south. The meridional bou aries of the townships will have precedence in the order of sur and will be run from south to north on true meridians; qua section and section corners will be established alternately at inter of 40 chains, and meander corners at the intersection of the line all meanderable bodies of water; a temporary township corner be set at a distance of 480 chains, pending a determination of controlling factor upon which its final position will be govern whereupon the temporary point will be replaced by a perman corner in proper latitudinal position. The latitudinal towns boundary will be run first as a random line, setting tempor corners, on a cardinal course, from the old toward the new meridio boundary, and corrected back on a true line if ideal conditions

Fig. 17.


West on random, correct to true line
6
5
4
3
2
7
18
19
30
31
North 480.00 chs.
To be Subdivided.
STANDARD PARALLEL

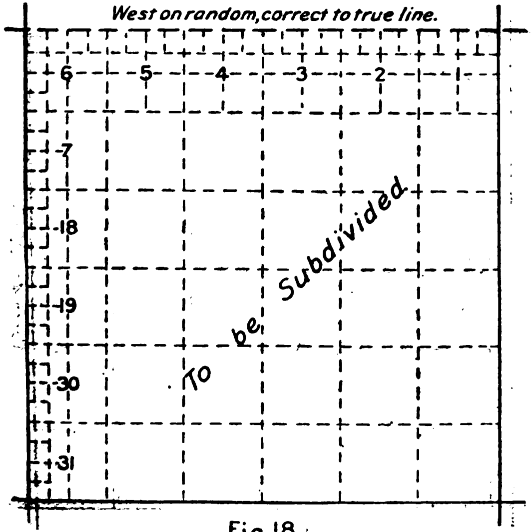
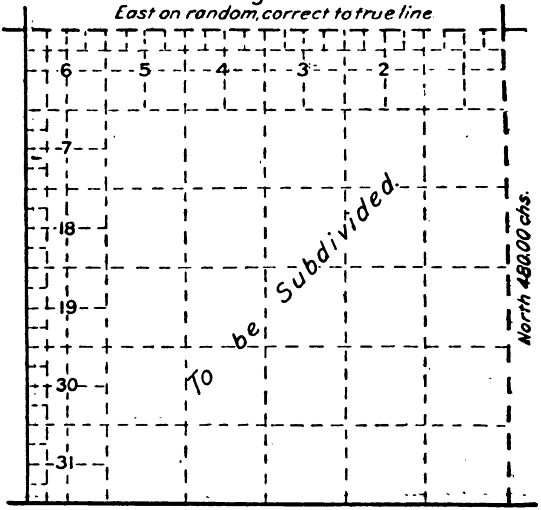

West on random, correct to true line.
6
5
4
3
2
7
18
19
30
31
To be Subdivided.

Fig. 18.

Fig. 19.



STANDARD PARALLEL

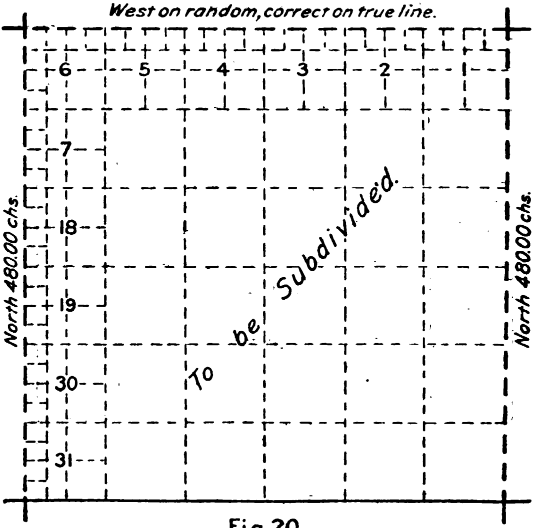
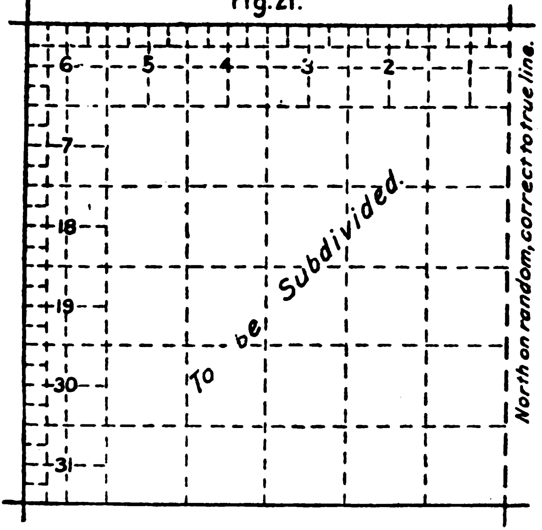


Fig. 20.

Fig. 21.



STANDARD PARALLEL

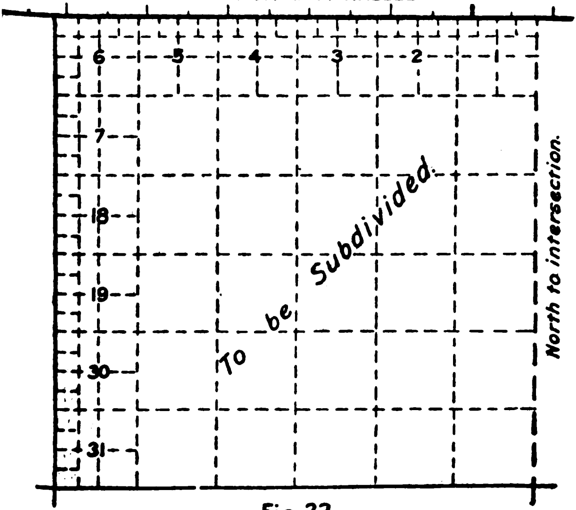


Fig. 22.

found to obtain. Where both meridional boundaries are new lin or where both have been previously established, the random lat tudinal boundary will be run from east to west. In either case, defective conditions are not encountered, the random line will corrected back on a true line, upon which will be established reg lar quarter-section and section corners at intervals of 40 chai alternately, counting from the east, and meander corners at t intersection of the true line with all meanderable bodies of wa The bearing of the true line will be calculated on the basis of falling of the random, and the fractional measurement will be pla in the west half mile. A meridional township exterior will terminated at the point of its intersection with a standard paral placing the excess or deficiency in measurement in the northe most half mile. At the point of intersection of the meridio boundary with a standard parallel a closing township corner will established; the parallel will be retraced between the first stand corners east and west of the point for the closing corner, in orde determine the exact alinement of the line closed upon, and distance will be measured and recorded to the nearest corner on s standard parallel.

152. In order to complete the exteriors of a township it will o remain to establish a meridional boundary between previously est lished township corners; such boundaries will be run from south north on random lines, with temporary corners set at intervals 40 chains, and, if defective conditions are not encountered, random will be corrected to a true line; by this plan the excess deficiency of measurement will be placed in the north half mile, required by law, and double sets of corners will be avoided wh unnecessary.

153. The temporary points on any random exterior will be placed by permanent corners, in proper position, when the final tr line adjustments for the latter have been fully determined; true line will be properly blazed through timber, and distances important items of topography will be adjusted to correct tr line measurements.

154. The field notes will embrace a full and complete record the manner in which the township exteriors are run and establishe The notes will show how the alinement of the random latitudir curve was determined, the direction of the projection, the amou of the falling north or south of the objective township corner, and t 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.

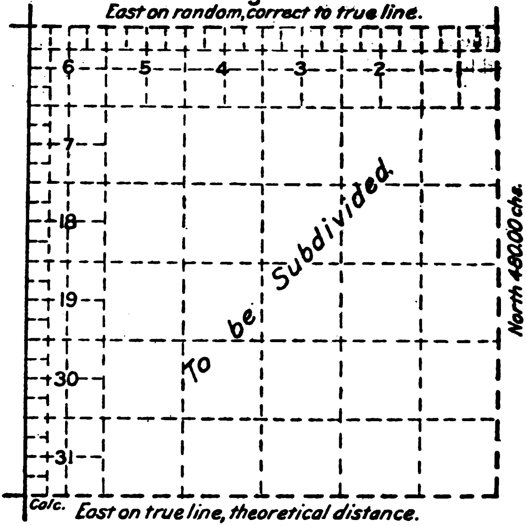
In authorizing surveys to be executed it will not usually be provided that exteriors are to be carried forward until the township is to be subdivided; thus where causes operate to prevent the establishment of the boundaries in full it is not imperative that the survey of the exterior lines be completed; 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

Fig. 23.


East on random, correct to true line.
6
5
4
3
2
7
18
19
30
31
To be Subdivided.
North 480.00 chs.
Calc.
East on true line, theoretical distance.

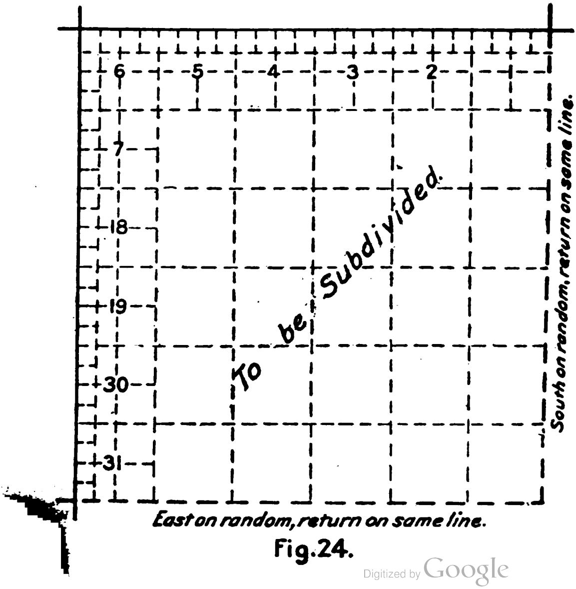
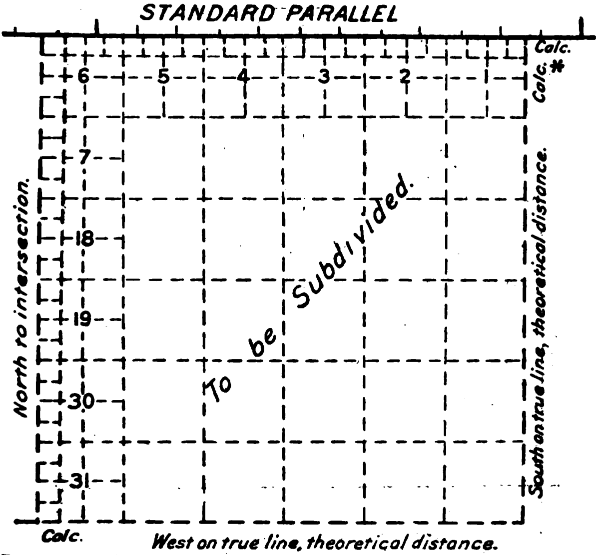

6
5
4
3
2
7
18
19
30
31
To be Subdivided.
South on random, return on same line.
East on random, return on same line.

Fig. 24.

Fig. 25.



Exteriors initiated at a theoretical point for a closing corner.

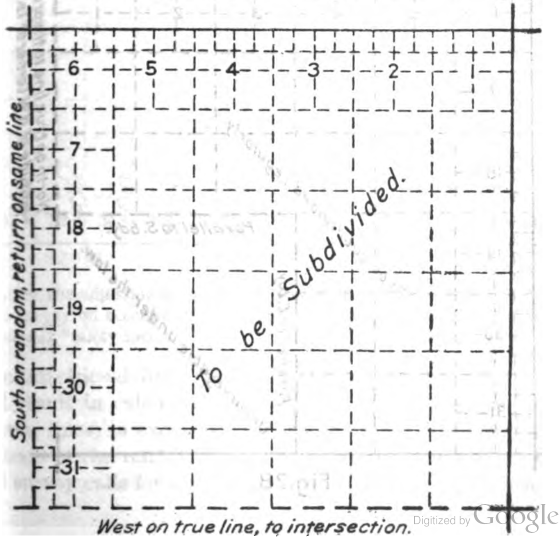
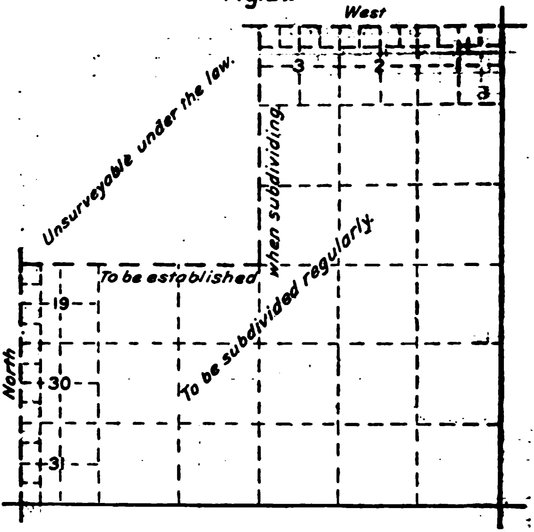


Fig. 27.


West
3
2
3
Unsurveyable under the law.
when subdividing
To be subdivided regularly
To be established
19
30
31
North

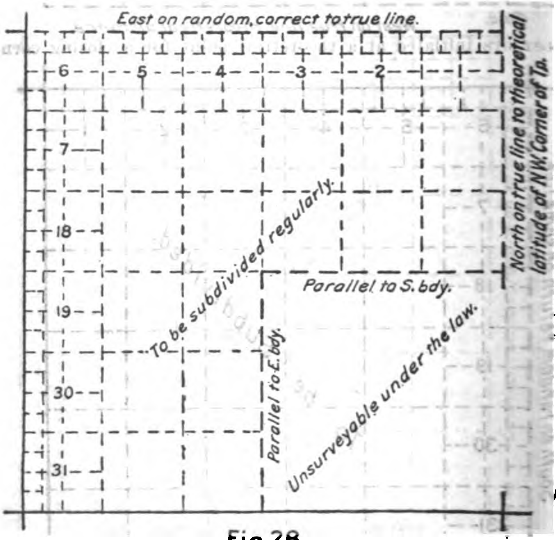
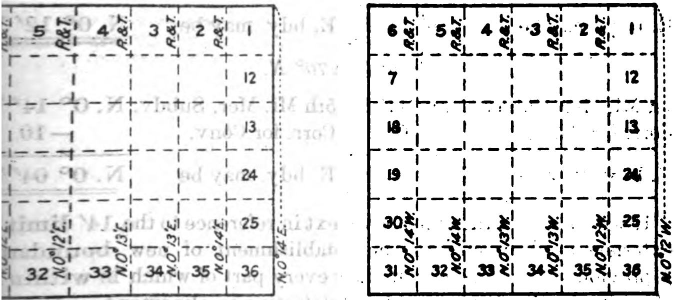

East on random, correct to true line.
6
5
4
3
2
7
18
19
30
31
To be subdivided regularly.
Parallel to S. bdy.
Parallel to E. bdy.
Unsurveyable under the law.
North on true line to theoretical latitude of N.W. Corner of Tp.

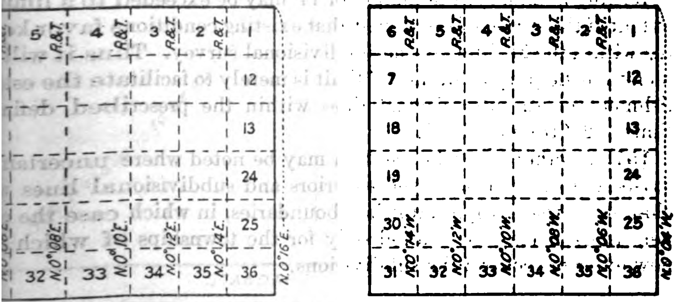
Fig. 28.

ridional boundary, or its projection to the north or south as the e may be. Likewise, where a meridional boundary is run as a dom, the random will be made the true line if the adjustment for ing plus the usual correction to secure parallelism of the meridi-

Fig. 29.



Latitude 25° N.



Latitude 70° N.

the adjustment in the direction of the meridional lines of a subdivi-nal survey on account of convergency of meridians, also the 14′ limit of the tangular "safety zone."

subdivisional lines (on account of convergency of meridians) uld result in calculated bearings (in the northernmost miles of latter lines) in excess of 14′ from cardinal. This margin for the nement of the random and true meridional lines of the subdivi-nal survey calls for a governing east boundary whose bearing will

fall within certain extremes suited to the latitude of the townshi
as for example (see second part of Table 2, Standard Field Table

Latitude 25° N.

1st Mi. Mer. Subdv.	N. 0° 14′ E.	5th Mi. Mer. Subdv.	N. 0° 14′
Corr. for Conv.	+00	Corr. for Conv.	—02
E. bdy. may be	N. 0° 14′ E.	E. bdy. may be	N. 0° 12′

Latitude 70° N.

1st Mi. Mer. Subdv.	N. 0° 14′ E.	5th Mi. Mer. Subdv.	N. 0° 14′
Corr. for Conv.	+02	Corr. for Conv.	—10
E. bdy. may be	N. 0° 16′ E.	E. bdy. may be	N. 0° 04′

It will be noted that the above text in reference to the 14′ limit exteriors applies only to the establishment of new boundar A previously established boundary every part of which is within of cardinal will not be considered defective in alinement. Eve the case of new exteriors, where the surveyor who establishes line is also to subdivide the township of which such exterior governing boundary, the margin of 14′ may be exceeded to a limi extent if the surveyor is satisfied that existing conditions favor k ing within the 21′ limit in the subdivisional survey. Thus it wil seen that the purpose of the 14′ limit is merely to facilitate the es lishment of all subdivisional lines within the prescribed defi limit of 21′ from cardinal.

157. Another general exception may be noted where uncerta exists as to how unsurveyed exteriors and subdivisional lines close upon the newly established boundaries, in which case the ners thereon may be marked only for the townships of which new exteriors control the subdivisions.

COMPLETION OF PARTIALLY SURVEYED EXTERIORS.

158. Where the end portions of a township exterior have b previously surveyed and closed upon, the fractional unsurve middle part will be completed by random and true line, with offset regardless of the deviation from cardinal; the fractional m urements will be placed as a general rule in the north and w half miles, thereby permitting the subdivisional lines to be exten as usual from the south to the north and from the east to the w In the case of a fractional part of an exterior remaining unsurvey ıer end of the line, the boundary will be completed by random initiated at the previously established terminal monument, will be projected on a cardinal course in the direction of the ive township corner. The random will be corrected to a ine where the calculated bearing of any subdivisional line, ed by such exterior, comes within 14′ from cardinal, and the

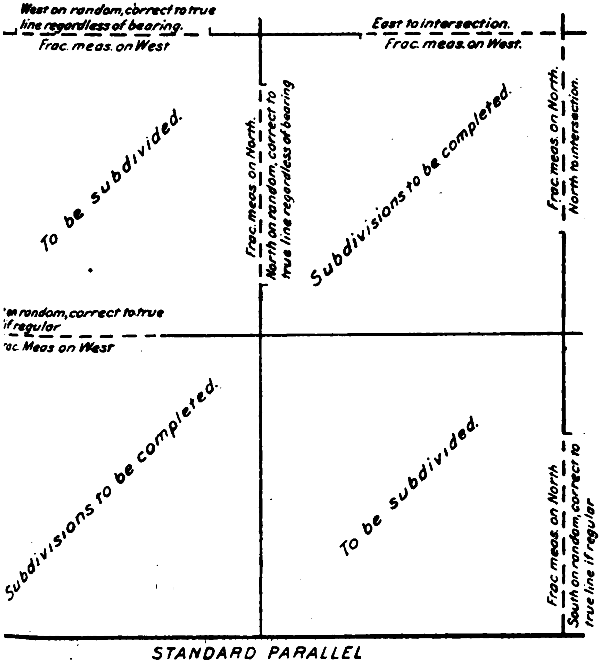


Fig. 30.

ıal measurement will be placed generally in the north or alf miles. However, should irregularity be developed, or ıbsence of a previously established objective township corner, rtially surveyed exteriors will be completed on cardinal beginning as above; and in either case the fractional measıts 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 whi is to be subdivided have been previously surveyed, and the pro supervising officer has reason to question the accuracy of any port of such exteriors, or the condition of the corner monuments there the fact will be stated in the written special instructions, and surveyor will be authorized and required, as a condition preced to beginning the subdivisional survey of such township, to ret such boundaries in order to determine the true alinement and len of the lines, to rebuild any corners found to be in a poor condit and otherwise to accomplish the following purposes:

(*a*) To locate all material errors, (*b*) to test every line as to alterations may be required, and (*c*) to determine all data neces for the computation of the areas of all fractional lots.

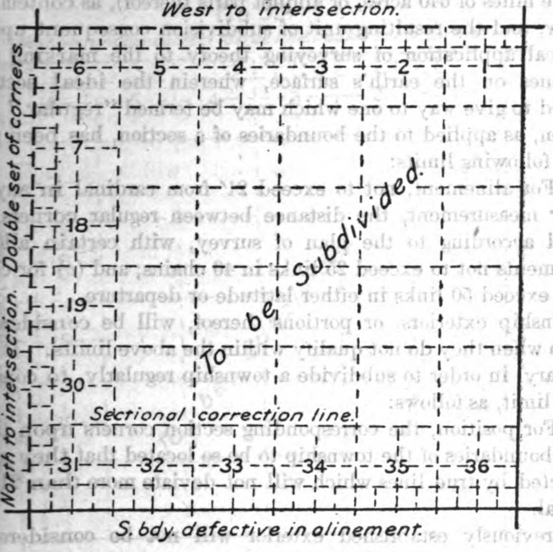
160. All data obtained in the retracements will be embodie the field notes and shown upon the plat of the survey, unless retracement results are in substantial agreement with the reco the original survey, in which case a general statement to that e may be made in the field notes, and the original record may be mitted to govern the data to be placed upon the plat.

RECTANGULAR LIMITS.

161. Before approaching the subject of "subdivision of townsh it is necessary to consider the requirement of law relative to rec gular surveys, wherein the square mile, or section, is the un subdivision. The normal township will include 36 sections in 25 of which are returned as containing 640 acres each; 10 section the north and west boundaries) each contain regular aliquot totaling 480 acres with 4 additional fractional lots in each sec each lot containing 40 acres plus or minus definite differences t determined in the survey; and, section 6 containing regular ali parts totaling 360 acres with 7 additional fractional lots each taining 40 acres plus or minus certain definite differences t determined in the survey, all as contemplated by law. The a mentioned aliquot parts of 640 acres may be termed "regular or subdivisions of a section," as a quarter section, a half-quarter sec or a quarter-quarter section, the legal minimum of which, for pur of disposal under the general land laws, is 40 acres.

162. In the administration of the surveying laws it has necessary to establish a definite relation between rectangul

Fig. 31.


West to intersection.
Double set of corners.
North to intersection.
6
5
4
3
2
7
18
19
30
31
32
33
34
35
36
To be Subdivided.
Sectional correction line.
S. bdy. defective in alinement.

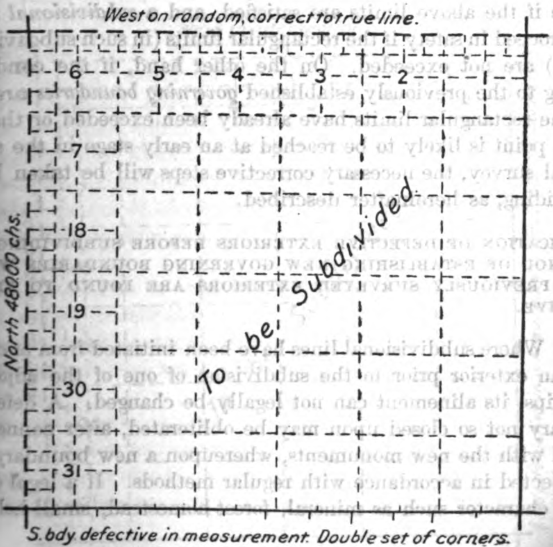

West on random, correct to true line.
North 480.00 chs.
6
5
4
3
2
7
18
19
30
31
To be Subdivided.
S. bdy defective in measurement. Double set of corners.

Fig. 32.

(square miles of 640 acres, or aliquot parts thereof), as contemplat by law, and the resulting unit of subdivision consequent upon t practical application of surveying theory to the marking out the lines on the earth's surface, wherein the ideal section allowed to give way to one which may be termed "regular." Su relation, as applied to the boundaries of a section, has been plac at the following limits:

(*a*) For alinement, not to exceed 21′ from cardinal in any p (*b*) for measurement, the distance between regular corners to normal according to the plan of survey, with certain allowa adjustments not to exceed 25 links in 40 chains; and (*c*) for clos not to exceed 50 links in either latitude or departure.

Township exteriors, or portions thereof, will be considered fective when they do not qualify within the above limits. It is necessary, in order to subdivide a township regularly, to conside fourth limit, as follows:

(*d*) For position, the corresponding section corners upon the posite boundaries of the township to be so located that they may connected by true lines which will not deviate more than 21′ f cardinal.

A previously established exterior will not be considered fective if the above limits are satisfied, and a *subdivisional su* may proceed in safety if the rectangular limits (in such subdivisio survey) are not exceeded. On the other hand, if the conditi relating to the previously established *governing boundaries* are s that the rectangular limits have already been exceeded or that danger point is likely to be reached at an early stage in the sub visional survey, the necessary corrective steps will be taken be subdividing, as hereinafter described.

RECTIFICATION OF DEFECTIVE EXTERIORS BEFORE SUBDIVIDING METHOD OF ESTABLISHING NEW GOVERNING BOUNDARIES WH THE PREVIOUSLY SURVEYED EXTERIORS ARE FOUND TO BE FECTIVE.

163. Where subdivisional lines have been initiated from or cl upon an exterior prior to the subdivision of one of the adjoi townships, its alinement can not legally be changed. A defec boundary not so closed upon may be obliterated, after connec the old with the new monuments, whereupon a new boundary be projected in accordance with regular methods. If a legal cl of any character such as mineral, forest-homestead, small-hold

Fig. 33.

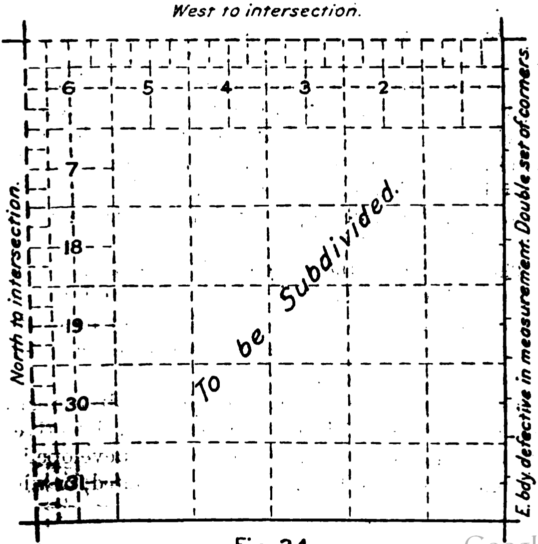


Fig. 34.

55485°—19——11

railroad or canal right-of-way, reservoir site, etc., has been connec with any corner on an exterior which may be subject to rectificati the fact will be specifically stated in the written special instructio and in case such exterior is found to be defective the surveyor accurately connect the old corner by course and distance with new monument. Such old corners will not be destroyed, but letters "W P" (signifying "witness point") will be distinctly ad to the original markings. A complete record of the connection f the new to the old monument, a description of the latter and accessories, and the new markings, will be included in the f notes, and the position of the old monument will be shown on plat of the survey.

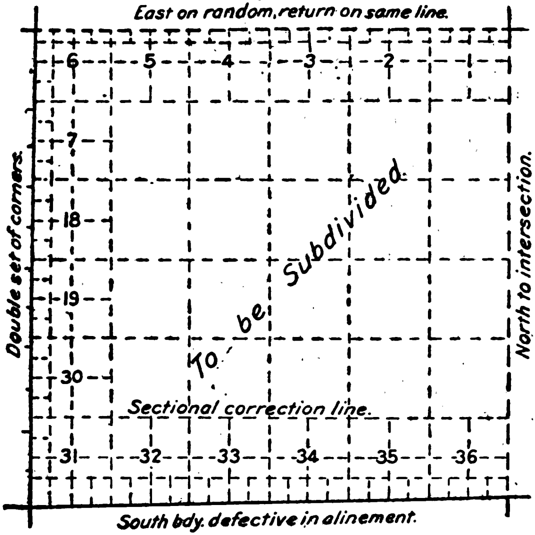
164. If a boundary is defective in measurement or position an not subject to rectification, the location of the original corners not be changed, but the marks thereon, and the marks upon position of the accessories, may be appropriately altered to st only for the sections of the previously established surveys. N corners to control the surveys of the adjoining township may be established on the old line, but at regular distances of 40 an chains. Where new corners are placed on an oblique exterior (whose bearing departs more than 1° from cardinal) the same wil so located for measurement that the oblique distance multip by the cosine or sine of the bearing angle, as the case may be, result in cardinal equivalents of 40 and 80 chains.

165. Where subdivisional lines have been initiated from closed upon one side of a portion of a township boundary prio the subdivision of the township on the opposite side, while u the remaining portion of the same such conditions do not interf said remaining portion may be obliterated, if found defecti whereupon a new line will be projected in accordance with reg methods.

166. The position of the new exteriors, or of new corners defective township boundaries must be established by an act rerunning of such lines; the data acquired in surveying subdivisio lines closing upon defective exteriors can not be accepted in l of such retracement or resurvey.

167. Instances will occur both in closing subdivisional surv upon regular exteriors and in the retracement of defective bou aries not subject to rectification where it will be developed that original monuments have become lost or obliterated, or where su

Fig. 35.


East on random, return on same line.
6
5
4
3
2
7
18
19
30
To be Subdivided.
Sectional correction line.
31
32
33
34
35
36
Double set of corners.
North to intersection.
South bdy. defective in alinement.

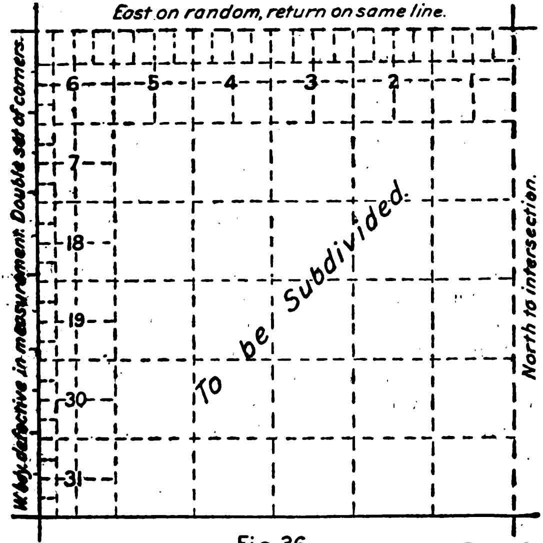

East on random, return on same line.
6
5
4
3
2
7
18
19
30
31
To be Subdivided.
W. bdy. defective in measurement. Double set of corners.
North to intersection.

Fig. 36.

corners may be identified in an advanced state of deterioration. A such exterior corners will be reestablished and remonumented i their correct original positions in strict accordance with the pr visions of Chapters IV and V, and a complete record thereof will embodied in the field notes.

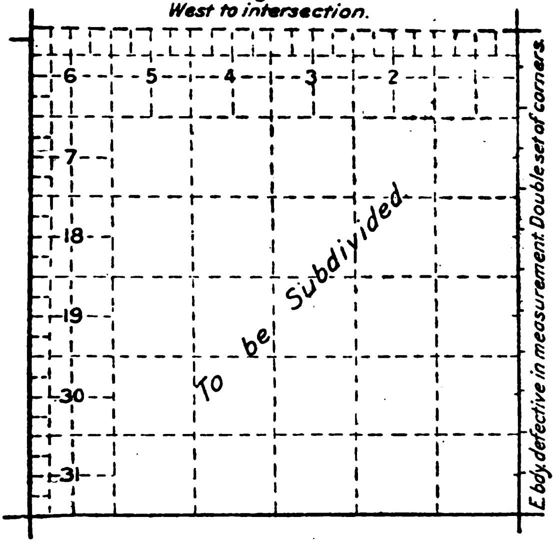
168. The south boundary of a township is regularly the gover ing latitudinal boundary and will be used as such unless defecti in alinement; if defective in measurement, and not subject to r tification, the position of the original corners will not be chang but the marks thereon and the accessories will be appropriat altered to stand only for the sections of the township to the sou new corners of two sections and quarter-section corners common the sections of the township to the north will be established at r ular intervals of 40 chains, counting from the east, and the exc or deficiency in measurement placed in the west half mile. If t south boundary is defective in alinement, a sectional correcti line will be required.

169. The east boundary of a township is regularly the governi meridional boundary and will be used as such unless defective alinement; if defective in measurement, and not subject to recti cation, the position of the original corners will not be changed, b the marks thereon and the accessories will be appropriately alte to stand only for the sections of the township to the east; new c ners of two sections and quarter-section corners common to the se tions of the township to the west will be established at regular int vals of 40 chains, counting from the south. If the east boundary defective in alinement a sectional guide meridian will be requir

170. New west and north boundaries of a township become t governing meridional and latitudinal boundaries of the townshi to the west and north, respectively, and are required to be prope established as such.

171. New east and south boundaries of a township become t closing meridional and latitudinal boundaries of the townships the east and south, respectively, and where by peculiar necess the ideal plan must be modified and doubt exists as to how uns veyed lines may close upon same, the corners thereon may be esta lished common only to the sections of the township of which t new lines are the governing boundaries. The corners appropria to the sections upon the opposite side will be duly established ...ing corners at the time of the survey of the subdivisional lin

Fig. 37.


West to intersection.
6
5
4
3
2
7
18
19
30
31
To be Subdivided.
E. bdy. defective in measurement. Double set of corners.

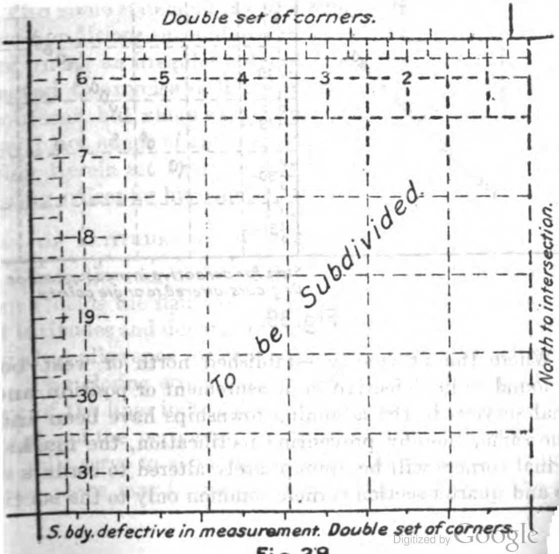

Double set of corners.
6
5
4
3
2
7
18
19
30
31
To be Subdivided.
North to intersection.
S. bdy. defective in measurement. Double set of corners.

Fig. 38

of the adjoining townships if the original corners are then found be defective in position, and where regular connections can made the marks upon the original corners will be appropriat altered to corners of maximum control.

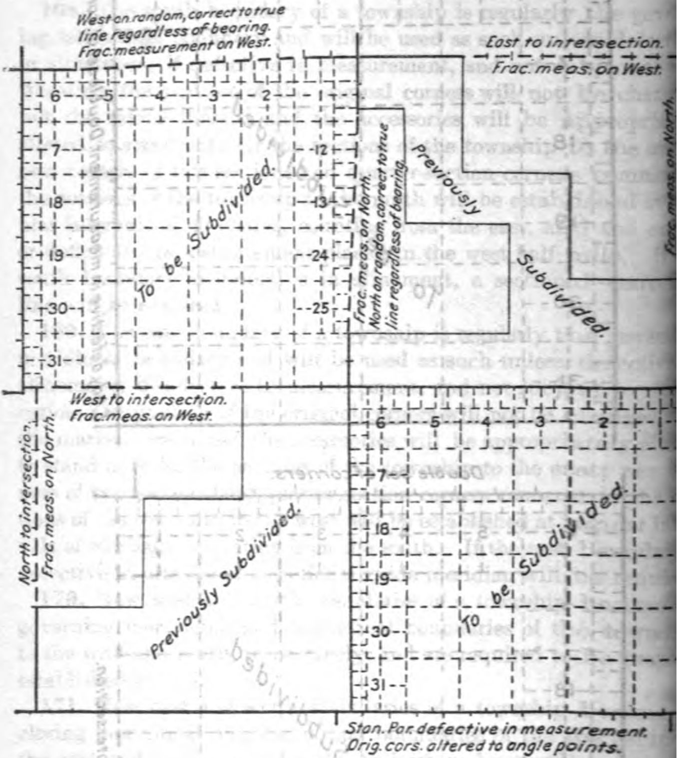


Fig. 39.

172. Where the previously established north or west boun ries are found to be defective in measurement or position and s divisional surveys in the adjoining townships have been initia upon the same, thereby preventing rectification, the marks u the original corners will be appropriately altered to corners of t sections and quarter-section corners common only to the section townships to the north or west, respectively. Closing section ners will be established when subdividing and the distance measd to an original corner; new quarter-section corners, common to sections of the township which is being subdivided, will be ed on the old line at the mean distances between the closing ion corners, or at 40 chains from one direction, depending upon plan of the subdivision of the section. Where such previously blished north and west boundaries are defective in alinement, not in measurement or position, no changes are required, and ection lines of the township which is being subdivided will be ected regularly to the original corners; the resulting fractional urements will be placed uniformly in the north and west half s.

3. The diagrams which accompany the text illustrate the guidprinciples involved in the method of establishing new governboundaries where the previously surveyed exteriors are found defective. Each diagram illustrates a simple condition affectne boundary only, and the examples are taken only from the ar order of procedure. Combinations of two or more of the le defective conditions are best solved by an analysis of the plex problem into its several parts of simple defective condi-. The same statement is applicable to the solution of complex ctive conditions encountered in the establishment of township riors under an irregular order of procedure. The surveyor will xpected to exercise skill and judgment in dealing with similar problems, but where extraordinary conditions are encountered h will not admit of analysis and solution in harmony with the ciples herein set forth he will report the facts to the proper rvising officer for his counsel.

BLES OF LATITUDES AND DEPARTURES AND CLOSING ERRORS.

74. Upon the completion of the survey of one or more township riors closing the figure of either a full or fractional township, a e of latitudes and departures and closing errors will be prepared, rein due allowance for convergency of meridians will be introed. The closing errors will furnish an immediate guide to the racy of the lines included in the table and, in case the limit of ure ($\frac{1}{640}$ of the perimeter, in either latitude or departure) is exded, will serve to show what additional retracements or other ective steps may be necessary in order to perfect the survey.

before leaving the field. The table of latitudes and departures closing errors, including every part of any closed figure embrac township exteriors, based upon final field determination after necessary retracements and final true lines have been complet will be incorporated in the field notes of the survey. The gen subject of "limits of closure" will be amplified hereinafter.

SUBDIVISION OF TOWNSHIPS.

REGULAR BOUNDARIES.

175. The boundaries of a township will be considered wi satisfactory governing limits from which to control the subdivisi survey when the calculated position of the latter lines may be t retically projected from said boundaries without invading the da zone in respect to rectangular limits as previously described. danger zone has already been placed at theoretical bearings exc ing 14′ from cardinal, and the corresponding zone in respec lengths of lines may be placed at theoretical adjustments excee 33 links per mile.

176. The direction of the east boundary may qualify anyw within the governing limits set forth under the subject of "town exteriors," and where this boundary is broken in alinement, otherwise within the governing limits, its mean course wil adopted when considering the control upon the direction of meridional subdivisional lines.

177. The subdivision of a township may proceed in the no order, where the above conditions are satisfied, as follows:

The meridional section lines will be initiated at the regu established section corners on the south boundary of the town and will be run from south to north parallel to the governing boundary, or, in case the east boundary is within limits, but been found by retracement to be imperfect in alinement, the me ional section lines will be run parallel to the mean course of such boundary. Regular quarter-section and section corners will established alternately at intervals of 40 chains, as far as the north most interior section corner. The last miles of the meridional sec lines will be continued as random lines, each successive line b un parallel to the true east boundary of the section to whic belongs; a temporary quarter-section corner will be set at 40 cha the distances will be measured to the points of intersection of lom lines with the north boundary of the township, and llings of the random lines east or west of the objective section rners will be noted. The randoms will then be corrected to true nes by returning to accomplish the required markings between the ction corners, including the permanent establishment of the arter-section corners on the true lines at distances of 40 chains om the south, thus placing the fractional measurements in the north lf miles. The bearings of the true lines will be calculated on the sis of the fallings of the randoms (see Table 3, Standard Field bles). Where the north boundary of the township is a base line or ndard parallel, the last miles of the meridional section lines will continued as true lines parallel to the east boundary of the town-p, setting permanent quarter-section corners at 40 chains from south and closing section corners at the points of intersection he several lines with the base or standard or correction line, where distances will be measured to the nearest corners on said line. e adjustment of the bearing of all meridional section lines on ount of convergency of meridians has already been explained in apter II.

178. The latitudinal section lines, except in the west range of tions, will normally be run from west to east on random lines allel to the south boundaries of the respective sections, setting nporary quarter-section corners at 40 chains; the distances will be asured to the points of intersection of the random lines with the rth and south lines passing through the objective section corners, d the fallings of the random lines north or south of said corners will noted. Each random will be corrected to a true line by returning accomplish the required markings between the section corners, luding the permanent establishment of quarter-section corners the *mid-points* on the true lines. The bearings of the true lines ll be calculated on the basis of the fallings of the randoms (see ble 3, Standard Field Tables). In the west range of sections the dom latitudinal section lines will be run from east to west, parallel the south boundaries of the respective sections, and on the true es the permanent quarter-section corners will be established at chains from the east, thus placing the fractional measurements in e west half miles.

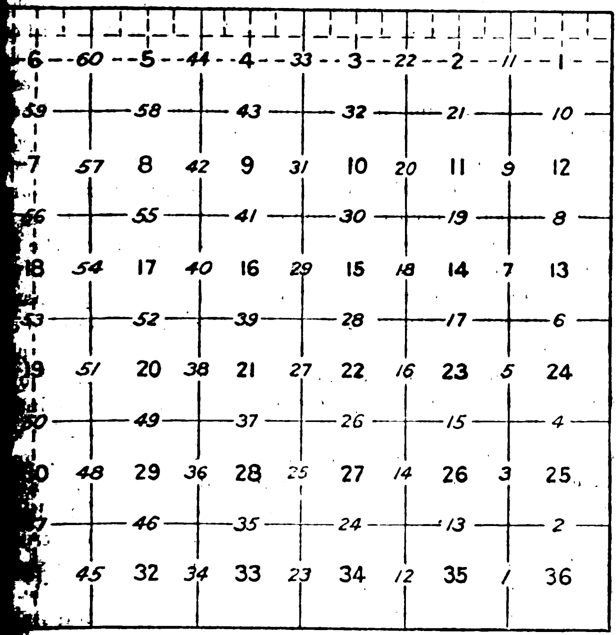
179. Meander corners will be established at the points of inter-ction of the several true lines with all meanderable bodies of water.

180. The meridional section lines will have precedence in the der of execution, and these will be surveyed successively, begin-

ning with the first meridional section line counting from the ea A meridional section line will not be continued beyond a secti corner until after the connecting latitudinal section line has be surveyed, and in the case of the fifth meridional section line, bo latitudinal section lines connecting east and west will be survey before continuing with the meridional line beyond a secti corner. The successive meridional lines may be taken up at t convenience of the surveyor at any time in order as previou stated, but none will be carried beyond uncompleted sections to t east. The field notes will be compiled in ranges of sections beg ning with the easternmost, and the west two ranges will be compi by alternating with the adjoining east and west sections. T specimen field notes exemplify the usual order of survey and t prescribed method of arranging the field notes.

181. Thus, to recapitulate, the subdivisional survey will be co menced at the corner of sections 35 and 36, on the south boundary the township, and the line between sections 35 and 36 will be r parallel to the east boundary of the township, or to the mean cou thereof, if it is imperfect in alinement, but within limits, establ ing the quarter-section corner at 40 chains, and at 80 chains, the cor of sections 25, 26, 35 and 36. From the last-named corner, a rand line will be run eastward, without blazing, parallel to the so boundary of section 36, to its intersection with the east boundar the township, placing at 40 chains from the point of beginning, a p for temporary quarter-section corner. If the random line inters said township boundary exactly at the corner of sections 25 and it will be blazed back and established as the true line, the perman quarter-section corner being established thereon, midway betw the initial and terminal section corners. If the random inters said township boundary to the north or south of said corner, falling will be carefully measured, and from the data thus obtain the true return course will be calculated, and the true line bla and established, and the position of the quarter-section co determined, as directed above. The meridional section line w be continued on the same plan, likewise the successive latitudi section lines except that each random will be run parallel to the t south boundary of the section to which it belongs. After hav established the west and north boundaries of section 12, the l between sections 1 and 2 will be projected northward, on a rand ne, parallel to the east boundary of the township, or to its m

ge, as the case may be, setting a post for temporary quarter-sec- corner at 40 chains, to its intersection with the north boundary he township. If the random intersects said north boundary ly at the corner of sections 1 and 2, it will be blazed back and lished as the true line, the quarter-section corner being estab- permanently in its original temporary position, and the frac- measurement thrown into that portion of the line between the



.—The numbers on the section lines indicate the normal order of subdivision and arrangement of the field notes.

ent quarter-section corner and the north boundary of the p. If, however, said random intersects the north boundary ownship, to the east or west of the corner of sections 1 and 2, ing will be carefully measured, and from the data thus the true return course will be calculated and the true line ed, the permanent quarter-section corner being placed upon e at 40 chains from the initial corner of the random line,

thereby throwing the fractional measurement in that portion ly
between the quarter-section corner and the north boundary of
township. When the north boundary of a township is a base
or standard parallel, the line between sections 1 and 2 will be
as a true line parallel to the east boundary of the township, or t
mean course, as the case may be; the quarter-section corner wil
placed at 40 chains, and a closing corner will be established at
point of intersection with such base or standard line; and in such c
the distance from said closing corner, to the nearest standard co
on such base or standard line, will be carefully measured and no
The successive ranges of sections proceeding from east to west
be surveyed in the same manner; then after having established
west and north boundaries of section 32, a random line wil
initiated at the corner of sections 29, 30, 31 and 32, which wil
projected westward parallel to the south boundary of the towns
setting a temporary quarter-section corner at 40 chains, to an i
section with the west boundary of the township, where the fa
will be measured and the bearing of the true line calculated, wh
upon the line between sections 30 and 31 will be perman
marked between the section corners, and the quarter-section co
thereon will be established at 40 chains from the east, thereby pla
the fractional measurement in the west half mile as required by
The survey of the west two ranges of sections will be continue
the same plan, and the random line between sections 6 and 7 wil
run westward parallel to the true line between sections 7 and
the random will be corrected to a true line and the fractional meas
ment placed in the west half mile; finally the random line betw
sections 5 and 6 will be run northward parallel to the true l
between sections 4 and 5; the random will be corrected to a true l
and the fractional measurement placed in the north half mile.

It may well be noted again that the meridional section lines
surveyed as true lines for 5 miles, i. e., the lines are surve
and permanently monumented in the first instance without la
adjustment. Every means is placed at the disposal of the surve
by which he is expected to accomplish accurate results, and
system of survey provides amply for the adjustment of all reasona
closing errors. Thus, a slight error in the alinement of the meridio
section lines is taken up in the measurement of the latitudinal li
which, in order to come within the rectangular limit, must
within 50 links of 80 chains in length, except in the west range

tions where the convergency of the meridional lines is regularly vided for; the accumulated error in alinement for the 5 miles of meridional line is taken up in the sixth mile, which is run dom and true; here the true line must be within 21′ of cardinal der to come within the rectangular limit. The slight, ordinary s in the measurement of the meridional section lines are taken y the adjustment of the bearings of the latitudinal section lines h, in order to come within the rectangular limit, must be within f cardinal; the accumulated error in measurement in running is placed in the last fractional half mile; here the meridional nce will be checked by a calculated closing around the last n, and the latitudinal error must not exceed 50 links (or $\frac{1}{640}$) er to come within the usual limits of closure. The accuracy of ubdivisional survey will everywhere be tested by the usual for limits of closure, hereinafter described. The surveyor d discriminate carefully between the limits for subdivision imits of closure and note with due respect that whereas the may admit of differences as great as 50 links in any one section, rmer are controlled by the limit of rectangularity and will be ded if the accumulative error is greater than 3½′ in alinement, links per mile in measurement. The accumulative error must be guarded against and avoided, and the order of survey is ed with a view to furnishing continuous checks upon the cy of all lines.

. Any random subdivisional line may be run for distance only the objective section corner is in sight, but the bearing will corded, and the usual rules for running random and true lines e duly observed in every other respect. The random latitudinal n lines, except in the west range of sections, will normally n from west to east, thus always closing upon a previously lished section corner; but when under the exigencies of the field in order to economize the time of his party, the surveyor may to project the random from east to west (always parallel to the boundary of the section), a temporary section corner (if the anent corner has not already been established) will be set at ains, and the true point for the section corner will be determined nal at the 80-chain point on the meridional section line, where- the connection of the random latitudinal line and the perma- marking of the true line will be completed as regularly provided. nples of the authorized rules for running subdivisional lines will found in the specimen field notes.

IRREGULAR BOUNDARIES.

183. Where either of the governing boundaries of a townshi[p] disqualified as a controlling line upon which to initiate a subdi[vi]sional survey, the necessary retracements and resurveys or alt[era]tions will be accomplished before subdividing as previo[usly] explained under the subject of township exteriors; thus may [be] assured every possible provision for a correct subdivisional su[rvey] except as either the south or the east boundary may be defectiv[e in] alinement and not subject to rectification.

SECTIONAL GUIDE MERIDIAN.

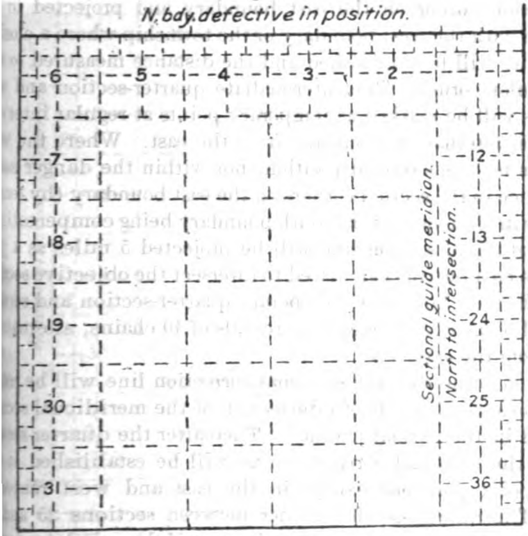
184. If the east boundary of the township is defective in al[ine]ment, and can not be rectified, and the north boundary is thus m[ade] defective in position, the first meridional section line will be [pro]jected on a true meridian to an intersection with the north boun[dary] of the township where a closing section corner will be establi[shed] and the distance measured to the nearest regular corner. The i[nter]mediate quarter-section and section corners will be establi[shed] alternately at regular intervals of 40 chains, counting from the so[uth] unless the south boundary of the township is itself defectiv[e in] alinement. Where the north boundary is not defective in posi[tion] (nor within the danger zone) with reference to the section co[rners] on the south boundary (by reason of the errors in the alineme[nt of] the east boundary being compensating), the first meridional sec[tion] line will be projected 5 miles as a true line on a bearing calculate[d 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 [cor]rected to a true line after the falling has been measured. [The] remaining meridional section lines will be run parallel to the first established, in the usual manner, to closing section corne[rs,] the last mile or random and true as the case may be.

The fractional measurements of the latitudinal section line[s of] the first range of sections will be placed in the east half mile; e[lse]where, unless the south boundary is defective in alinement, latitudinal section lines will be run in the usual manner.

SECTIONAL CORRECTION LINE.

185. If the south boundary of the township is defective in ali[ne]ment, and can not be rectified, and the west boundary is thus m[ade] defective in position, a sectional correction line will be surve[yed]

Fig. 41.


N. bdy. defective in position.
6
5
4
3
2
1
7
12
18
13
19
24
30
25
31
36
Sectional guide meridian.
North to intersection.
E. bdy. defective in alinement.

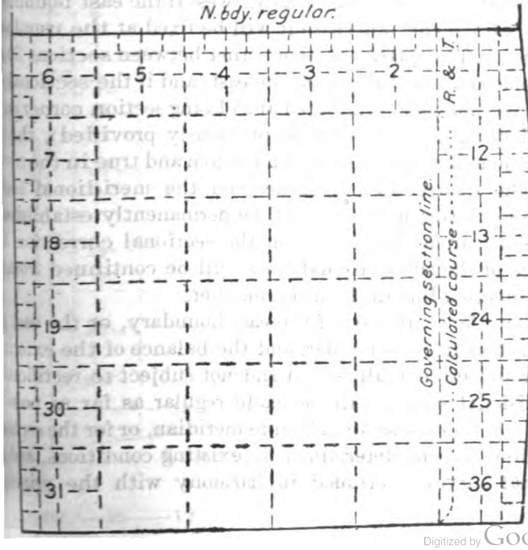

N. bdy. regular.
6
5
4
3
2
1
R. & T.
7
12
18
13
19
24
30
25
31
36
Governing section line.
Calculated course.
E. bdy. defective in alinement.

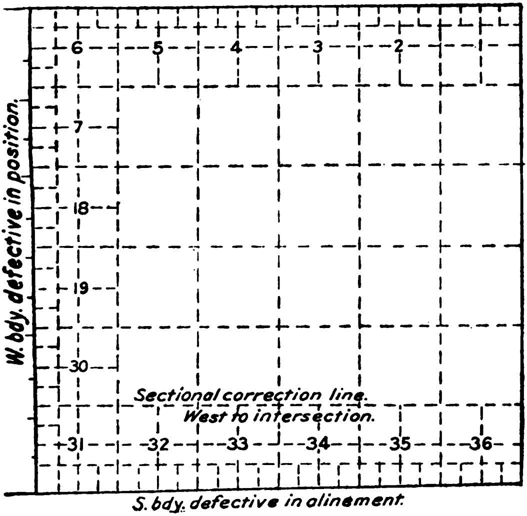
Fig. 42.

as a permanent line on a true latitudinal curve initiated at the fi regular section corner on the east boundary and projected to intersection with the west boundary of the township where a closi section corner will be established and the distance measured to t nearest regular corner. The intermediate quarter-section and s tion corners will be marked as temporary points at regular interv of 40 chains, alternately, counting from the east. Where the w boundary is not defective in position (nor within the danger zo with reference to the section corners on the east boundary (by rea of the errors in alinement of the south boundary being compensatin the first latitudinal section line will be projected 5 miles as a p manent line on a bearing calculated to intersect the objective sect corner on the west boundary; temporary quarter-section and sect corners will be marked at regular intervals of 40 chains, alternate counting from the east.

The section corners on the sectional correction line will be est lished at the several points of intersection of the meridional sect lines alined in the normal manner. Thereafter the quarter-sect corners on the sectional correction line will be established at usual mid-point positions except in the east and west range sections. The quarter-section corner between sections 25 and will be established at 40 chains from the west if the east boundar defective in alinement; otherwise it will be fixed at the usual m point position. The quarter-section corner between sections 30 31 will be placed at 40 chains from the east, and if the sectional rection line has not been terminated at a closing section corner on west boundary of the township (as previously provided), the between sections 30 and 31 will be run random and true in the nor manner. The quarter-section corners on the meridional sec lines in the south tier of sections will be permanently establishe 40 chains south from the corners on the sectional correction l The balance of the subdivisional lines will be continued from sectional correction line in the usual manner.

186. Where the south part of the east boundary, or the east of the south boundary, is regular, and the balance of the exteri found to be defective in alinement and not subject to rectificat the subdivisional survey will be made regular as far as possi The initial point for the sectional guide meridian, or for the secti ection line, will be determined by existing conditions, and livisional survey continued in harmony with the princi

Fig. 43.


W. bdy. defective in position.
6
5
4
3
2
1
7
18
19
30
Sectional correction line.
West to intersection.
31
32
33
34
35
36
S. bdy. defective in alinement.

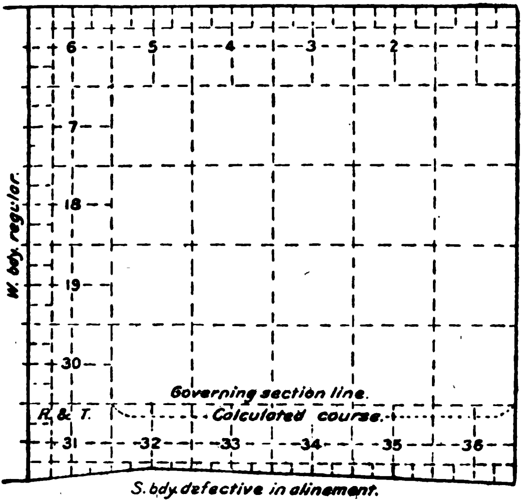

W. bdy. regular.
6
5
4
3
2
1
7
18
19
30
Governing section line.
R. & T.
Calculated course.
31
32
33
34
35
36
S. bdy. defective in alinement.

Fig. 44.

already outlined. Thus the first meridional section line would continued as a sectional guide meridian if the north part of the ea boundary is defective in alinement and the north boundary thereby made defective in position, but if the north boundary is n defective in position (nor within the danger zone) the first meridion section line should be continued on a course calculated to inters the objective section corner on the north boundary. The same pr ciple would be observed if the west part of the south boundary defective in alinement and the west boundary is not defective position (nor within the danger zone), but if the west boundary thus made defective in position the sectional correction line sho be established on the true latitudinal curve.

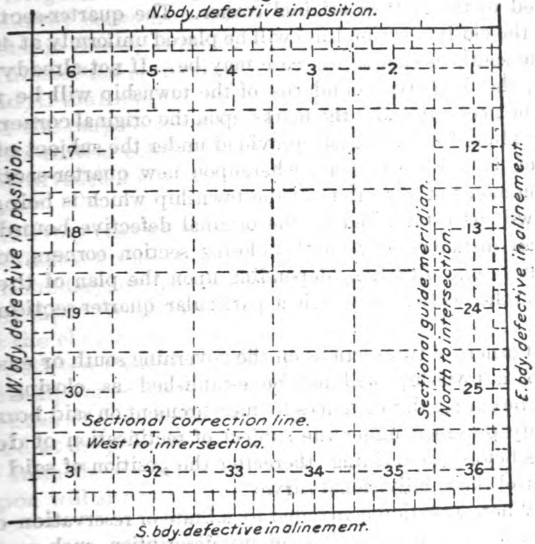
Under the provisions of the above paragraph it will be seen t the maximum number of normal sections are to be secured where condition of the governing boundaries warrants a combination of several general plans of subdivisional surveys. The sections adjo ing the east boundary may be considered regular to the full ext of their conformity with the usual rectangular limits, and wh such agreement obtains the quarter-section corners on the latitudi section lines will be placed at the normal mid-point position. T sections adjoining the south boundary of the township can not considered regular unless the meridional lines are established at chains in length, and the sections are otherwise in conformity w the usual rectangular limits; certain exceptions to this rigid requi ment will be noted under the subject of "fragmentary subdivisio

187. The field notes of subdivisional surveys embracing eithe sectional guide meridian, a sectional correction line, or other g erning section line, will be compiled in the same regular or heretofore described, but appropriate explanatory remarks will added indicative of the method and order of procedure.

CLOSING SECTION LINES.

188. In the event of defective north or west boundaries, not su ject to rectification, where the subdivisional lines can not be co nected with the previously established exterior section corne regularly by random and true lines not exceeding 21′ from cardi and at the same time not deviating more than 21′ from a line paral to the opposite (regular) boundary of the section, the normal po tions of the randoms will be made the true lines; a closing secti corner will then be established at the point of intersection of t

Fig. 45.


N. bdy. defective in position.
W. bdy. defective in position.
E. bdy. defective in alinement.
S. bdy. defective in alinement.
Sectional guide meridian.
North to intersection.
Sectional correction line.
West to intersection.
6
5
4
3
2
7
12
18
13
19
24
30
25
31
32
33
34
35
36

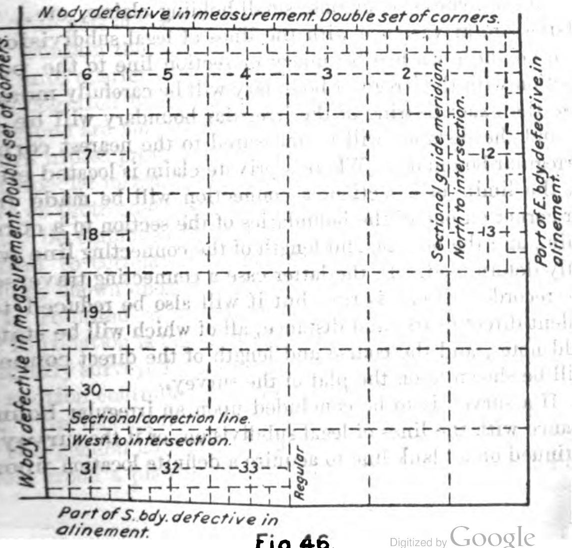

N. bdy defective in measurement. Double set of corners.
W. bdy. defective in measurement. Double set of corners.
Part of E. bdy. defective in alinement.
Part of S. bdy. defective in alinement.
Sectional guide meridian.
North to intersection.
Sectional correction line.
West to intersection.
Regular
6
5
4
3
2
7
12
18
13
19
30
31
32
33

Fig. 46.

section line with the original boundary, and the distance will measured to the nearest original corner. The quarter-section c ners on the closing section lines will be placed uniformly at 40 cha from the south or east as the case may be. If not already acco plished, the defective boundaries of the township will be retrac as may be necessary, and the marks upon the original corners app priately altered as previously provided under the subject of rect cation of defective exteriors, whereupon new quarter-section c ners, common to the sections of the township which is being sub vided, will be established on the original defective boundarie the mean distance between the closing section corners, or at chains from one direction, depending upon the plan of the sub vision of the section to which a particular quarter-section cor belongs.

189. Corners of two sections on the governing south or east bo daries of a township will not be established as closing sect corners, but at regular distances by measurement on said bounda as already provided under the subject of rectification of defect exteriors before subdividing; thereafter the position of said cor will control the subdivisional survey.

190. Where a section is invaded by a State or reservation or g boundary, or by a private claim of any description, such as min claims, forest-homestead claims, small-holding claims, etc., wh boundaries are at variance with the lines of legal subdivision, distance on the township boundary or section line to the poin intersection with the irregular boundary will be carefully measu likewise the exact bearing of the irregular boundary will be de mined and the distance will be measured to the nearest corne such irregular boundary. Where a private claim is located enti within the limits of a section, a connection will be made fro regular corner on one of the boundaries of the section to a corne the claim, and the bearing and length of the connecting line wil carefully determined. In the latter case a connecting traverse will be recorded, if one is run, but it will also be reduced to equivalent direct course and distance, all of which will be state the field notes, and the course and length of the direct connec line will be shown upon the plat of the survey.

191. If a survey is to be concluded upon an irregular bound at variance with the lines of legal subdivision, or if the survey i be continued on a blank line to acquire a definite location upon

osite irregular boundary, but without monumenting the rec-
gular survey between such irregular boundaries, a closing town-
or section corner, as the case may be, will be required at the
t of intersection of the regular with the irregular line. On the
r hand, if the survey is not to be so concluded, but is to be con-
ed for the purpose of establishing a full complement of section
quarter-section corners for the control of the subdivision of a
on so invaded by a private claim, no closing corner will be
ired.

2. In every case where a closing township or section corner is
established upon a standard parallel, State, reservation, grant,
im boundary, or upon an irregular section line or exterior, the
closed upon (if the latter was not established by the surveyor
runs the closing line, or if not already retraced by him), will be
ced between the first corners to the right and left of the point
e closing corner, in order to determine the exact alinement of
ine closed upon, to the end that the closing corner may be
lished at the precise point of intersection of the two lines. The
nce from the closing corner to the nearest corner on the line
d upon will always be measured and recorded.

SUBDIVISION OF SECTIONS.

3. The acts of Congress approved February 11, 1805, and April
32, contain the fundamental provisions for the subdivision of
ons into quarter sections and quarter-quarter sections; the prin-
s recognized by law have already been stated in Chapter I.
sections are not subdivided in the field by the United States
yors unless provision therefor is specifically mentioned in the
en special instructions, but certain subdivision-of-section lines
lways protracted upon the official plats, and the local surveyor
may be employed by entrymen to run said lines in the field is
pelled to correlate the conditions as found upon the ground
those shown upon the approved plat. The United States sur-
r is required to so establish the official monuments that a
er foundation is laid for the subdivision of the section, whereby
officially surveyed lines may be identified and the subdivision
he section controlled as contemplated by law.

4. The rectangular system provides for the unit of disposal
er the general land laws, broadly, the quarter-quarter section of
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 tow ship of 36 sections. All agricultural entries are based upon descr tions in accordance with legal subdivisions shown upon the cial plat. The plats are constructed in harmony with the offi field notes returned by the surveyor. The land included in entry is identified on the ground by fixed monuments establis by the surveyor. A United States land patent grants to the en man a title of ownership to a tract defined by certain fixed mo ments on the ground and related by description and outline to official plat. The function of the United States surveyor has fulfilled when he has properly executed and monumented his sur and returned an official record thereof in the shape of comp detailed field notes and a plat. The function of the local surve begins when he is employed as an expert to identify the lands w have passed into private ownership; this may be a simple or a complex problem, depending largely upon the condition of original monuments as affected principally by the lapse of time s the execution of the official survey. The work of the local surve usually includes the subdivision of the section, already mentio as the official unit of subdivision, into the fractional parts sh upon the approved plat. In this capacity the local surveyor is forming a function contemplated by law, and he can not prop serve his client or the public unless he is familiar with the requirements concerning the subdivision of sections. In the e that the original monuments have become lost the surveyor not hope effectively to recover said corners without a full un standing of the record concerning their original establishment, can the surveyor hope legally to restore the same until he mastered not only the principles observed in the execution of original survey, but the principles upon which the courts hav jurisdiction over such matters have based their rulings.

195. The General Land Office assumes no control or direct over the acts of local and county surveyors in the matters of s division of sections and reestablishment of lost corners of orig surveys where the lands have passed into private ownersh nor will it issue instructions in such cases. It follows general rule that disputes, arising from uncertain or erroneous lo tion of corners, originally established by the United States, are be settled by the proper local authorities or by amicable adjustme and the office desires that the rules controlling the acts of its o surveying service be considered by all other surveyors as mer

ory and explanatory of the principles which should prevail in
ming such duties.

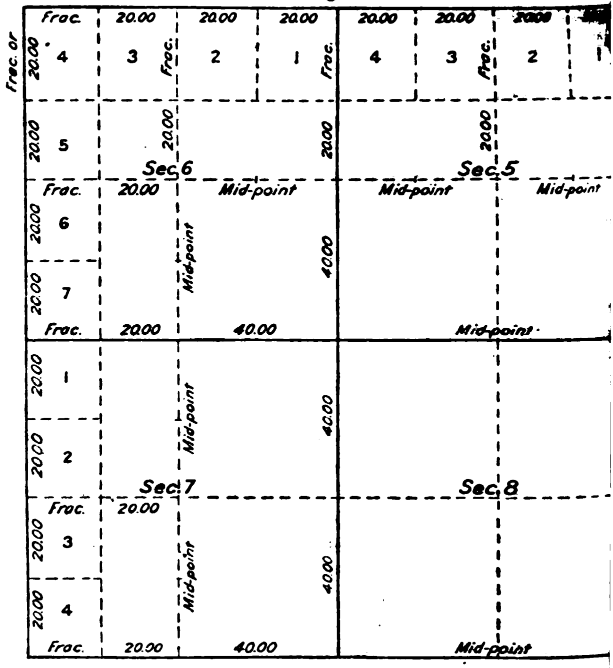
e subject of restoration of lost corners will be treated in a
chapter, as the purpose here is to outline the principles con-
ng the subdivision of sections, which will be recognized alike
e General Land Office surveying service and by all local sur-
s.

SUBDIVISION BY PROTRACTION.

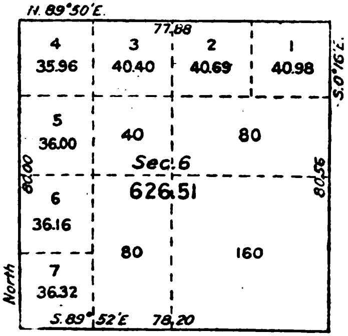
. Upon the plat of all regular sections the boundaries of the
r sections are shown by broken straight lines connecting the
ite quarter-section corners. The sections bordering the north
est boundaries of a normal township, excepting section 6,
rther subdivided by protraction into parts containing two regu-
lf-quarter sections and four lots, the latter containing the frac-
areas resulting from the plan of subdivision of normal town-
the lines of the half-quarter sections are protracted from three
20 chains distant from the line connecting the opposite
r section corners, two of said distances counting on the oppo-
ction lines and one counting on the line between the fractional
r sections; the lines subdividing the fractional half-quarter
s into the fractional lots are protracted from mid-points on
posite boundaries of the fractional quarter section. The two
r sixteenth-section corners on the boundaries of the fractional
est quarter of section 6 are similarly fixed at points 20 chains
t north and west from the center of the section, from which
lines are protracted to corresponding points on the west and
boundaries of the section, resulting in subdivisions containing
gular quarter-quarter section and three fractional lots. The
al lots herein described will be numbered in a regular series
sively from east to west or from north to south, in each sec-
As section 6 borders on both the north and west boundaries
township, the fractional lots in the same will be numbered
ncing with No. 1 in the northeast, thence progressively west
4 in the northwest, and south to No. 7 in the southwest frac-
quarter-quarter section.

ymen are allowed, under the law, to acquire title to any
r quarter-quarter section, but as such subdivisions are aliquot
of quarter sections based upon mid-point protraction, it is not
d necessary to indicate these lines upon the official plat.

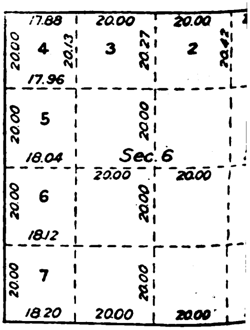
Fig. 47.



Showing normal subdivision of sections.



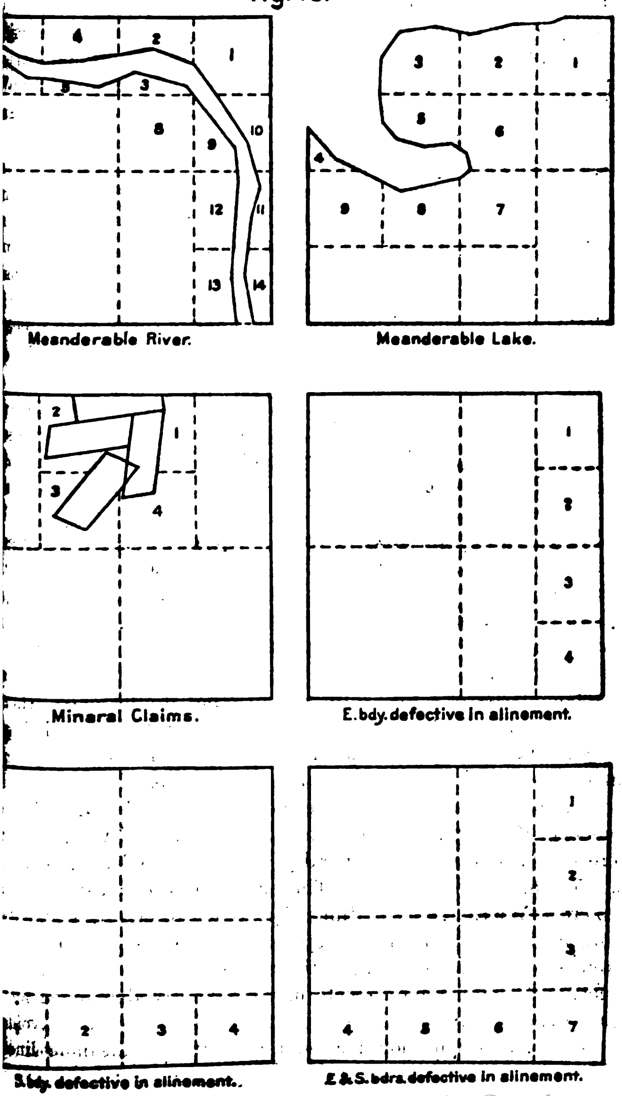
Showing areas.



Showing calculated dista[nces]

Examples of subdivision by protraction.

Fig. 48.



Examples of subdivision of fractional sections.

197. Sections which are invaded by meanderable bodies of wa[ter] or by approved claims at variance with the regular legal subdivisi[ons] are subdivided by protraction into regular and fractional parts [as] may be necessary to form a suitable basis for the entry of the pub[lic] lands remaining undisposed of, and to describe the latter separat[ely] and apart from the segregated areas.

The meander line of a body of water and the boundary line[s of] private claims are platted in accordance with lines run or con[nec]tions made in the field; thereupon the sections so invaded are s[ub]divided as nearly as possible in conformity with the uniform p[lan] already outlined. The subdivision-of-section lines are termin[ated] at the meander line or claim boundary, as the case may be, but [the] position of the subdivision-of-section lines is controlled preci[sely] 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 priv[ate] claim, the said fractional section lines are, for the purpos[e of] uniformity, completed in theory, and the protracted positio[n of] the subdivision-of-section lines is controlled by the theoret[ical] points so determined.

198. In the subdivision of fractional sections as many reg[ular] parts should be secured as possible, except to avoid thus creat[ing] poorly shaped fractional lots. Skill and judgment must be exerci[sed] to accomplish a subdivision which embraces simplicity of plat[ting] as well as a form to each and every lot that will prove to be equita[ble] to the entryman. In the case of fractional lots along the north [and] west boundaries of a township, and in other similar cases whe[re a] lot has a full normal width of 20 chains in one direction, it is g[en]erally advisable to avoid areas of less than 10 or more than 50 ac[res]; but in the instance of fractional lots along a meander line or o[ther] irregular broken boundary, where the width of the lot in both di[rec]tions may be considerably less than 20 chains, resulting in tract[s of] more compact form, it is generally better to avoid an area of l[ess] than 5 or more than 45 acres. The purpose of the aforestated lim[its] is to create fractional lots of dimensions that will facilitate all ent[ries] being made in a form that is optional with the entryman; an[d ad]herence to this practice will greatly reduce the necessity for the co[n]struction of supplemental plats now frequently demanded for [that] other purpose. Extreme lengths or narrow widths should be avoid[ed]; longer direction should extend back from a meander line ı boundary rather than along the same. It is inconsistent that :tional lot lie partly in two sections, and it is generally better, ı consistent with other rules, to avoid fractional lots extending one into another fractional quarter section.

). To secure a uniform system for numbering lots of fractional ons, including those above specified, imagine the section ed by parallel latitudinal lines into tiers, numbered from to south; then, beginning with the eastern lot of the north call it No. 1, and continue the numbering west through the then east in the second, west in the third, east in the fourth etc., until all fractional lots have been numbered. A lot exng north and south through two, or part of two tiers, will be ered in the tier containing its greater area. In case any tier is ut numbered lots, the numbering will be continued in the tier to the south. This method of numbering will apply to art of a section. A section that has been partly surveyed at ent times should have no duplication of lot numbers.

). When, by reason of irregular surveys or from other causes, ngth of a township from south to north exceeds the regular ı of 480 chains, or the width from east to west exceeds 480 s, to such an extent as to require two or more tiers of lots along orth boundary, or two or more ranges of lots along the west lary, as the case may be, the entire north or west portions of ections beyond the regular legal subdivisions usually provided se sections, will be suitably lotted, and to each lot will be ed a proper number. Certain exceptions to this rule will be in Chapter VII, in the instance of townships which possess mal dimensions in one or both directions.

. If the first meridional section line of a township has been ished as a sectional guide meridian, or the first latitudinal n line has been established as a sectional correction line, onal lots will result along the east or south boundary of the hip, as existing conditions may necessitate. Thus, where the east or south boundaries of a township are defective in nent (and not subject to rectification before subdividing) the ns bordering such defective boundaries will be subdivided by ction in accordance with rules similar to those which operate ard to sections bordering the north and west boundaries of a al township. Other examples of subdivision of sections will be l under the general subject of "fragmentary subdivision."

SUBDIVISION BY SURVEY.

202. The rules for subdivision of sections by actual survey in field are based upon the laws governing the survey of the public lar When cases arise which are not covered by these rules, and advice of the General Land Office in the matter is desired, the le of inquiry should, in every instance, contain a description of particular tract or corner, with reference to township, range section of the public surveys, to enable the office to consult record; also a diagram showing conditions found, giving dista in chains and links and not in feet.

203. Preliminary to subdivision it is essential to know the ac boundaries of the section, as it can not be subdivided legally u the section corners and quarter-section corners have either l found or restored by proper methods, and the resulting courses distances determined by survey. The practice of entering a sec to survey a tract from only one or two corners, and those per unreliable, is unlawful.

204. The order of procedure is: First, identify or reestablish boundary corners; next, fix the lines of quarter sections; then, smaller tracts by equitable and proportionate division, accor to the following rules:

205. *Subdivision of sections into quarter sections.*—Under provisions of the act of Congress approved February 11, 1805, course to be pursued in the subdivision of sections into quarter tions is to run straight lines from the established official qua section corners to the opposite corresponding corners. The poi intersection of the lines thus run will be the corner common to several quarter sections, or, in other words, the legal center of section.

Upon the lines closing on the north and west boundaries regular township the quarter-section corners are established by United States surveyors at 40 chains to the north or west of the interior section corners, and the excess or deficiency in the meas ment is thrown into the half mile next to the township or range l as the case may be.

Where there are double sets of section corners on township range lines the quarter-section corners for the sections south of township lines and east of the range lines have not always b established in the field by the United States surveyors, but in dividing such sections said quarter-section corners should b as to suit the calculations of the areas of the quarter sections ng the township boundaries as expressed upon the official dopting proportionate measurements where the new measure- of the north or west boundaries of the section differ from the l measurements.

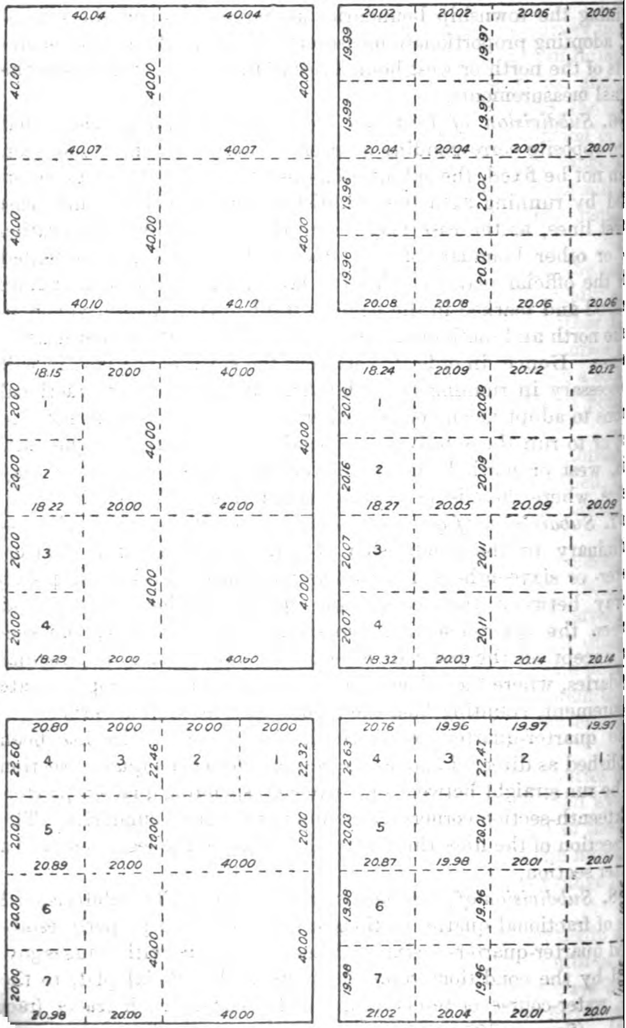
Subdivision of fractional sections.—The law provides that opposite corresponding quarter-section corners have not been not be fixed, the subdivision-of-section lines should be ascer- by running from the established corners north, south, east ; lines, as the case may be, to the water course, reservation r other boundary of such fractional section, as represented he official plat. In this the law presumes the section lines ed and marked in the field by the United States surveyors to north and south or east and west lines, but this is not usually e. Hence, in order to carry out the spirit of the law, it will essary in running the subdivisional lines through fractional s to adopt mean courses, where the section lines are not due r to run the subdivision-of-section lines parallel to the east, west or north boundary of the section, as conditions may , where there is no opposite section line. (See sec. 197.)

Subdivision of quarter sections into quarter-quarter sections.— inary to the subdivision of quarter sections, the quarter- r- or sixteenth-section corners will be established at points y between the section and quarter-section corners, and n the quarter-section corners and the center of the sec- xcept on the last half mile of the lines closing on irregular aries, where they should be placed at 20 chains, proportionate ement, counting from the regular quarter-section corner.

quarter-quarter- or sixteenth-section corners having been shed as directed above, the center lines of the quarter section run straight between opposite corresponding quarter-quarter- eenth-section corners on the quarter-section boundaries. The ction of the lines thus run will determine the legal center of a r section.

. *Subdivision of fractional quarter sections.*—The subdivisional f fractional quarter sections will be run from properly estab- quarter-quarter- or sixteenth-section corners, with courses gov- by the conditions represented upon the official plat, to the water-course or reservation which renders such tracts frac- . (See sec. 197.)

Fig. 49.



Official measurements. Remeasurements.

above examples of subdivision by survey show the relation of the official meas[urem]ents and calculated distances to the remeasurements, and indicate the prop[orti]onal distribution of the differences.

By "proportionate measurement" is meant a measurement the same ratio to that recorded in the original field notes as gth of the line by re-measurement bears to its length as given record. Reasonable discrepancies between former and new ements may generally be expected. Errors may occur through auses and should be as carefully avoided in re-measurements riginal surveys. Instead of the old practice of "adjusting in" to suit the former measure, the distance obtained by se method is compared with that of the record, and the or surplus is computed by proportion, producing the same a more reliable manner. For example: The length of the n the quarter-section corner on the west boundary of section north line of the township, by the United States surveyor's ment was reported as 43.40 chains, and by the county sur-measurement was found to be 42.90 chains; then the distance the quarter-quarter- or sixteenth-section corner should be north of the quarter-section corner would be determined by ion as follows: As 43.40 chains, the official measurement of le distance, is to 42.90 chains, the county surveyor's measure-the same distance, so is 20 chains, original measurement, to ains by the county surveyor's measurement, showing that ortionate measurement in this case the quarter-quarter- or h-section corner should be set at 19.77 chains north of the section corner, instead of 20 chains north of said corner, as ted on the official plat. In this manner the discrepancies original and new measurements are equitably distributed.

By way of recapitulation it should be emphasized that when n have acquired title to certain legal subdivisions they have the owners of the identical ground area represented by the bdivisions upon the official plat. It is a matter of expert or l procedure to mark out the legal subdivisions called for in t, and entrymen are advised that a competent surveyor be employed. The surveyor must necessarily identify the boundaries and locate the legal center of the section in order to ne the boundaries of a quarter section. Then, if the boun-f quarter-quarter sections, or fractional lots, are to be deter-n the ground, the boundaries of the quarter section must be d, and the sixteenth-section corners thereon should be fixed dance with the proportional distances represented upon the d plat, thereupon the legal center of the quarter section may be duly located. Thus will be produced in the field the fi represented upon the plat, every part of the former in true pro tion to the latter, where the elements of absolute distance and have given away to corresponding proportional units as define fixed monuments established in the original survey.

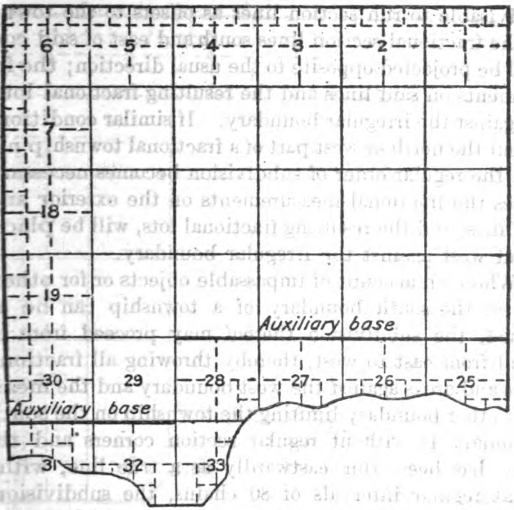
FRAGMENTARY SUBDIVISION OF TOWNSHIPS.

211. In the preceding articles covering the subject of subdivi of townships every assumption was based upon initiating the divisional survey upon regularly established exteriors, or, w necessary, a sectional guide meridian or a sectional correction l or both, were to be established, upon which rested the contr the subdivision of the township. The subdivision of every township may always be governed by the aforestated rules, but m other factors operate in determining the method and order of cedure to be adopted in the instance of fractional townships w have no linear south or east boundary, or in the case of contin with the survey of partially subdivided townships, where one or i of the previously established section lines may be found to be fective in respect to the rectangular limit, or where partially veyed sections, or sections containing outlying areas protracte surveyed, are to be completed. The surveyor can not hop master the subject of fragmentary subdivision of townships u he has become thoroughly familiar with every question relatin the subdivision of sections, nor is it possible to give in the Ma an example of every intricate problem which may be encount in the field; thus the following discussion deals primarily with principles, which must be considered in the field, operatin control the surveyor's method and order of procedure. It is possi however, that cases may arise so complex in their character a produce a feeling of doubt relative to the proper solution of the p lem; in which case the surveyor will at once communicate with proper supervising officer, submitting information, by letter diagram, of the exact condition as found by him, and the neces instructions will be forwarded as soon as practicable.

FRACTIONAL TOWNSHIPS.

212. Where by reason of the presence of a large meander body of water, impassable objects, a State or reservation or g boundary, or for other similar reasons a township is made fracti

Fig. 50.


6
5
4
3
2
7
18
19
Auxiliary base
30
29
28
27
26
25
Auxiliary base
31
32
33

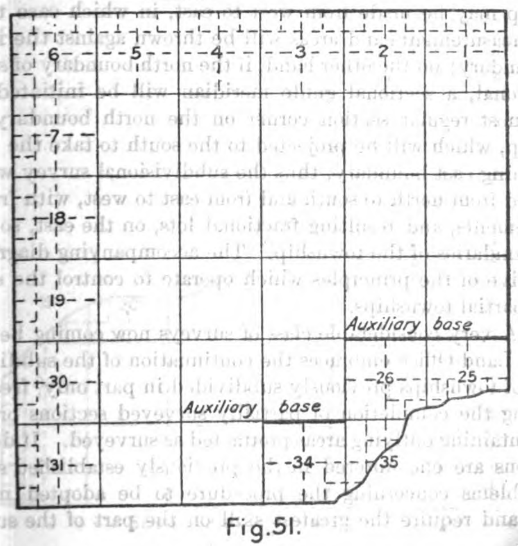

6
5
4
3
2
7
18
19
Auxiliary base
30
26
25
Auxiliary base
31
34
35

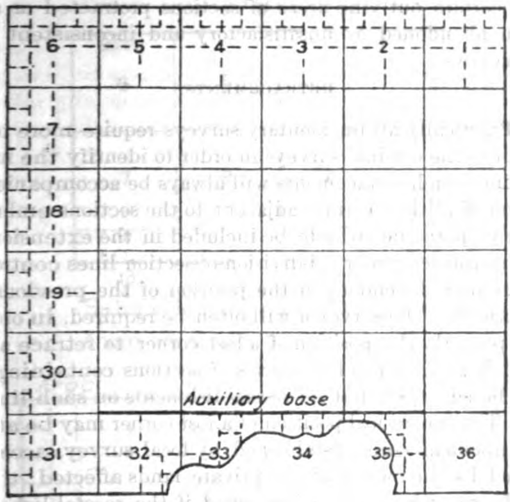
Fig. 51.

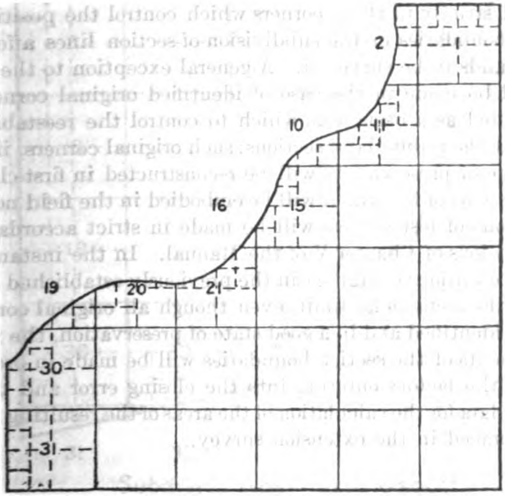
and is without a full linear south or east boundary, and it has bee found advisable to run section lines as offsets to the township ex teriors, the fractional section lines south and east of said controllin lines will be projected opposite to the usual direction; the fraction measurements on said lines and the resulting fractional lots will l placed against the irregular boundary. If similar conditions obta throughout the north or west part of a fractional township no depa ure from the regular order of subdivision becomes necessary; in such cases the fractional measurements on the exterior and sub visional lines, and the resulting fractional lots, will be placed to t north and west against the irregular boundary.

213. Where on account of impassable objects or for other reas no part of the south boundary of a township can be regula established, the subdivision thereof may proceed from north south and from east to west, thereby throwing all fractional me urements and areas against the west boundary and the meander stream or other boundary limiting the township on the south; if east boundary is without regular section corners and the no boundary has been run eastwardly as a true line, with sect corners at regular intervals of 80 chains, the subdivision of township may be made from west to east, in which case the fr tional measurements and areas will be thrown against the irreg east boundary; on the other hand, if the north boundary of sectio is fractional, a sectional guide meridian will be initiated at easternmost regular section corner on the north boundary of township, which will be projected to the south to take the place a governing east boundary, thus the subdivisional survey would projected from north to south and from east to west, with fractio measurements, and resulting fractional lots, on the east, south west boundaries of the township. The accompanying diagrams illustrative of the principles which operate to control the subdi sion of partial townships.

214. A very considerable class of surveys now coming before t General Land Office embraces the continuation of the subdivision survey of townships previously subdivided in part only, frequen including the completion of partially surveyed sections or of s tions containing outlying areas protracted as surveyed. If defecti conditions are encountered in the previously established survey the problems concerning the procedure to be adopted multip rapidly and require the greatest skill on the part of the survey

Fig. 52.





Subdivide Regularly.

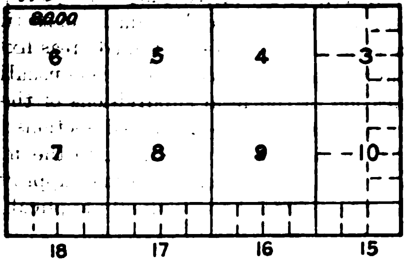
Fig. 53.

In the construction of new township plats the former practi showing certain outlying areas of sections protracted as surv has been abandoned as unsatisfactory and inconsistent witl surveying laws.

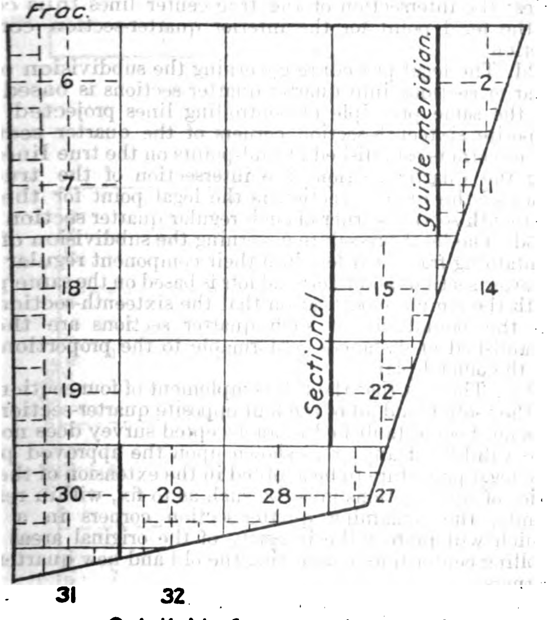
RETRACEMENTS.

215. Practically all fragmentary surveys require more or le tracement of the original surveys in order to identify the initia closing lines; such retracements will always be accompanied b restoration of all lost corners adjacent to the sections embraci whole or in part, the areas to be included in the extension su in-so-far as the section or subdivision-of-section lines controllin new areas may depend upon the position of the previously lished corners. The surveyor will often be required, in order termine properly the position of a lost corner, to retrace addi lines which are not the boundaries of sections containing th areas to be surveyed, but no reestablishments on such lines quired. The theoretical position of a lost corner may be at va with an unofficial corner established by local survey, accepte recognized by the owners of the private lands affected; thus trouble between landowners is avoided if the reestablishmen confined strictly to those corners which control the position section boundaries or the subdivision-of-section lines affecti public lands to be surveyed. A general exception to the for rule will be made in the case of identified original corners are adopted as a basis from which to control the reestablish bordering the public land sections; such original corners, if n good state of preservation, will be reconstructed in first-class a complete record of which will be embodied in the field note restorations of lost corners will be made in strict accordanc the provisions of Chapter V of the Manual. In the instance fective conditions contained in the previously established lin ceeding the rectangular limit, even though all original corne be fully identified and in a good state of preservation, the nec retracements of the section boundaries will be made in order termine the factors entering into the closing error and to f suitable data for the calculation of the areas of the resulting fra 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 co pletion of the survey of portions of boundaries of sections heretof unsurveyed, in which sections are contained areas fixed in posit by less than the regular complement of corners usually establisl for the identification of the legal subdivisions of the section. the completion of such partially surveyed sections, the surve will be expected to give full consideration to the manner of p tecting acquired rights based upon the former approved plats.

The following ten principles are distinctly applicable to the s ject:

1st. The legal procedure governing the subdivision of normal section into quarter sections is based broadly on principle that the partition lines may be definitely fixed four opposite quarter-section corners established on its bou aries; the intersection of the true center lines thus control is the legal point for the interior quarter-section corner c section.

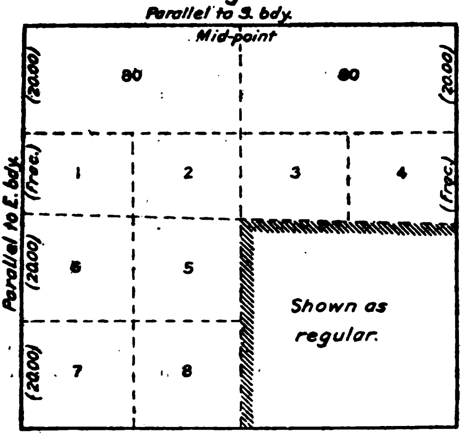
2d. The legal procedure governing the subdivision of regu quarter sections into quarter-quarter sections is based broa on the same principle of controlling lines projected betw opposite sixteenth-section corners of the quarter section, latter corners established at mid-points on the true lines bou ing the quarter section; the intersection of the true cer lines of the quarter section is the legal point for the inte sixteenth-section corner of such regular quarter section.

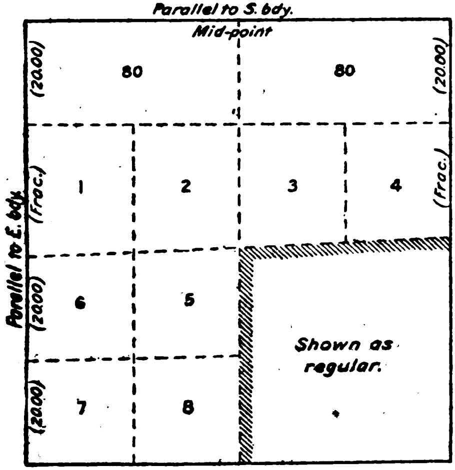
3d. The legal procedure governing the subdivision of secti containing fractional lots into their component regular quar quarter sections and fractional lots is based on the same princi with the simple modification that the sixteenth-section cor on the boundaries of such quarter sections are themsel established at distances conformable to the proportions sho on the official plat.

4th. The fact that the full complement of four section cor of the section and all of the four opposite quarter-section cor has not been established in an accepted survey does not imp the validity of any areas shown upon the approved plat, the legal procedure to be adopted in the extension of the bou aries of such sections must be such as to fix, within reasona limits, the remaining quarter-section corners in a posit which will protect the integrity of the original areas by c trolling center lines connecting the old and new quarter-sect corners.

5th. In the rectangular system the section is recognized the unit of subdivision, and in proceeding with the extens of fragmentary surveys first consideration must necessarily

Fig. 56.





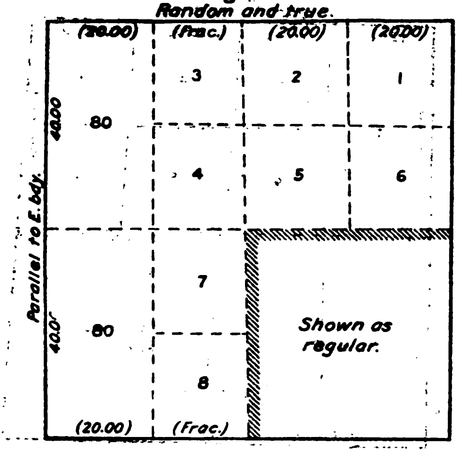
boundary of section out of limits in measurement; southeast quarter protracted as surveyed; and section to be completed given to the completion of the survey of fractional sectic No invasion of the original unit is tolerable if any portion such unit has been surveyed, or if outlying areas have b shown protracted as surveyed.

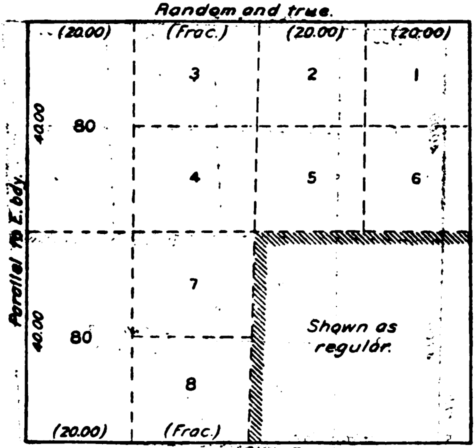
6th. "Reasonable limits" for the fixation of the remain quarter-section corners of a section in a position which protect the integrity of the original areas of such section n be considered such as for alinement when not to exceed from a cardinal course, and for measurement when not to exc 25 links from 40 chains where the opposite portion of the sec boundary is shown as 40 chains, or in proportion as a limi difference when the opposite portion of the section is mor less than 40 chains. This concession as to limits is mad the interest of simplicity, where by such concession recta larity of both the old and new surveys may be maintaine so harmonized.

7th. The position of the new quarter-section corner whi to be established on the new opposite boundary of a fracti section will be controlled from one direction only if the opposite distance has been made to count from one dire only, and the controlling measurement will be made to ha nize with the length of the opposite portion of the section if the old opposite distance has been made to count from directions the position of the new quarter-section corner be controlled from the two directions and the proport lengths of the two portions of the new line will be ma harmonize with the proportional lengths of the two pa the old opposite boundary, all as indicated by the dist and areas shown on the original approved plat.

8th. The underlying principles governing the rectan surveying system are equally applicable to the completi the survey of fractional sections, and given a condition i original survey which in all its various elements is "w limits" within the meaning of the rectangular surveys simple plan of continuing in the same manner and ord would have been adopted in the original survey, if the had not been discontinued, will accomplish usually i simplest form the completion of the survey of fractional sect this becomes the first duty of the surveyor before proce with the survey of additional sections, so that should irregul be developed, no invasion of partially surveyed sections result from the irregularities of other sections. It follo principle, when irregularity is developed, that the surv will be best prepared to determine the proper method of su adapted to procure simplicity of correction of existing ir larities and an early resumption of regularity, when he possession of full data concerning the conditions of all th lines limiting the fragmentary surveys and upon which new lines are to be initiated or closed, his knowledge b based upon the results of actual retracement of such irre

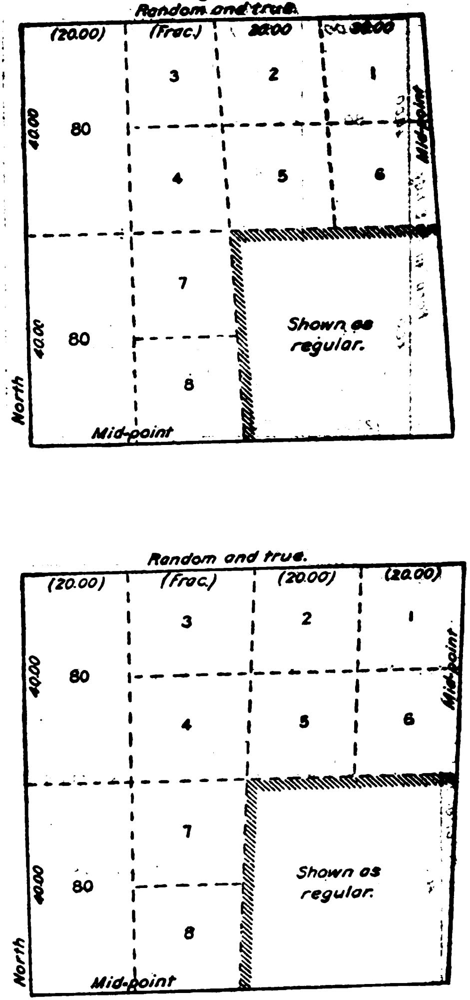
Fig. 57.





boundary of section out of limits in measurement; southeast quarter protracted as surveyed; and section to be completed.

Fig. 56.



East boundary of section out of limits in alinement; southeast quarter protra
as surveyed; and section to be completed.

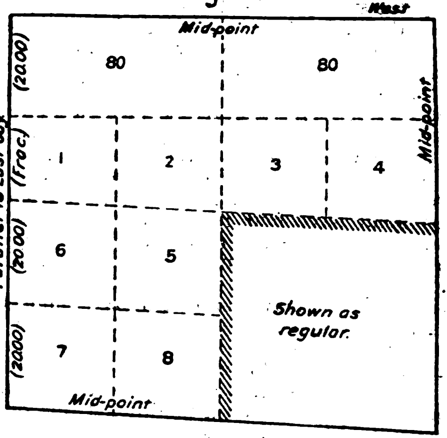
old lines. It must be granted that a skillful exercise of judgment by the surveyor based upon his knowledge of the facts is far more desirable than to restrict him to the application of empirical rules devised to cover possible, but innumerable combinations of irregularity.

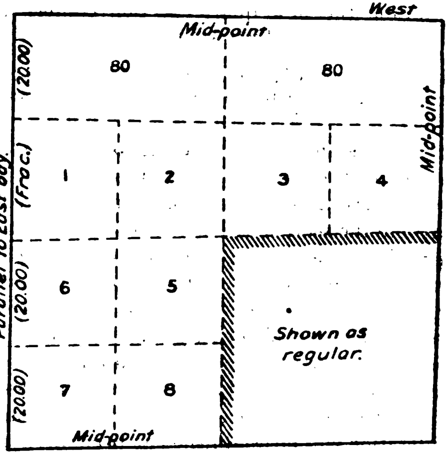
9th. The completion of the survey of the partially surveyed sections will be made as nearly as possible in accordance with the regular rules for subdividing when the original lines are found to be within limits, otherwise, such sections will be completed by surveying all lines in such a manner that each 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.

7. Let it be assumed that adjacent to two established section , the *meridional* line of which is out of limits in measurement, tlying regular quarter section has been protracted as surveyed; to complete the section the new section lines will be extended the previously established section corners, parallel to the site established boundaries, or mean course thereof, to a mutual section. The quarter-section corner on the new latitudinal on line would be established regularly at the mean point, and ld ordinarily be marked to control the subdivision of two sections. he new meridional boundary one or two quarter-section corners be required; one marked to control the subdivision of the section er consideration will be established at 40 chains from the original ion corner; the same quarter-section corner would be marked to rol the subdivision of the adjoining section if the fractional

Fig. 59.



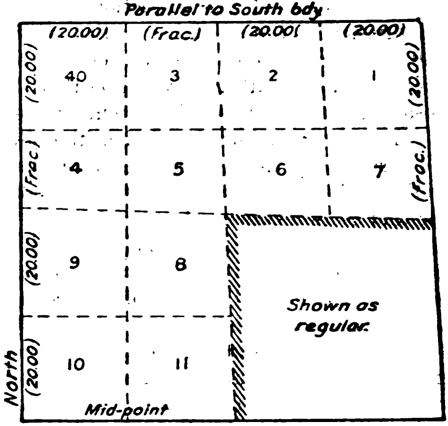


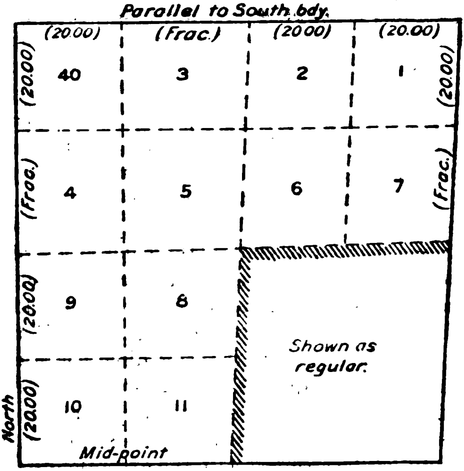
South boundary of section out of limits in alinement; southeast quarter pr
as surveyed; and section to be completed.

easurement is to be thrown in the same direction in the two secons, otherwise an additional quarter-section corner marked to ntrol the subdivision of the adjoining section would ordinarily placed at 40 chains from the new section corner. Again, let the me condition be assumed with the exception that the *latitudinal* ction line instead of the meridional line is found to be defective in easurement. Then, to complete the section, the new meridional le would be surveyed as in regular subdivision, parallel to the posite meridional line, or mean course thereof, ordinarily with arter-section and section corners of maximum control at 40 and chains, respectively. The new latitudinal section line would then established on a true line between the section corners, and one or o quarter-section corners will be established as required; one rked to control the subdivision of the section under consideration ll be established at 40 chains from the original section corner; the me quarter-section corner would be marked to control the subision of the adjoining section if the fractional measurement is be thrown in the same direction in both sections, otherwise an ditional quarter-section corner marked to control the subdivision the adjoining section would ordinarily be placed at 40 chains from e new section corner.

218. Let another assumption be made that adjacent to two estabhed section lines, the *meridional* line of which is out of limits in sement, an outlying regular quarter section has been protracted surveyed; then to complete the section, the new meridional line ll be projected as a sectional guide meridian, in accordance with e usual rules, ordinarily with quarter-section and section corners maximum control at 40 and 80 chains, respectively. The new itudinal section line would then be established on a true line tween the section corners, with one or two quarter-section corners required; one marked to control the subdivision of the section der consideration will be required at 40 chains from the original ction corner; the same quarter-section corner would be marked control the subdivision of the adjoining section if the fractional easurement is to be thrown in the same direction in both sections; herwise an additional quarter-section corner marked to control e subdivision of the adjoining section will ordinarily be established 40 chains from the new section corner. On the other hand, if e same conditions be assumed with the exception that the original *itudinal* section line instead of the meridional line is found to be

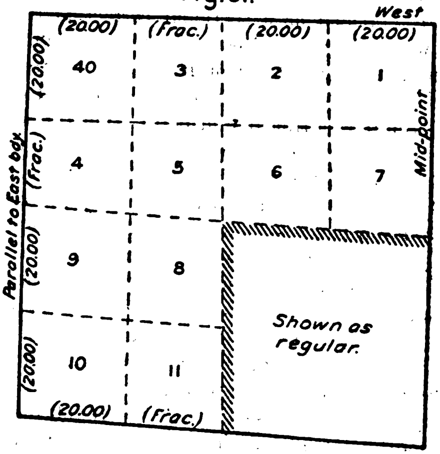
Fig. 60.

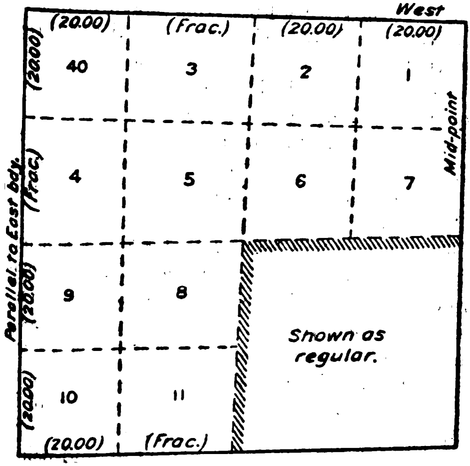




East boundary of section out of limits in alinement and measurement; south quarter protracted as surveyed; and section to be completed.

Fig. 61.





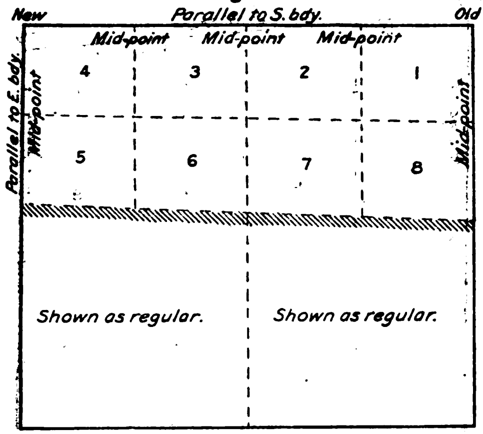
undary of section out of limits in alinement and measurement; southeast quarter protracted as surveyed; and section to be completed.

defective in alinement, then the new latitudinal section li have to be established as a sectional correction line, exa accordance with the rules already given for running such ordinarily with section corner of maximum control at it section with the new meridional section line, and quarter- corner of maximum control at mid-point. On the new me section line one or two quarter-section corners may be re one marked to control the subdivision of the section under eration will be established at 40 chains from the original corner; the same quarter-section corner may be marked to the subdivision of the adjoining section if the fractional n ment is to be placed in the same direction in the two secti if the fractional measurement is to be thrown in the opposite d in the adjoining section an additional quarter-section corner to control the subdivision of that section would ordinaril quired at 40 chains from the new section corner.

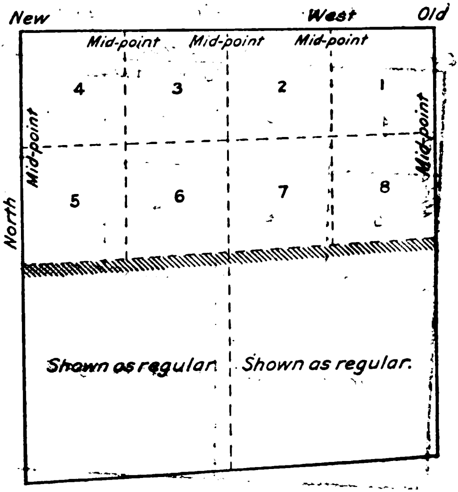
219. Many cases will arise in the field involving comb of two or more of the above simple examples, in which the surveyor is advised to prepare a diagram illustrating t ditions found in the original survey, whereupon the new lines may be shown with alinement in accordance with th rules for subdividing townships, noting that the new secti are to be initiated at the previously established original corners, and that the *length* of the meridional boundary will both upon the regularity of the length of the opposite origina ional section line and upon the alinement of the previous lished latitudinal section line; thereupon the surveyor may show upon his diagram the position of the necessary quarte corners on the new section lines, all in conformity with the rules already stated.

220. Other instances will be found where half sections ar upon the original approved plat protracted as surveyed, cases where only the opposite section line has not been est and in other cases where parts of the adjacent as well as the section lines have not been established. In case only one line remains to be established, it will be located upon the t connecting the original section corners, regardless of beari new opposite quarter-section corner marked to control the vision of the stated section will be placed at mid-point, re of the length of the new section line; the position of the

Fig. 62.



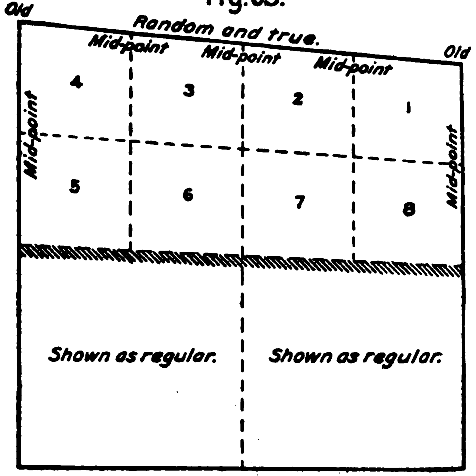
Old bdrs. defective in measurement.



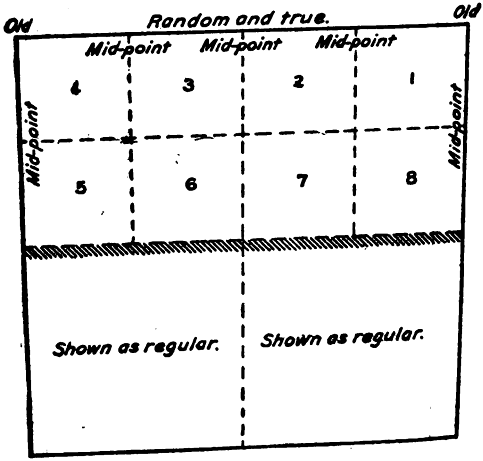
Old bdrs. defective in alinement.

South half protracted as surveyed, and section to be completed.

Fig. 63.



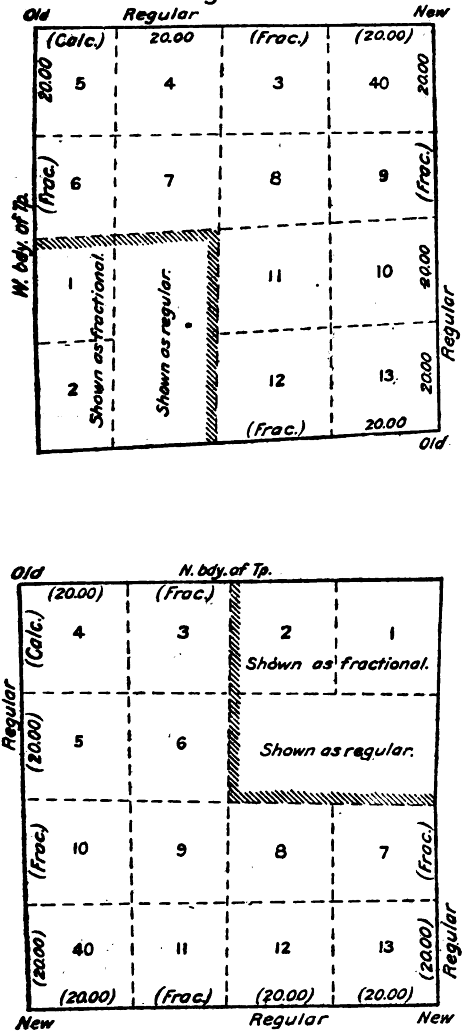
Old bdrs. defective in measurement.



Old bdrs. defective in alinement.

South half protracted as surveyed, and section to be completed.

Fig. 64.



surveys irregular; protracted areas shown as fractional; and section to be completed.

section corner marked to control the subdivision of the adj section will depend upon the plan of subdividing the rem public land. Partially surveyed section lines will be com by extension, the alinement of the same being governed usual rules for regular subdivision; the latitudinal or meri position of the remaining section line (opposite to the half s protracted as surveyed) will usually be controlled by the p of the nearest original section corner, and the alinement of th will depend upon the usual rules for regular subdivision; th opposite quarter-section corner marked to control the subd of the section containing such half section protracted as su will be placed at mid-point in every case; the position of the q section corner marked to control the subdivision of the adj section will depend upon the manner of subdividing the rem public land.

221. Various other examples will be found where fractional as along the north or west boundary of a township, are shown the original approved plat protracted as surveyed. In al instances the same rules, heretofore stated, may be applied, w single exception that a calculation must be made, based up areas shown upon the original plat, of the theoretical length lines not established in the original survey. Such calculated dis will then control instead of the usual regular lengths of sectio as heretofore assumed; also, if such calculated distances coun two directions, and irregularities are developed, the calcu must again be resolved into proportional distances to agre actual measurements between the controlling points.

222. On the accompanying diagrams are shown various ex ated examples of the manner of completing the survey of ir sections containing outlying areas protracted as surveyed, sh the application of the means necessary for the protection integrity of such areas. It is recognized that the general prin above set forth will not always permit the complete establis and appropriate marking of all corners at the first determinat their locations, by reason of the fact that only the bringing up new surveys to be closed upon the completed units will de the appropriate markings of the finished corner, but this nee impair the surveyor's confidence in his knowledge of necessar cedure in the initiatory work, to be recognized and applied a priately when the new surveys are brought up to their closings

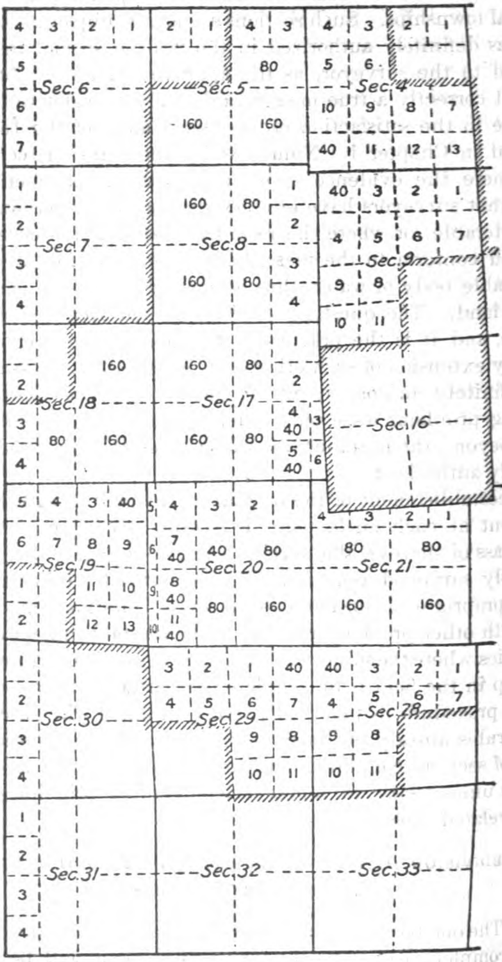
3. A distinctly different class of partially surveyed sections is d along erroneous meander lines shown upon approved plats of ional townships. Such sections are never subject to completion pt as definitely authorized in the written special instructions shed to the surveyor, as the approved plat must be held to sent correctly a true meanderable body of water until proven rwise to the satisfaction of the Department of the Interior, as lated in Chapter I. Numerous instances are on record, how-, where the evidence submitted to the Department is con-ve that surveyors have erroneously classified overflowed lands eanderable, or where the recorded meander line does not and r did conform to the mean high-water elevation of an actual derable body of water, thus erroneously omitting considerable of land. The questions of title to such areas are extremely cate, and it is the practice of the General Land Office not to any extension of such original surveys until the procedure has definitely authorized by the Secretary of the Interior. The ying problems arise only when the extension of the original y beyond the meander line shown upon the approved plat has duly authorized.

e reestablishment of the original meander line with a suitable ment at each angle point is a usual accompaniment of the e class of surveys, the purpose being to segregate definitely the iously surveyed areas from the unsurveyed public lands; it is appropriate to consider the surveying questions thus involved with other problems relating to the reestablishment of broken daries, where the subject will be found in sec. 380, Chapter V. The step in the field is to complete the partially surveyed sections the procedure in practically every instance will be controlled he rules already outlined in respect to the completion of the ey of sections containing outlying areas protracted as surveyed; ems unnecessary to repeat the governing principles in such ly related cases.

SUBDIVISION OF FRACTIONAL SECTIONS RESULTING FROM FRAGMENTARY SURVEYS.

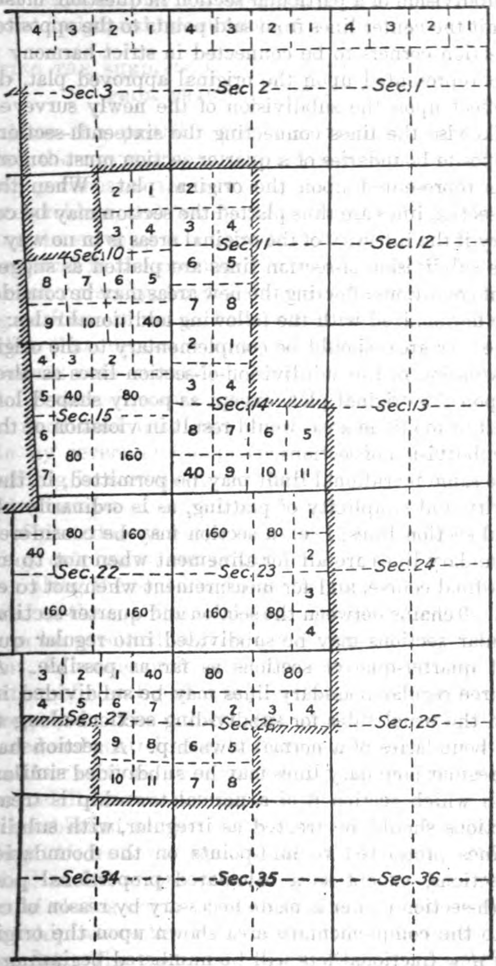
4. The one best test of the fitness of a proposed method incident ae completion of partially surveyed sections will be found in ting the section for subdivision by protraction; thereupon the lar rules for subdivision of sections should be applicable. Thus

Fig. 65 (West half)



Example showing the completion of partially surveyed sections, the subdivisio
resulting f

Fig. 65 (East half)



...sections, and the completion of the subdivisional lines of a partial township ...by surveys.

the position of the new quarter-section corners, established to trol the subdivision of a particular section in question, must be as to permit the center lines from said points to the opposite orig quarter-section corners to be connected in strict harmony with conditions represented upon the original approved plat, disreg ing the effect upon the subdivision of the newly surveyed pu land. Likewise the lines connecting the sixteenth-section cor on the opposite boundaries of a quarter section must conform to conditions represented upon the original plat. When the su vision-of-section lines are thus platted the section may be consid satisfactory if the integrity of the original areas is in no way viol When the subdivision-of-section lines are platted as suggested, permanent conditions affecting the new areas may be considered, should be harmonized with the following additional rules:

1st. The new areas should be complementary to the original by the extension of the subdivision-of-section lines as already tracted upon the original plat, except as poorly shaped lots, of too great or too little area, would result in violation of the re rules for subdivision of sections.

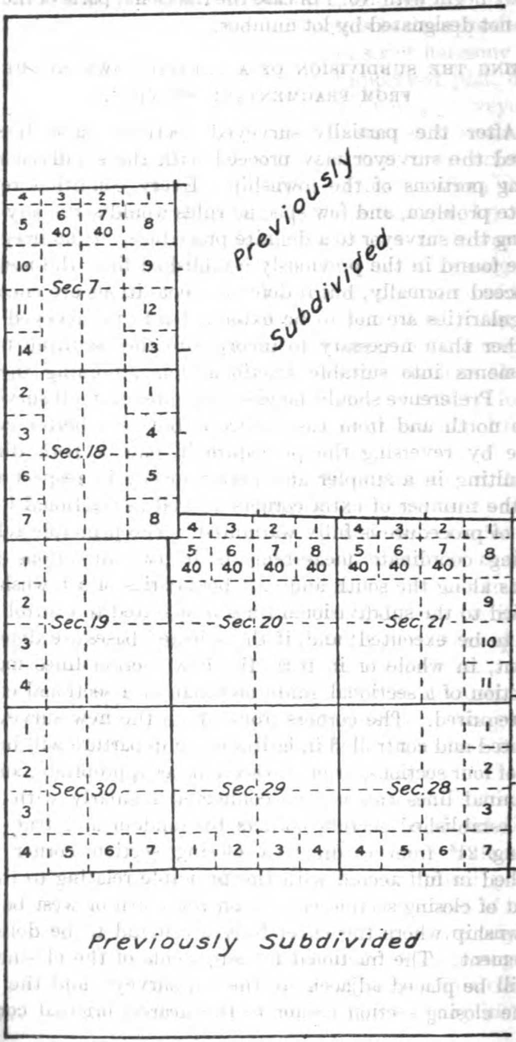
2d. The same meridional limit may be permitted, in the int of regularity and simplicity of platting, as is ordinarily allow latitudinal section lines; i. e., a section may be considered re whose boundary lines are all for alinement when not to exce from a cardinal course, and for measurement when not to exce links from 40 chains between the section and quarter-section co Such regular sections may be subdivided into regular quarte tions and quarter-quarter sections as far as possible. A se having three regular boundary lines may be subdivided in ac ance with the usual rules for subdividing sections along the and west boundaries of a normal township. A section having adjacent regular boundary lines may be subdivided similarly t manner in which section 6 of a normal township is treated. other sections should be treated as irregular, with subdivisio section lines protracted to mid-points on the boundaries of quarter sections, except as a calculated proportional positio a sixteenth-section corner is made necessary by reason of condi relating to the complementary area shown upon the original

3d. All new fractional lots will be numbered beginning wit next higher number in the series of the same section already b upon the previously approved plat, and proceeding in the r in which fractional lots are normally numbered. The new s may begin with No. 1 in case the fractional parts of the original are not designated by lot number.

PLETING THE SUBDIVISION OF A PARTIAL TOWNSHIP RESULTING FROM FRAGMENTARY SURVEYS.

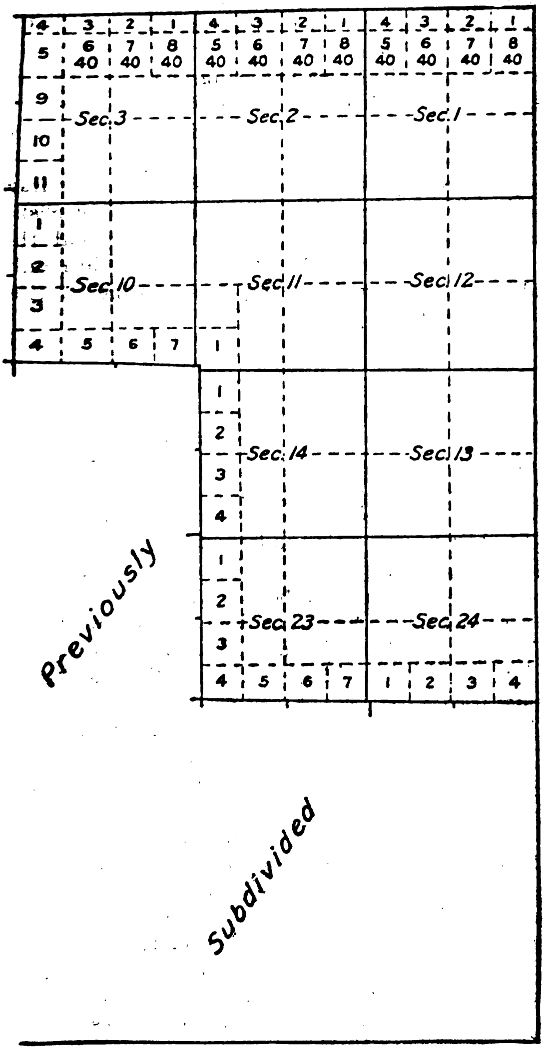
!5. After the partially surveyed sections have been fully pleted the surveyor may proceed with the subdivision of the ining portions of the township. Every condition represents arate problem, and few specific rules would serve any purpose iding the surveyor to a definite procedure. If no irregularities o be found in the previously established lines the new survey proceed normally, but if defective conditions are encountered irregularities are not to be extended into unsurveyed sections farther than necessary to incorporate the resulting fractional urements into suitable fractional lots adjoining the former eys. Preference should be given to extending all surveys from h to north and from east to west, but if a better control is lable by reversing the procedure in one or both directions, resulting in a simpler and better survey in respect to mini-ng the number of extra corners as well as fractional lots, such rsal of procedure is fully warranted. The principle relating to rolling coördinate measurements in two directions at right es, as along the south and east boundaries of a township, may pplied to the subdivisional lines best suited to control the new eys to be executed; and, if the selected bases are defective in ement, in whole or in part, the new section lines may serve function of a sectional guide meridian or a sectional correction as required. The corners from which the new surveys are to nitiated and controlled in latitude and departure will be termed ers of four sections, or of two sections as appropriate, and where terminal lines can not be connected regularly with the pre-sly established section corners by random and true line not eeding 21′ from cardinal, a closing section corner will be blished in full accord with the principle relating to the estab-ment of closing section corners on the north or west boundaries township where the latter lines are found to be defective in surement. The fractional measurements of the closing section s will be placed adjacent to the old surveys, and the distance n the closing section corner to the nearest original corner will

Fig. 66 (West half)



Example showing the completion of the subdivisional lin

Fig. 66 (East half)



artial township resulting from fragmentary surveys.

be measured; the original lines forming the boundary of the l
to be surveyed will be retraced, as already provided, and the m
upon the original corners will be appropriately modified as ne
sary; new quarter-section corners marked to control the subdivi
of the new sections will be established on the original lines at
points between the closing section corners, or at 40 chains from
direction, according to the manner in which a new section is t
subdivided.

There are generally two or more ways in which a fragmen
subdivision may be executed, but a careful study of a sketch
representing existing conditions will generally reveal the su
ority of one method over another, and objectionable results sh
be avoided as far as existing conditions relating to the ori
surveys will permit.

MEANDERING.

226. All navigable bodies of water and other important ri
and lakes (as hereinafter described) are to be segregated from
public lands at mean high-water elevation. The traverse of
margin of a permanent natural body of water is termed a mea
line.

The running of meander lines has always been authorized in
survey of public lands fronting on large streams and other bodi
water, but the mere fact that an irregular or sinuous line mus
run, as in case of a reservation boundary, does not entitle it t
called a meander line except where it closely follows the bank
stream or lake. The legal riparian rights connected with mea
lines do not apply in case of other irregular lines, as the latte
strict boundaries.

Mean high-water mark has been defined in a State decision
Iowa, 370) in substance as follows: High-water mark in the Mi
sippi River is to be determined from the river bed; and that
is river bed which the river occupies long enough to wrest it
vegetation. In another case (14 Penn. St., 59) a bank is define
the continuous margin where vegetation ceases, and the shore i
sandy space between it and low-water mark.

Numerous decisions in the United States Supreme Court
many of the State courts assert the principle that meander l
are not boundaries defining the area of ownership of tracts adja
to waters. The general rule is well set forth (10 Iowa, 549
saying that in a navigable stream, as the Des Moines River in I

rater mark is the boundary line. When by action of the the river bed changes, high-water mark changes and owner-f adjoining land progresses with it.

nder lines will not be established at the segregation line en upland and swamp or overflowed land, but at the ordinary rater mark of the actual margin of the river or lake on which wamp or overflowed lands border.

Practically all inland bodies of water pass through an l cycle of changes from mean low water to flood stages, en the extremes of which will be found mean high water. ions of broken topography, especially where bodies of water unded by sharply sloping lands, the horizontal distance n the margins of the various water elevations is compara-slight, and the surveyor will not experience much difficulty ermining the horizontal position of mean high-water level pproximate accuracy; but in level regions, or in any locality the meanderable bodies of water are bordered by relatively nds, the horizontal distance between the successive levels is ely great. The surveyor will find the most reliable indica-f mean high-water elevation in the evidence made by the s action at its various stages, which will generally be found arked in the soil, and in timbered localities a very certain ion of the locus of the various important water levels will be in the belting of the native forest species.

n high-water elevation will be found at the margin of the ccupied by the water for the greater portion of each average t this level a definite escarpment in the soil will generally eable, at the top of which is the true position for the surveyor the meander line. A pronounced escarpment, the result of tion of storm and flood waters, will often be found above the al water level, and separated from the latter by the storm l beach; another less evident escarpment will often be found average low-water level, especially of lakes, the lower escarp-eing separated from the principal escarpment by the normal or shore. While these questions properly belong to the realm ogy, they should not be overlooked in the survey of a meander

re native forest trees are found in abundance bordering of water, those trees showing evidence of having grown under ble site conditions will be found accurately belted along contour lines; thus a certain class of mixed varieties common t particular region will be found only on the lands seldom if e overflowed; another group of forest species will be found on lands which are inundated only a small portion of the growing sea each year, and indicate the area which should be included in classification of the uplands; other varieties of native forest t will be found only within the zone of swamp and overflowed la All timber growth normally ceases at the margin of permanent wa

228. At every point where either standard, township or sect lines intersect the bank of a navigable stream, or any meanders body of water, corners at such intersections will be establishe the time of running these lines. Such monuments are called me der corners. In the survey of lands bordering on tide waters, me der corners may be temporarily set at the intersection of the veyed lines with the margin of mean high tide, but no monum should be placed in a position exposed to the beating of waves the action of ice in severe weather. In all such cases a wit corner on the line surveyed, at a secure point near the true p for the meander corner, will be established. The crossing dista between meander corners on the same line will be ascertained triangulation or direct measurement, and the full particulars wil given in the field notes.

229. Inasmuch as it is not practicable in public-land survey meander in such a way as to follow and reproduce all the mi windings of the high-water line, the United States Supreme C has given the principles governing the use and purpose of meande shores in its decision in a noted case (R. R. Co. *v.* Schurmei Wallace, 286–287) as follows:

"Meander lines are run in surveying fractional portions of public lands bordering on navigable rivers, not as boundarie the tract, but for the purpose of defining the sinuosities of the ba of the stream, and as the means of ascertaining the quantity of l in the fraction subject to sale, which is to be paid for by the p chaser. In preparing the official plat from the field notes, the me der line is represented as the border line of the stream, and show a demonstration that the water-course, and not the meander lin actually run on the land, is the boundary."

230. The surveyor will commence the meander line at on the meander corners, follow the bank or shore line, and determ the true bearing and measure the exact length of each course, f beginning to the next meander corner. All meander courses to be taken or counted from the true meridian and will be de- ined with precision; "transit angles" showing only the amount he deviation from the preceding course are not acceptable in notes of meanders. For convenience the courses of meander s should be adjusted to the exact quarter degree; meander are not strict boundaries and this method will give approxi- agreement with the minute sinuosities of mean high-water tion. Again, for convenience of platting and computation, urveyor is required to adopt turning points at distances of whole ns, or multiples of ten links, with odd links only in the final e.

cases where the surveyor finds it impossible to carry his meander along mean high-water mark, his notes should state the distance efrom and the obstacles which justify the deviation. A table titudes and departures of the meander courses should be com- d before leaving the vicinity, and if misclosure is found, indi- g error in measurement or in reading courses, the lines should run.

streams flowing into a river, lake or meanderable bayou be noted, and the width at their mouths stated; also, the posi- , size and depth of springs, whether the water be pure or min- also, the heads and mouths of all bayous, all rapids and bars, be noted, with intersections to the upper and lower ends of the r, to establish their exact situation. The elevation of the s of lakes and streams, the height of falls and cascades, and length and fall of rapids, will be recorded in the field notes.

he field notes of meanders will show the corners from which the nders commenced and upon which they closed, and will ibit the meanders of each fractional section separately; following, composing a part of such notes, will be given a description of the ining land, soil and timber, and the depth of inundation to ch the bottom land is subject. The utmost care will be taken ass no object of topography, or change therein, without giving a icular description thereof in its proper place in the notes of the nders.

RIVERS.

81. Proceeding downstream, the bank on the left hand is termed left bank and that on the right hand the right bank. These ns will be universally used to distinguish the two banks of a

river or stream. Navigable rivers and bayous, as well as all ri not embraced in the class denominated "navigable," the ri angle width of which is 3 chains and upwards, will be m dered on both banks, at the ordinary mean high-water mark taking the general courses and distances of their sinuosities. Ri not classed as navigable will not be meandered above the p where the average right-angle width is less than 3 chains, ex that streams which are less than 3 chains wide and which a deep, swift and dangerous as to be impassable may be meand where good agricultural lands along the banks require their se tion into fractional lots for the benefit of settlers.

Shallow fresh-water streams, without any well-defined chann permanent banks, will not be meandered. Tidewater stre whether more or less than 3 chains wide, should be meander ordinary high-water mark, as far as tidewater extends.

LAKES.

232. The meanders of all lakes of the area of 25 acres and wards, will be commenced at a meander corner and continue above directed for navigable streams; from said corner, the co and distances of the entire margin of the same, and the intersec with all meander corners established thereon, will be noted.

In the case of lakes which are found to be located entirely w the boundaries of a section, a quarter-section line, if one cr the lake, will be run from one of the quarter-section corners, theoretical course to connect with the opposite quarter-se corner, to the margin of the lake, and the distance will be meas then at the point thus determined a "special meander corner" be established. If a meanderable lake is found to be locate tirely within a quarter section, an "auxiliary meander corner" be established at some suitable point on its margin, and a con ing line will be run from said monument to a regular corner o section boundary. A connecting traverse line will be recorde one is run, but it will also be reduced to the equivalent direct necting course and distance, all of which will be stated in the notes, and the course and length of the direct connecting line wi be shown on the plat of the survey.

The meander line of a lake lying within the interior of a se will be initiated at the established special or auxiliary mea corner, as the case may be, and continued around the margin o nal lake at its mean high-water level, to a closing at the point eginning. All proceedings are to be fully entered in the field s.

rtificial lakes and reservoirs are not to be segregated from the ic lands, unless specially provided in the instructions, but the position and extent of such bodies of water will be determined e field and shown on the plat.

ISLANDS.

3. In the progress of the regular surveys every island above the high-water elevation of any meanderable body of water, exg only those islands which may have formed in navigable bodies ter after the date of the admission of a State into the Union, will efinitely located by triangulation or direct measurement or r suitable process, and will be meandered and shown upon the ial plat.

the survey of the mainland fronting on any non-navigable of water, any island opposite thereto, above mean high-water tion, is subject to survey. Also, even though the United s may have parted with its title to the adjoining mainland, an d in any meandered body of water, navigable or non-navigable, n or proven to have been in existence at the date of the admisof a State into the Union, and at the date of the survey of the land, if omitted from said original survey, remains public land e United States, and as such the island is subject to survey.

e survey of islands not shown upon the original approved plats bdivided townships is authorized by the Department only upon receipt of formal application, and subject to the approval thereof. roof of the time of the formation of such islands is often more or difficult, and it is the practice of the Department to make a ful examination of the history of an island in relation to the tion of its legal ownership before approving the application for urvey.

ny township boundary or section line which will intersect an d will be extended as nearly in accordance with the plan of lar surveys as conditions will permit, and the usual township, ion, quarter-section and meander corners will be established he island. If an island falls in two sections only, the line been those particular sections should be established in its proper retical position based upon suitable sights and calculations.

If an island falls entirely in one section, and is large enough subdivided (over 50 acres in area), a suitable sight or calcu will be made to locate on the margin of the island an inters with the theoretical position of any suitable subdivision-of-s line, and at the point thus determined a "special meander co will be established. In the case of an island falling entirely i section and found to be too small to be subdivided, an "aux meander corner" will be established at any suitable point margin, which will be accurately connected with any regula ner on the mainland. The direct course and length of the co ing line will be given in the field notes, together with all s measurements, triangulations and traverse lines upon whic calculation may be based. The course and length of the direc necting line will be shown on the plat.

The meander line of an island will be surveyed in harmony principles and rules heretofore stated; all township and section crossing the island will be shown on the plat; and, if the isl large enough to be subdivided, the subdivision will be accompl by the protraction of suitable subdivision-of-section lines in correct theoretical position.

Agricultural upland within the limits of swamp and overfl lands should be so classified and shown upon the plat accordi but such land will not be meandered as an island.

LIMITS OF CLOSURE.

284. Under the general subjects of "township exteriors' "subdivision of townships" certain definite limits were presc beyond which previously established surveys are classed as fective," or in the case of new surveys corrective steps are requ Such limits constitute the standard of accuracy of the United S rectangular surveys, and, for convenience, have been variousl ferred to as the "rectangular limit," "limit for the control of surveys," "limit relating to defective exteriors and section li "limits for subdivision," etc., each expression having been fo to suit the descriptive exigency of the text. A more gener quirement known as the "limit of closure" will be applied as a of the accuracy of the alinement and measurement of all class lines embraced in any closed figure incident to the public-land veys, and corrective steps will be required wherever this test closes an error beyond the allowable limit.

The "error of closure" of a survey may be defined, in general ms, as the ratio of the length of the line representing the equiva- t of the errors in latitude and departure (as found by a table of tudes and departures) to the length of the perimeter of the figure stituting the survey; but, with due regard for the controlling rdinate governing lines of a rectangular survey, pronounced uracy in latitude will not be permitted to offset gross error in arture, or vice versa, and, in order to be consistent with this damental theory, a double test must be applied in place of the expressed in general terms. The "limit of closure" fixed for United States rectangular surveys may be expressed by the tion $\frac{1}{452}$ provided that the limit of closure in neither latitude departure exceeds $\frac{1}{640}$, and where a survey qualifies under the er limit the former is bound to be satisfied; thus an accumulative or of 12½ links per mile of perimeter, in either latitude or departure, not be exceeded in an acceptable survey. The limit of closure hus expressed may be applied to various specific conditions as etofore stated.

he latitudes and departures of a normal section shall each close hin 50 links; of a normal range or tier of sections, within 175 ks; and of a normal township, within 300 links. The boundaries each fractional section including irregular claim lines or meanders, the meanders of an island or lake in the interior of a section, should se within a limit to be determined by the fraction $\frac{1}{640}$ when the or in either latitude or departure is considered separately; the e rule will be applied to all broken or irregular boundaries.

urveyors are required to compute all doubtful closings while in field in the immediate vicinity of a particular line, or series of es, in question, and to accomplish all necessary corrective work ore concluding a survey.

MARKING LINES BETWEEN CORNERS.

235. The marking of a survey upon the ground in such a manner to fix forever the position of the legal lines in relation to the rth's surface is the final step in the field work, and is accomplished three ways, which, if well executed, will individually or collec- rely furnish the means of the identification of the survey at even mote future dates. Careful attention to these details is one of the ost important phases of the surveyor's field work. (*a*) The regular rners of the public-land surveys are marked by fixed monuments

of specified character as described in Chapter IV; (*b*) the relation the officially surveyed lines to natural topographical features recorded in much detail as hereinafter outlined, and again exe plified in the specimen field notes; and, (*c*) the locus of the le lines, wherever living timber is encountered, is plainly mark upon the forest trees, which is accomplished by the process "blazing" and by "hack" marks.

A "blaze" is an ax mark which is made upon a tree trunk at ab breast height, in which a flat scar is left upon the tree surface. T bark and a very small amount of the live wood tissue are remov leaving a smooth surface which forever brands the tree. The s of the blaze depends somewhat upon the size of the tree, bu never made larger than the surface of an ax blade; a blaze 5 o inches in height and from 2 to 4 inches in width is ample to m any tree.

A "hack" is also an ax mark which is made upon a tree trun about breast height, in which a horizontal notch is cut into surface of the tree. The notch is made "V-shaped," and is through the bark and well into the wood. Two hacks are cut order to distinguish those made in the survey from accidental ma resulting from other causes; a vertical section of the comple official hack mark resembles a "double-V" ($\leq$) extending acro tree from 2 to 6 inches in length, depending upon the diamete the tree. The "hack" and "blaze" marks are equally perman but so different in character that one mark should never be mista for the other.

The marking of trees along the surveyed lines was required law as positively as the erection of monuments, by the act of 17 which is still in force. All lines on which are to be established legal corners will be marked after this method, viz: Those t which may be intersected by the line will have two hacks or notc cut on each of the sides facing the line, without any other ma whatever. These are called sight trees or line trees. A suffic number of other trees standing within 50 links of the line, on eit side of it, will be blazed on two sides quartering toward the line, order to render the line conspicuous, and readily to be traced either direction, the blazes to be opposite each other coincid in direction with the line where the trees stand very near it, and approach nearer each other toward the line the farther the line pas from the blazed trees.

Due care will ever be taken to have the lines so well marked as to readily followed, and to cut the blazes plainly enough to leave ognizable scars as long as the trees stand. This can be accomshed by blazing just through the bark into the live wood tissue. here trees 2 inches or more in diameter occur along a line, the uired blazes will not be omitted. Where trees have branches wing to the ground, the blazes will be omitted unless it is neces- to remove the branches to permit sighting.

ines are also to be marked by cutting away enough of the under-wth to facilitate correct sighting of instruments. Where lines s deep wooded valleys, by sighting over the tops, the usual zing of trees in the low ground when accessible will be performed, settlers may find their proper limits of land and timber without tial survey. The undergrowth will be especially well cut along lines within distances of 5 chains of corner monuments and within hains of arteries of travel, to enable other surveyors and settlers ocate the survey readily, but the cutting of the undergrowth be omitted in deep untraveled ravines unless necessary for urate sighting or measurement.

ne trees and blazing will be marked only with reference to the blished true line, and where lines are run by the "random and " line method, the marking of line trees and the blazing will be mplished by returning over the line after all corrections or ad-ments to the final line are definitely known. A sufficient number mporary stakes should be set along a random line to render it erally unnecessary to rerun the true line instrumentally merely the purpose of blazing the line through timber, as this can usually accomplished by properly estimating the distance from the porary stakes, but intersections with line trees will be made with cision, and distances thereto accurately measured.

SUMMARY OF OBJECTS TO BE NOTED, AND SKETCHES.

26. The field notes and plat of a survey are designed to furnish only a technical record of the procedure, but also of equal im-tance a report upon the character of the land, soil and timber ersed by the survey, and a detailed schedule of the topographical ures along every line, with accurate connections showing the tion of the rectangular surveys to other surveys, to natural ects and to improvements. A triple purpose is thus served: (a) technical procedure is made a matter of official record; (b)

general information relating to a region is gathered; and, (c) "calls" of the field notes and the representations of the pla respect to objects along the surveyed lines furnish important dence by which the locus of the survey becomes practically changeable as contemplated by law.

The specimen field notes and plats are intended to standar the form of record, and many special matters relating to these jects are brought together in Chapters VIII and IX, but b concluding the special questions concerning rectangular sur it is deemed expedient to outline the technical and topograpl features which are to be carefully observed and recorded in field during the progress of the public-land surveys:—

1. The precise course and length of every line run, notin necessary offsets therefrom, with the reason for making them, method employed.

2. The kind and diameter of all bearing trees, with the co and distance of the same from their respective corners, and markings; all bearing objects and marks thereon, if any; and precise relative position of witness corners to the true corners.

3. The kind of material of which corners are constructed, t dimensions and markings, depth set in the ground, and t accessories.

4. Trees on line. The name, diameter and distance on line t trees which it intersects, and their markings.

5. Intersections by line of land objects. The distance at w the line intersects the boundary lines of every reservation, t site, or private claim, noting the exact bearing of such boun lines, and the precise distance to the nearest boundary corner; center line of every railroad, canal, ditch, electric transmission l or other right-of-way across public lands, noting the width of right-of-way and the precise bearing of the center line; the ch from one character of land to another, with the approximate bea of the line of demarcation, and the estimated height in feet of ascents and descents over the principal slopes typifying the to raphy of the country traversed, with the direction of said slo the distance to and the direction of the principal ridges, sp divides, rim rock, precipitous cliffs, etc.; the distance to where line enters or leaves heavy or scattering timber, with the appr mate bearing of the margin of all heavy timber, and the dista to where the line enters or leaves dense undergrowth.

Intersections by line of water objects. All unmeandered s, creeks and smaller water-courses which the line crosses; the nce measured on the true line to the center of the same in the of the smaller streams, and to both banks in the case of the r streams, the course downstream at points of intersection, and widths on line, if only the center is noted. All intermittent r-courses, such as ravines, gulches, arroyos, draws, dry-drains, etc.

The land's surface; whether level, rolling, broken, hilly or ıtainous.

The soil; whether rocky, stony, gravelly, sandy, loam, clay, and also whether first, second, third or fourth rate.

Timber; the several kinds of timber and undergrowth, in the in which they predominate.

Bottom lands to be described as upland or swamp and over- l, as contradistinguished under the law, noting the extent and ximate position of the latter, and depth of overflow at sea- periods. The segregation of lands fit for cultivation without ial drainage, from the swamp and overflowed lands, where the are subject to selection by the States, is always accomplished al subdivision, and any smallest legal subdivision is classified upland or all swamp and overflowed land accordingly as more ıalf of the same may be of the character of the one or of the class of lands; bottom lands will be classified with special eration to these matters.

Springs of water, whether fresh, saline, or mineral, with the of the stream flowing therefrom. The location of all streams, s, or water-holes, which because of their environment may med to be of value in connection with the utilization of public g lands, and which may be designated as public watering , will be specially noted.

Lakes and ponds, describing their banks, tributaries and out- d whether the water is pure or stagnant, deep or shallow.

Improvements; towns and villages; post offices; Indian occu- ; houses or cabins, fields, or other improvements, with owner's mineral claims; mill-sites; United States mineral monuments, l other official monuments not belonging to the system of gular surveys; will be located by bearing and distance or by cting bearings from given points.

Coal banks or beds, all ore bodies, with particular description same as to quality and extent; all mining surface improvements and underground workings; and salt licks. All reliabl formation that can be obtained respecting these objects, wh they be on the line or not, will appear in the general descri

15. Roads and trails, with their directions, whence and wh

16. Rapids, cataracts, cascades, or falls of water, in their ap mate position and estimated height of their fall in feet.

17. Stone quarries and ledges of rocks, with the kind of stone afford.

18. Natural curiosities, petrifactions, fossils, organic remains also all archaeological remains, such as cliff dwellings, mo fortifications, or objects of like nature.

19. The general average of the magnetic declination in the ship, with maximum known range of local attraction and variations, will be stated in the general description, and the ge average for the township, subject to local attraction, will be s upon the plat.

20. *General description.*—The above information will be sum ized by townships in a general description which will be mad concluding part of the field notes of every survey. The ge description will be made to embrace many more comprehensiv tails in regard to the characteristics of the region than is feasil cover as an intimate part of the technical record of the surve follows:—

Land.—A general outline of the drainage and topographica tures of the township and approximate range of elevation abov level.

Soil.—The prevailing and characteristic soil types. (See sp reference to soil classification, Chap. VII.)

Timber.—The predominant forest species, age, size, condition

Evidence of mineral.—All known bodies of mineral, and l whose formation suggests mineral-bearing characteristics, espec with reference to lands of volcanic or igneous origin, will be l by appropriate legal subdivision, with brief description of the eral indications. On the other hand, if the surveyor finds no parent indication of mineral deposits, a report to that effect wi embodied in the general description.

Watering places.—The areas embracing all streams, spring water holes as may be of special value as public watering pl in connection with the utilization of public grazing lands, wi listed by appropriate legal subdivision, with brief description o nature of such water supply.

ttlement.—The extent of the settlement at the time of the survey.
dustry.—The industrial possibilities of the township, especially
o the adaptability of the region to agricultural pursuits, stock
ng, lumbering, mining, or other profitable enterprise.
ecial.—All exceptional steps in the technical process of the
ey, and other special matters required in paragraphs Nos. 1 to
aclusive, of the above summary, not otherwise suitably recorded
be reported in the general description.

addition to the field notes the surveyors are required to prepare,
e work progresses, an outline diagram showing the course and
th of all established lines with connections, and a topographical
h embracing all features usually shown upon the completed
al township plat. These maps will be made to scale, drawn in
il only, if desired, and will be kept up with the progress of the
work. The interiors of the sections will be fully completed;
opographical features will be sketched with care while in the
of the surveyor, and the position within the section of the
us details which are to be shown on the completed plat will be
ed with an accuracy commensurate with their relative impor-
. The design of the specimen township plat will be followed
ly in the preparation of the outline diagram and topographical
h plat, except that it will generally be desirable to employ
arate sheet for each of the two purposes. These maps will
form the basis of the official plat, the ultimate purpose of
h is a true and complete graphic representation of the public
s surveyed.

CHAPTER IV.

CORNER MONUMENTS.

THE LEGAL SIGNIFICANCE OF A CORNER MONUMENT.

17. It is one of the fundamental principles of the surveying laws absolute permanency be attached to the public-land surveys n the lines have been officially established. The "survey" em- es certain definite technical procedure, heretofore described, the marking of certain fixed points, as will be described in this pter, though the establishment of a survey may not be termed npleted" until the field notes and plat and every detail of the nical operation constituting the survey have been finally ac- ed by the Commissioner of the General Land Office, all as con- plated by law. The law provides that the original corners blished during the process of the survey shall forever remain l in position, even to disregarding technical errors in the execu- of the survey—where discrepancies may have passed undetected r to the acceptance of the survey and the opening of the lands ntry—and, as an aid to the matter of permanency, the Congress ides for the purchase of durable material for the corner monu- ts, also a penalty for the defacing of any marks relating to the s of the survey. If it were possible to carry out the full intent ne surveying laws in regard to the aforementioned particulars, most intricate of all technical and legal problems relating to sur- —the questions pertaining to the reestablishment of lost cor- —would be avoided.

ne courts attach major importance to authentic evidence relating ne original position of an official corner monument, such evidence g given far greater weight than the technical record relating to ings and lengths of lines, and it is assumed in the first instance the original corners shall serve every necessary purpose for the ntification of the survey delineated upon the official approved , and of the lands which have passed into private ownership. legal significance of the original monuments, as thus briefly ined, makes it mandatory upon the surveyor to exercise constant diligence in the workmanlike construction of lasting co and alertness in skillfully connecting the same with natural ol or improvements, to the end that the greatest possible permar may be secured for the public-land surveys.

238. Accordingly, if a surveyor is called upon to alter the dition of a previously established point, the utmost regard s be shown for the evidence of the original location of the monu and the corner will be carefully reconstructed by such addi means as may be appropriate, without destroying the evidence served to identify its legal position. A complete record will be of the description of the old monument as identified, and all a tions and additions thereto.

239. Regulation monuments are employed to mark perman the position of the quarter-section, section, township and me corners, appropriate to the subdivision of the public lands, a scribed in Chapter III; also at such sixteenth-section corners a requirements of the written special instructions or the exigenc the survey of fractional sections may demand; also at all angle p along an irregular boundary line, and at intermediate interv 40 and 80 chains along such limiting boundary. A more exte discussion of the subject of "angle points" and other monumer be established upon irregular boundaries will be found in Chapter

240. The position of every corner monument will be "eviden by the best of such accessories as may be available, and when corner point itself can not be marked in the usual manne appropriate "witness corner" will be established. A "wi meander corner" will be established upon secure ground whe the intersection of a surveyed line with the mean high-water vation of a meanderable body of water falls at a point where monument would be liable to destruction.

241. The field notes relating to the establishment of a co monument will be introduced into the technical record of the su at the logical place in the record where the true position for corner is indicated as having been attained. The record of monument itself will embrace a description of:

(*a*) The corner material, including its dimensions, in the c of length and diameter of an iron post; or length, width and brea of a stone; or the breast height diameter of a tree; (*b*) the de set in the ground, with mention of additional support if a (*c*) the significance of its position; (*d*) the markings upon the mo

; and (*e*) the nature of the accessories, including character, position and markings.

CORNER MATERIAL.

!. The General Land Office has adopted a model iron post for menting the public-land surveys, which will be generally unless exceptional circumstances warrant a departure from ule. This practice is deemed so important that the surveyor authorized to exercise an option in the matter, but he may he question to the proper supervising officer, who may grant ity for the use of other suitable material, provided the reasons parting from the general rule are sufficient, in which case a tatement of the facts will be given in the field notes, in the of an explanation as to why the model iron posts were not yed.

model iron post is made from commercial iron pipe, from 1 to es in diameter, which is cut into lengths of about 36 inches; d of the pipe is split for a distance of about 4 or 5 inches, and o halves are spread (when heated) to form flanges or foot plates, t angles to the axis of the pipe; a brass cap is securely riveted opposite end of the pipe; and finally the pipe is filled with te. Unless otherwise provided in the written special instruc- the iron posts will be employed as follows: 3-inch, for standard osing township corners, corners of one, two or four townships, required for mile corners and angle points of special bound- rveys; 2-inch, for standard and closing section corners, and s of one, two or four sections; and, 1-inch, for quarter-sec- ad meander corners, and as required for miscellaneous angle , sixteenth-section corners and corners of special tract surveys. tness corners are to be of the same size as would be used for ie corner.

. The caps of the iron posts are to be suitably and plainly d with steel dies at the time when used; the posts will be the ground about three-fourths of their length; and earth and if the latter is at hand, will be tamped into the excavation the post a solid anchorage.

. Durable native stone may be substituted for the model iron f the procedure has been duly authorized, but no stone will d which measures less than 20 inches in length, or less than es in either of its minor dimensions, or less than 1,000 cubic in volume. A stone should always be selected with regard

to its durability when exposed to the usual weathering influe
Stone will not be used as a corner monument where its position
among large quantities of loose surface stone or slide rock.

245. A stone will be suitably and legibly marked with a chisel or punch with such letters, figures, grooves or notche may be required, and will be set firmly in the ground about t fourths of its length.

246. Both iron post and stone monuments will always b the usual depth in the ground unless it is impossible to com the excavation, in which case the monument will be plant deep as conditions will permit, and the necessary support wi secured by a stone mound.

247. Where the corner point falls upon solid surface rock, venting excavation, a cross (X) will be cut at the exact corner and, if feasible, the monument will be erected in the same pos supported by a large stone mound of broad base, so well constr that it will possess thorough stability.

248. Where the corner point falls exactly at the position occ by a sound living tree, which is too large to be removed, th will be appropriately marked for the corner.

WITNESS CORNERS.

249. Where the true point for a corner falls within a roadw such a place as to interfere with travel, a marked (X) stone w deposited in the ground at the true corner point and a witness c will be established at some suitable point, preferably on a sur line, outside of the roadway.

250. Where the true point for a corner falls upon insecure gr or in an inaccessible place, such as within an unmeandered st lake or pond, or in a marsh, or upon a precipitous slope or c witness corner will be established at some suitable point, prefe on a surveyed line, where the monument may be perman constructed.

251. The surveyor will be expected to exercise his best judg in selecting the position for a witness corner, with a view to a ing a definite and convenient connection from the witness cor the true point for the monument, for use in subsequent surve recover the legal position of the true corner. Extra effort wi exerted to accomplish the permanent establishment of a monu at its true corner point, wherever this is feasible, in order to as much as possible the confusion to settlers and others caus witness corners.

!. Only one witness corner will be established in each instance, ıe same will be placed upon any one of the surveyed lines lead- a corner, if a suitable place, within a distance of 10 chains, is ble, but if there is no secure place to be found on a surveyed ithin the stated limiting distance, the witness corner may be d in any direction within a distance of 5 chains. On the other if there is no suitable place within the latter radius, one or legal subdivisions will be eliminated from the survey as pro- in Chapter VII.

. All of the lines of a survey will be completed in the regular ır, if the true point for a corner is accessible, but where the oint can not be attained, a line connecting therewith may be ed as surveyed if the same has been completed by the pro- ı and measurement of a suitable offset or traverse, resulting losed figure which approaches the true point for a monument the limit prescribed for the establishment of witness corners.

. The field notes will show every detail of the relation of a s corner to the true point for a monument, and the direct con- g course and distance will be shown upon the plat of the survey.

MARKING CORNERS.

. All classes of corner monuments are to be marked in accord- ith a system hereinafter described which has been devised to ı a ready identification of the character and position of the ıent which bears the marks. Capital letters and Arabic figures ployed to mark iron post and tree corners, while upon stone ; certain additional marks termed "notches" and "grooves" ployed to convey the same information, but to lessen the labor ıt to the marking process. The letters and figures upon a ıent are designed to relate to the township, range and sec- ı which the corner belongs; the notches and grooves upon a nonument relate—in the case of an exterior corner—to the number of miles from the monument to the adjoining town- ırners, and—in the case of a subdivisional corner—to the nor- ımber of miles from the monument to the township boundary ıs hereinafter described, thus furnishing the means of ascer- ; the appropriate section numbers.

. All markings should be accomplished neatly, distinctly and y; and the marks are to be carefully arranged. An assort- of steel dies, chisels, punches and timber scribes, in perfect ion for use, should always be at hand.

257. A witness corner and its accessories will be constructed marked similarly to a regular corner for which it stands, with additional letters "W C" to signify "witness corner."

258. The following schedule is an index of the ordinary mark 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 cor
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 alw be made to read from the south side of the monument, and all posts will be marked with the year number at the date when es lished.

260. *Standard township corners* are to be marked "S C" and township on the north half, and the ranges and sections in the pr quadrants; as for example:

SC
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 from which the closing line approaches the monument, with township (or range) on the same half, and the ranges (or townsh and sections in the proper quadrants; also (as far as known at time) the township, range and section, or the initials or abbre of the State, reservation, grant or private claim, upon which township exterior closes; as for example:

T25N R17E
S 36
S1 | S6
R17E | R18E
T 24 N
CC
1916

T 24 N
T 24 N | R 17 E
S 36 | S 31 —CC
| S 6
R 16 E | T 23 N
1916

T 20 N
R 120 W
UTAH | S 32 —CC
| S 5
T 19 N
1916

62. *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:

T 23 N
R 17 E | R 18 E
S 36 | S 31
S 1 | S 6
T 22 N
1916

63. *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:

T 3 N
R 7 W
S 36 | T 2 N
| R 6 W
S 1 | S 6
T 2 N
1916

T 14 S
R 7 W | R 6 W
S 36 | S 31
T 15 S R 7 W S 1
1916

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:

T 20 N R 5 W
T 19 N | S 31
R 6 W
S 1
1916

T 23 N
R 19 W
S 36
T 22 N R 19 W
S 1
1916

T 35 N
R 44 E
S 31
T 34 N R 43 E
S 1
1916

55465°—19——16

265. *Standard section corners* are to be marked "S C" and township and range on the north half, and the sections in the pro quadrants; as for example:

SC
T25 N | R17 E
S 35 | S 36
1916

266. *Closing section corners* are to be marked "C C" and township and range on the half from which the closing line approa the monument, and the sections in the proper quadrants; also far as known at the time) the township, range and section, or initials or abbreviation of the State, reservation, grant or pri claim, upon which the section line closes, with the exception in the case of an interior closing section corner, the township 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 10
S 16
S 15
R 16 E
1916

267. *Corners common to four sections* are to be marked: (a) an exterior, with the township (or range) common to the adjoi townships, the ranges (or townships) upon the opposite sides of exterior, and the sections; and (b) a subdivisional corner, with township, range and sections; all appropriately set forth as foll

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 1
S 23 | S 2
S 26 | S 2
1916

268. *Section corners common to two sections only* are to be mar with the township and range on the half facing the sections to wh the corner belongs, and the sections in the proper quadrants; (as far as known at the time) the township, range and section u

›pposite half, except that in the case of an interior corner, the ship and range numbers will not be repeated; as for example:

14 S / S 12	T 14 S
S 13 / 17 E	R 18 E / S 7
1916	

T 27 N / S 31	R 17 W / S 32
T 26 N R 17 W / S 6 / 1916	

T 14 S / S 10	R 20 W / S 11
S 14 / 1916	

9. *Section corners referring to one section only* are to be marked the township, range and section in the particular quadrant h is concerned; also (if known at the time) the section upon ›pposite part; as for example:

S 10
4N
3W
; 16
1916

T 27 N
R 16 W
S 17
S 20
1916

S 28
T 57 N
R 63 W
S 34
1916

0. *Standard quarter-section corners* are to be marked "S C ¼" ;he section, all on the north half; as for example:

SC
¼ S 36
1916

1. *Quarter-section corners of maximum control* are to be marked n a meridional line, "¼" on the north, and the sections on the and west halves; and, (*b*) on a latitudinal line, "¼" on the and the sections on the north and south halves; as for example:

¼
S 13 | S 18
1916

¼ S 21 / S 28
1916

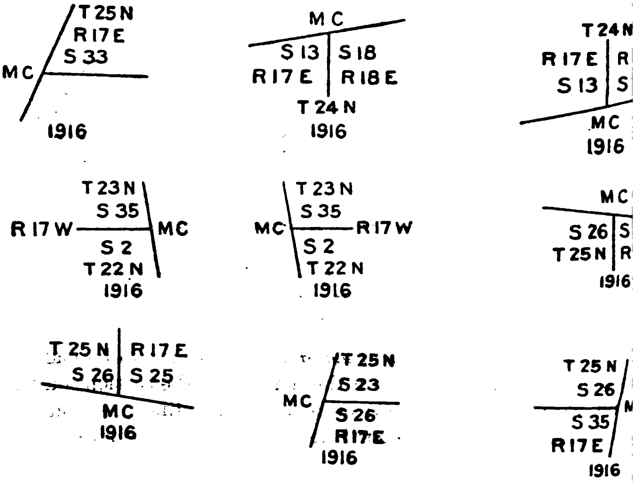
2. *Quarter-section corners of minimum control* are to be marked and the section, all on the half toward the particular section h is concerned; as for example:

¼ S 4
1916

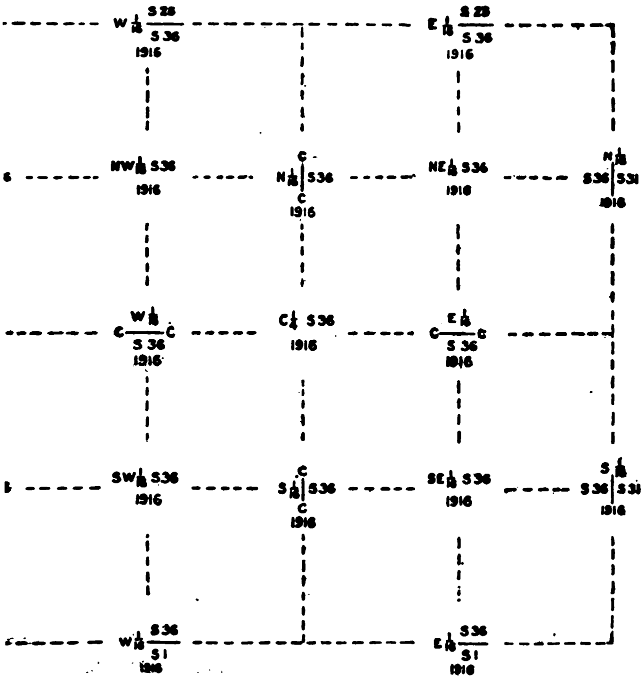
¼ S 16
1916

| ¼ S 7
1916

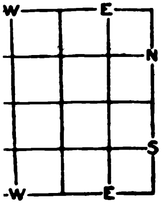
273. *Meander corners* are to be marked "M C" on the half to the meanderable body of water, and the additional marks (*a*) standard parallel or other line controlling surveys to one side with the township, range and section toward the surveyed (*b*) on an exterior, with the township (or range) common t adjoining townships, the ranges (or townships) upon the op sides of the exterior, and the sections; and, (*c*) on a subdivis line, with the township, range and sections; all appropriatel forth as follows:



274. *The interior quarter-section and all sixteenth-section cor* when required by the written special instructions, are to be ma in accordance with the scheme shown in the following diagram



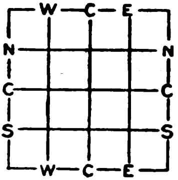
5. *Sixteenth-section corners of minimum control* are to be marked a key letter (N, E, S or W), to indicate the position of the ıment, and "$\frac{1}{16}$" and the section, all on the half toward the cular section which is concerned; as for example:



Key

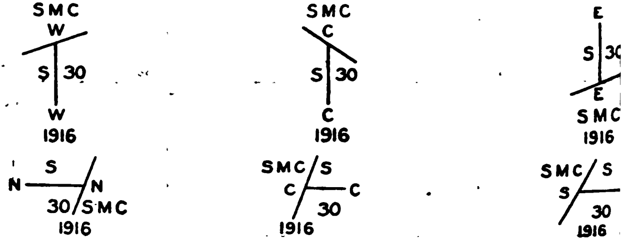
276. *Special meander corners* are to be marked in accordance w the following scheme:

Key letters (N, E, S, W or C) will be used in pairs to indi the position of the subdivision - of - section line.



Key

The marks "S M C" will be placed on the half toward the m derable body of water, and the section on the opposite half, as example:

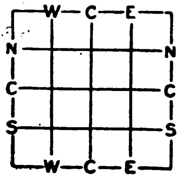


277. *Auxiliary meander corners* will be marked "A M C" and township, range and section; as for example:

A M C
T 64 N R 37 W
S 29
1916

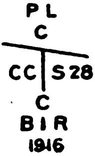
278. *Closing subdivision - of - section corners* are to be marked accordance with the following scheme:

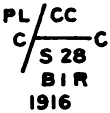
Key letters (N, E, S, W or C) will be used in pairs to indic the position of the subdivision - of - section line.

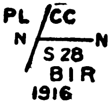


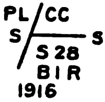
Key

marks "C C" and the section will be placed on the half from the closing line approaches the monument.
e marks "B I R" indicate "Blackfeet Indian Reservation.")



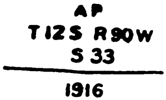




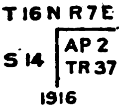


Markings for miscellaneous angle points along irregular aries:

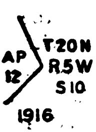
For "angle point No. 4" on the boundary of the "Blackfeet Indian Reservation," falling on surveyed land.



For "angle point" on the south boundary of section 33, superseding an old standard corner on a defective line, not subject to rectification.



For "angle point No. 2" on the boundary of a private claim ("Tract No. 37") falling on surveyed land.



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 bound

139 M
N MEX
TEXAS
1916

For "139th mile corner" on the boundary line between the States of "New Mexico and Texas."

B I R PL
3 M
1916

For "3d mile corner" on the boundary of the "Blackfeet Indian Reservation," falling on unsurveyed land.

B I R T 25 N
13 M R 17 W
S 25
1916

For "13th mile corner" on the boundary of the "Blackfeet Indian Reservation," falling on surveyed land.

MARKS ON STONE MONUMENTS.

281. Where a stone monument is established the letters, fig and grooves will be cut on the exposed faces or sides of the s but not on its top or end; the notches will be cut upon the ex vertical edges. Grooves are employed where the faces of a are oriented to the cardinal directions, and notches where the ve edges are turned to the cardinal points. All marks will be from 1 to 1½ inches in size, and will be plainly and perman chiseled into the stone.

282. *Standard township corners* (oriented with the faces t cardinal directions) are to be marked "S C" on the north face, the township on the same face, and the ranges on the adjoining f as for example:

S C 25 N on N.,
18 E " E., and
17 E " W. face.

288. *Closing township corners* (oriented with the faces to cardinal directions) are to be marked "C C" and with six (or f grooves on the face from which the closing line approache monument—the grooves to indicate the normal number of (or fractional parts) from the monument to the adjoining tow ner—with the township (or range) on the same face, and the nges (or townships) on the adjoining faces; also the initials or breviation of the State, reservation, grant or private claim, on e face toward such irregular tract as may be closed upon; as for ample:

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 cardinal points) are to be marked with the townships on the rtheast and southwest faces, and the ranges on the southeast and rthwest 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 es to the cardinal directions) are to be marked with the town- ip (or range) common to both on the face toward the townships, l 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 ges to the cardinal points) are to be marked with the township d range on the face toward the particular township; as for ample:

23 N 7 W on NW. face.

287. *Standard section corners* (oriented with the faces to the car- nal directions) are to be marked "S C" on the north face, and ith from one to five grooves on the east and west faces, the grooves

to indicate, respectively, the number of miles from the monumen 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 s tions 35 and 36).

288. *Closing section corners* (oriented with the faces to the cardi directions) are to be marked "C C" and with from one to six groo on the face from which the closing line approaches the monume and from one to five grooves on each of the adjoining faces— grooves to indicate the number of miles (or fractional parts) fr the monument to each of the three (regular) township bound lines in the same directions, respectively—also the initials abbreviation of the State, reservation, grant or private claim, the face toward such irregular tract as may be closed upon; as example:

2 grooves on E.,
C C and 6 " " S., and
4 " " W. face (on line between s tions 2 and 3 clos on a standard p allel).

289. *Corners common to four sections* (oriented with the edges the cardinal points) are to be marked (*a*) on an exterior, with fr one to five notches each on two opposite edges, north and south on meridional line, and east and west on a latitudinal line, each indicate, respectively, the number of miles from the monument the adjoining (regular) township corner; and (*b*) a subdivision corner, with from one to five notches on the east and south edg each to indicate, respectively, the number of miles from the mon ment to the (regular) east and south township boundary lines; t subdivisional section corners of a fractional township will be mark with reference to the theoretical position of normal east and sou boundaries, whether surveyed or not; as for example:

2 notches on N. and 4 notches on S. edge (for corner of se tions 7, 12, 13 and 18 on a range line).
2 notches on E. and 4 notches on W. edge (for corner of se tions 2, 3, 34 and 35 on a township line).
2 notches on E. and 4 notches on S. edge (for corner of se tions 10, 11, 14 and 15 of a subdivisional survey).

. *Section corners common to two sections only* (oriented with edges to the cardinal points) are to be marked with the sections on faces toward the particular sections to which the corner belongs; r 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).

. *Section corners referring to one section only* (oriented with dges to the cardinal points) are to be marked with the section e face toward the particular section which is concerned; as for ple:

S 17 on NW. face (for southeast corner of section 17).

. *Standard quarter-section corners* (oriented with the faces to rdinal directions) are to be marked "S C ¼" on the north face.

. *Quarter-section corners of maximum control* (oriented with the to the cardinal directions) are to be marked (*a*) on a meridional "¼" on the west face; and (*b*) on a latitudinal line, "¼" on the face.

. *Quarter-section corners of minimum control* (oriented with the to the cardinal directions) are to be marked "¼" and the secall on the face toward the particular section which is cond; as for example:

¼ S 4 on S. face (for quarter-section corner on the north boundary of section 4).

. *Meander corners* (oriented with the faces to the cardinal tions) are to be marked "M C" on the face toward the meanble body of water, and with from one to six grooves on each of other faces, each to indicate the number of miles (or fractional s) from the monument to the (regular) township boundary line he 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
to the cardinal directions) are to be marked "S M C" or "A M
as the case may be, on the face toward the meanderable bo
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 merid subdivision-of-section line in sectio on the south side of a meanderable of water).

S 20 on E., and
A M C " W. face (for auxiliary meander corner in sectio on the east side of a meanderable bo water).

MARKS ON TREE MONUMENTS.

297. Where the true point for a corner is found to fall in the tion occupied by a sound living tree, which is too large to be rem the tree will be made the monument. A tree will be remove is too small to be marked, and a witness corner will be establ in preference to marking an unsound tree, if the latter can n removed.

298. The species of the tree and its diameter, breast height, be noted, where a tree is to be made a monument, and the a priate marks will be made upon the trunk of the tree immedi above the root crown. A series of marks to be made upon a pa lar side of a tree will be scribed in a vertical line reading down

299. In the case of certain trees, including the aspen, beech locust (smooth, thin and permanently barked from sapling to turity), the marks may be made preferably by scribing well int bark and cambium (or live wood tissue) without blazing; the m thus made will remain and be visible as long as the tree is so on the other hand, in the case of practically all rough barked t the marks should be scribed into a smooth, narrow, vertical b specially prepared by removing just enough of the outer grow expose a flat surface of the live wood tissue immediately un neath the bark; the marks thus made will remain as long as the is sound, but the blaze and marks will be covered by a gradual o growth, showing an outward scar for many years. In regions ject to heavy snowfall it is desirable to make a small additi blaze at a height of 6 or 8 feet above the ground, which will s to attract attention to the tree during the winter season. The all blazes should be smoothed off gradually without making a rp cut into the cambium. The lower end of the blaze upon ich the marks are placed should be about 6 inches above the root wn, and its length should be just sufficient to take the marks.

The practice relating to the manner of marking trees, as above lined, is designed to cause the least possible injury to the tree, enabling a rapid overgrowth; also, to place the marks in a position re they will remain on the stump if the trunk should be re-ed. Various practices have obtained in the past in different lities, some of which are objectionable by causing unnecessary ry to a tree, or on account of the marks being placed in a position re there is danger of their removal with the trunk in case the is cut down.

00. The above theory applies equally to the marking of bearing s, and the surveyor is advised, when making retracements, re-eys, etc., not to remove the overgrowth on a tree monument or ing tree unless it is absolutely necessary to do so in order to tify positively the particular tree. In the case of trees which been blazed before marking, the number of rings contained in overgrowth (or its equivalent on the adjoining section of the) will furnish an exact count of the number of years (one annual for each growing season) from the date of original marking to late when uncovered. After an old blaze has been uncovered, litions are favorable for the decaying process to set in, and the eyor should adopt additional means to evidence the position e corner.

01. *Standard township corners* are to be marked "S C" and the nship on the north side, and the ranges and sections on the east 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.

02. *Closing township corners* are to be marked "C C" and the nship (or range) on the side from which the closing line ap-aches the monument, and the ranges (or townships) and sections the adjoining sides; also the initials or abbreviation of the State, ervation, grant or private claim, on the side toward any irregular ct 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 t township and section on the northeast and southwest sides, and t range and section on the southeast and northwest sides; as for e ample:

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 w the township, range and section on the sides toward the partic 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 w the township, range, and section on the side toward the partic 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 township and range on the north side, and the sections on the 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 township and range on the side from which the closing line approac the monument, and the sections on the adjoining sides; also initials or abbreviation of the State, reservation, grant or priv claim on the side toward any irregular tract which may be clo 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 exterior, with the township (or townships), ranges (or range) a sections; and (*b*) a subdivisional corner, with the township, ra 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.

9. *Section corners common to two sections only* are to be marked the township and section and the range and section on the toward the particular sections to which the corner belongs; r example:

T 14 S S 11 on NE., and
R 20 W S 10 " NW. side.

10. *Section corners referring to one section only* are to be marked the township, range and section on the side toward the parlar section which is concerned; as for example:

T 27 N R 16 W S 17 on NW. side.

11. *Standard quarter-section corners* are to be marked "S C ¼" the section, all on the north side; as for example:

S C ¼ S 36 on N. side.

12. *Quarter-section corners of maximum control* are to be marked on a meridional line, "¼" and the section on the west side, and section on the east side; and (*b*) on a latitudinal line, "¼" and section on the north side, and the section on the south side; as example:

S 18 on E., and
¼ S 13 " W. side.

¼ S 21 on N., and
S 28 " S. side.

13. *Quarter-section corners of minimum control* are to be marked " and the section, all on the side toward the particular section ich is concerned; as for example:

¼ S 7 on E. side (for quarter-section corner on the west boundary of section 7).

14. *Meander corners* are to be marked "M C" on the side toward meanderable body of water, and the additional marks (*a*) on a ndard parallel or other line controlling surveys to one side only, th the township, range and section on the side toward the sur-

veyed land; (*b*) on an exterior, with the township (or range) con to the adjoining townships on the side opposite the meande body of water, and the ranges (or townships) and the sectio the adjoining sides; and, (*c*) on a subdivisional line, with the t ship and range on the side opposite the meanderable body of w 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 standard parallel, e west side of a mea 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 on the north side of a meande 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 tow line, on the west side of a m 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 tudinal section line, on east side of a meande 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 merid section line, on the south si a meanderable body of wate

315. *Special and auxiliary meander corners* are to be ma "S M C" or "A M C", as the case may be, on the side toward meanderable body of water, and the section on the opposite as for example:

M C on E., and
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).

M C on N., and
9 " S. side (for auxiliary meander corner in section 9, on the south side of a meanderable body of water).

CORNER ACCESSORIES.

. The purpose of a corner accessory is to evidence the position original monument. A connection is made from the monu- to fixed natural or artificial objects in its immediate vicinity, by the former may be relocated from the latter, thus in the of the destruction or removal of the corner monument, its l position may be identified as long as any part of the acces- remains in evidence. The accessories consist of three general , one or more of which are to be employed at each and every established in the public-land surveys, preference being to the same in the order of their permanency conditional he character of the ground in the locality of the monument, ows:

) Bearing trees, or other natural objects such as notable cliffs ulders; permanent improvements; and memorials; (*b*) mound e; and (*c*) pits.

. The surveyor can not perform any more important service nection with his official duties than to employ whatever may be necessary permanently and accurately to evidence ation of the legal corners established in his survey, and where ual accessories, or combinations of the same, can not be em- l, such other means should be adopted as will best serve the e.

. The accessories for witness corners will be the same as though rner were established at its true point, but the marks upon aring trees or other objects will be preceded by the letters ", and the section number will be made to agree with the ı in which the tree or object actually stands.

BEARING TREES, BEARING OBJECTS, AND MEMORIALS.

319. Bearing trees, or other natural objects, are to be sele for marking when the same are available within a distance chains of the corner monument, and where the regular quota, l inafter described, is not available, one tree or object will be ma in each section affording such accessory. A full description o tree or object will be embodied in the field notes as a part of record of the corner monument. One tree, or object, will be ma in each section cornering at the monument, when available, and true course and horizontal distance from the exact corner poi the center vertical axis of the tree at its root crown, or to the (X) upon a marked object, will be carefully determined recorded with the description of the tree, or object, and its m The species of a tree and its diameter, at breast height, wi recorded; and, in the case of a cliff or bowlder, the description embrace such essential details as may be necessary to serve f ready identification.

320. The marks upon a bearing tree will be made upon the facing the corner and will be scribed in the manner already out for marking tree corner monuments. The marks will embrace information suggested in the schedule hereinafter given, with letters and figures as may be appropriate for a particular corner will include the letters "B T"; a tree will always be marked to with the section in which it stands, and will be marked in a ve line reading downward, ending in the letters "B T" at the l end of the blaze approximately 6 inches above the root crown

321. There is a great difference in the longevity of trees, ar their rate of decay, etc.; trees should therefore be selected, if poss with a view to the length of their probable life, their sound favorable site conditions and size. Sound trees from 6 to 8 in in diameter, of the most hardy species, favorably located, are t preferred for marking. Trees less than 4 inches in diameter not be selected for marking if larger trees are available, and generally better to avoid marking fully matured trees, espec those showing signs of decay. Trees less than 4 inches in diam if no better trees are available, will be marked with the le "B T" only. The species, size and exact position of the bea trees are of vital importance, as this data will generally serv identify a bearing tree without uncovering the marks, or eve identify two or more stumps after all evidence of the marks disappeared.

22. Generally only one tree will be marked in each section at rticular corner, but in certain instances, hereinafter described, trees are required in a section. In such cases it is better to ct trees of different species, or of widely different size, direction istance, if the trees are of the same species, in order that confusion be avoided in the future identification of a remaining tree where companion tree has disappeared.

23. A cross (X) and the letters "B O" and the section number be chiseled into a bearing object, if it is of rock formation, the record should be such as to enable another surveyor to mine where the marks will be found.

24. A connection to any permanent artificial object or improvet may be included in this general class of corner accessories. field notes should be explicit in describing such objects, and ld indicate the exact point to which a connection is made, as thwest corner of foundation of Smith's house," "center of h's well," "pipe of Smith's windmill," etc. No marks will be e upon private property.

5. In every case where it is impossible to make a single connecto a bearing tree or other bearing object, as above described, where a mound of stone or pits are impracticable, a suitable orial will be deposited at the base of the monument. A memonay consist of any durable article which will serve to identify ocation of the corner in case the monument is destroyed. Such les as glassware, stoneware, a marked (X) stone, a charred , a quart of charcoal, or pieces of metal will constitute a suitmemorial. A full description of such articles will be embodied e field notes wherever they are employed as a corner accessory.

MOUND OF STONE.

6. Where native stone is available and the surface of the ıd is favorable, a mound of stone will be employed as an acry to a corner monument, provided that a full quota of trees or r bearing objects can not be utilized. A mound of stone erected corner accessory will be built as stably as possible, will consist ot fewer than five stones, and will be not less than 2 feet and 1½ feet high. In stony ground the size of the mound will ufficiently increased to make it conspicuous. The position of mound will be as shown in the schedule hereinafter stated, and nearest point on its base will be separated about 6 inches distant the monument. The field notes will show the size and posiof the mound.

827. Where it is necessary to support a monument in a st mound, no additional mound will be employed as an accessory; a if bearing trees or other objects are not available, a marked (stone or other memorial will be deposited at the base of the mo ment.

PITS.

828. Where the full quota of trees or other bearing objects unavailable for marking, the position of the monument will, un certain favorable conditions, be evidenced by pits. No pits sho be dug in a roadway, or where the ground is overflowed for any c siderable period, or upon steep slopes, or where the earth will wa or in a loose or light soil, or where there is no native sod, or wh suitable stone for a mound is at hand.

A firm soil covered with a healthy native sod is most favor for a permanent pit. Under such conditions the pits will gradu fill with a material slightly different from the original soil, and a species of vegetation will generally take the place of the nat grass; these characteristics, under favorable conditions, mak possible to identify the original location of the pits after the la of many years.

829. All pits will be dug 18 inches square and 12 inches de with the nearest side 3 feet distant from the corner monum oriented with a square side (and not a corner) towards the mo ment, arranged as shown in the schedule hereinafter given; earth removed will be scattered in such a way that it will not ag fill the pits. A description of the pits will be embodied in field notes, and will include, in every instance, a statement of th size and position; this is particularly important in view of fact that the practice herein outlined differs materially (in the int est of simplicity) from that set forth in earlier editions of the Man

ARRANGEMENT AND MARKING OF CORNER ACCESSORIES.

830. *Standard township corners.*
Standard section corners.

Two bearing trees, one in each section north of the stand parallel, each marked "S C" and the township, range and section;

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.

81. *Closing township corners.*
Closing section corners.
'wo bearing trees, one in each section to the right and left of the ing line, each marked "C C" and the township, range and tion; as

T 24 N R 18 E S 6 C C B T.

lound of stone, on the closing line.
hree pits, one on the closing line and one each to the right and on the line closed upon.

82. *Corners common to four townships.*
our bearing trees, one in each section, each marked with the nship, range and section; as

T 22 N R 17 E S 1 B T.

ound of stone, south of corner.
ur pits, one each on line north, east, south and west.

83. *Corners common to two townships only.*
wo bearing trees, one in each section cornering at the monument, marked with the township, range and section; as

T 2 N R 7 W S 1 B T.

ound of stone, on the line between the two townships cornering e monument.
hree pits, one each on the three lines connecting at the ument.

84. *Corners referring to one township only.*
wo bearing trees, both in the township cornering at the monument, marked with the township, range and section; as

T 23 N R 19 W S 36 B T.

ound of stone, in the township cornering at the monument, at from cardinal direction at the monument.
wo pits, one each on the two lines connecting at the monument.

85. *Corners common to four sections.*
our bearing trees, one in each section, each marked with the nship, range and section; as

T 26 N R 17 E S 35 B T.

ound of stone, west of corner.
our pits, one in each section northeast, southeast, southwest and thwest.

86. *Section corners common to two sections only.*
wo bearing trees, one in each section cornering at the monument, 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 cornerii the monument.

Two pits, one in each section at 45° from cardinal direction at monument.

337. *Section corners referring to one section only.*

Two bearing trees, both in the section cornering at the monum 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 from cardinal direction at the monument.

Two pits, one 3 feet and one 6 feet distant, both in the section nering at the monument, at 45° from cardinal direction at the m ment.

338. *Standard quarter-section corners.*

Two bearing trees, both north of the standard parallel, each ma "¼" and "S C" and the section; as

¼ 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 "¼" and section; as

¼ S 16 B T.

Mound of stone: (*a*) On a meridional line, west of corner; (*b*) on a latitudinal line, north of corner.

Two pits, one in each direction on the line passing through monument.

340. *Quarter-section corners of minimum control.*

Two bearing trees, both in the particular section which is cerned, each marked "¼" and the section; as

¼ S 7 B T.

Mound of stone, in the particular section which is concerned, cardinal direction from the monument.

Two pits, one in each direction on the line passing through monument.

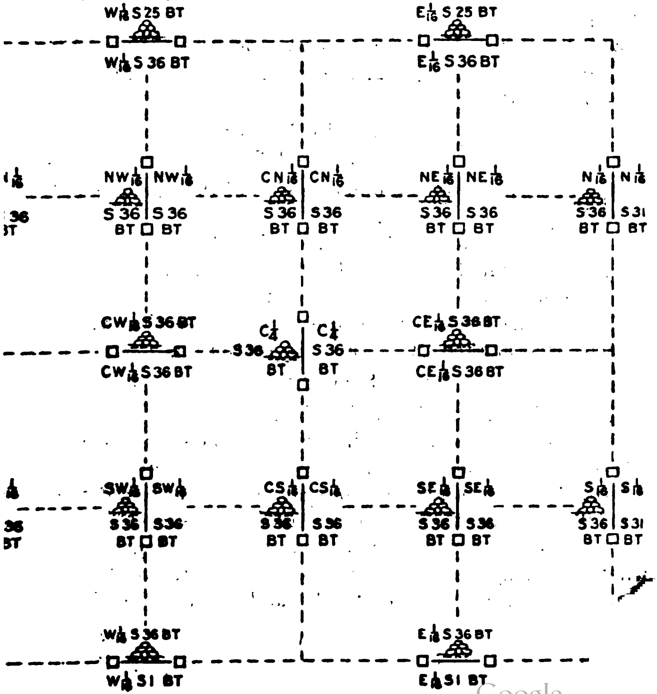
341. *Meander corners.*

Two bearing trees: (*a*) On a standard parallel or other line trolling surveys to one side only, both in the particular se which is concerned: and (*b*) on all other lines, one in each se he right and left of the line; all marked "M C" and with the nship, range and section; as

T 25 N R 14 E S 32 M C B T.

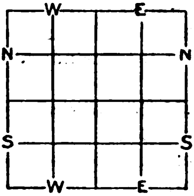
ound of stone, on the surveyed line on the opposite side of the iument from the meanderable body of water.
wo pits, one 3 feet and one 6 feet distant, on the surveyed line he opposite side of the monument from the meanderable body rater.

12. *The interior quarter-section and all sixteenth-section corners,* n required by the written special instructions.
wo bearing trees, marked (with letters and figures ending in T") as shown in the following diagram:
ound of stone, in a cardinal direction from the monument, as n (with symbol " ") in the following diagram:
ro pits, in a cardinal direction from the monument, as shown ı symbol "□") in the following diagram:



343. *Sixteenth-section corners of minimum control.*

Two bearing trees, both in the particular section which is c cerned, each marked with a key letter (N, E, S or W) to indic the position of the monument, and "$\frac{1}{16}$" and the section; as



Key

N $\frac{1}{16}$ S 18 B T

Mound of stone, in the particular section which is concerned, a cardinal direction from the monument.

Two pits, one in each direction on the section line passing thro the monument.

344. *Special and auxiliary meander corners.*

Two bearing trees, each marked "S M C" or "A M C," as the c 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 t meanderable body of water.

Two pits, one 3 feet and one 6 feet distant, on the opposite side the monument from the meanderable body of water.

345. *Closing subdivision-of-section corners.*

Two bearing trees, both in the particular section which is co cerned, 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 a left on the line closed upon.

346. *Miscellaneous angle points along irregular boundaries.*

(*a*) Two bearing trees, where the monuments are less than 1 mi apart, one on each side of the boundary; and (*b*) four bearing tre where the monuments are 1 mile or more apart, two on each side the boundary; each marked "A P" and a serial or section numbe oth, also the initials or abbreviation of the State, reservation, t, 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).

ound of stone, on the medial line between the boundary lines secting at the monument, and in the direction toward the State, rvation, grant or private claim.

o pits, one in each direction on the lines intersecting at the ment.

7. *Intermediate corners along irregular boundaries.*

Two bearing trees, where the monuments are less than 1 mile , one on each side of the boundary; and (*b*) four bearing trees, e the monuments are 1 mile or more apart, two on each side of boundary; each marked with the number of the mile or half-corner and the letter "M" (to indicate "mile corner"), and initials or abbreviation of the State, reservation, grant, private a or public land, as appropriate; as

7 M COLO BT, and
7 M OKLA BT (for "47th mile" corner on the boundary line between the States of "Colorado" and "Oklahoma").

und of stone, on a line at right angles to the boundary, and in tion toward the State, reservation, grant or private claim.

o pits, one in each direction on the boundary.

CHAPTER V.

RESTORATION OF LOST CORNERS.

IDENTIFICATION OF EXISTENT CORNERS.

348. It is the purpose of this chapter of the Manual to outline guiding principles which are to be observed in the identification existent corners, and thereafter to set forth the particular rules ich are to be applied in the recovery of the position of lost corners ginally established in the execution of the United States rec-gular surveys.

ll surveyors, whether employed by the United States or not, cautioned to note the difference between the regulations per-ning to the establishment of the original surveys of the public ds and those relating to the subsequent identification of said cial surveys and the replacement of missing monuments thereof. n the extension of the rectangular surveys it devolves upon the ited States surveyor to identify the initial lines of his group and replace all lost corners thereof. On the other hand in the sub-vision of sections and in the location of property lines generally, falls to the county or other local surveyor to identify the official rners, and where a required corner is missing the local surveyor ll be called upon to recover the point. Thus it will be seen that cal as well as United States surveyors are constantly called upon search for existing evidence of original monuments, and in this ork the surveyors will be guided by the same general methods. hould the search for a monument result in failure, the appropriate storative surveying process to be observed by either surveyor will based upon the same rules as hereinafter outlined. The text at follows draws no distinction between the duties of the two asses of surveyors.

349. The terms "corner" and "monument" are used largely in e same sense, though a distinction should be noted to clarify the ubject matter of this chapter. The term "corner" is employed denote a point determined by the surveying process, whereas the monument" is the physical structure erected for the purpose of arking the corner point upon the earth's surface.

350. An existent corner is one whose position can be identi by comparing the evidence of the monument or its accessories the ground, with the record contained in the field notes of original survey, or where the point can be determined otherw by suitable testimony.

351. The process of again bringing to light the physical evide of an original monument is founded on the principle of intellig search for the calls of the field notes of the original survey, gui by the controlling influence of known points. The probl incident to the search are vastly simplified whenever a retracem may be projected from known points, and the final search fo monument should cover the zone surrounding one, two, three four temporary points as may be determined by connections w known corners in one, two, three or four directions, accordin the number of points which will ultimately control the relocat in case the corner in question should be declared lost.

352. The character of the original monument is the most imp tant factor in regard to its lasting qualities, and the search sho be directed to an examination for such evidence as may reasona be expected to remain. The evidence is bound to range fr that which is least conclusive to that which is unquestionable, a the requisite support of corroborative evidence is necessary direct proportion to the uncertainty of any feature regarding wh authenticity there may be danger of dispute.

A stone, wooden post, tree corner, deposit corner, and the mode iron post monument are all subject to more or less deteriorati changes through various influences, depending upon the charac of the original monument, its local site conditions, and the lapse time, and all such factors should be taken into consideration wh comparing the particular evidence in question with the descripti contained in the original field notes.

353. If the evidence of the monument is not fully conclusive, t surveyor's attention will be directed at once to the record acce sories; this step is so generally necessary that it should be considere simultaneously with the search for the monument; in fact, in the broader significance the accessories are a part of the monument.

The underlying principles relating to the identification of th corner accessories, subject to the changes which may be expected i the period intervening after the date of the original survey, hav already been fully outlined in Chapter IV. It will suffice to stat

the evidence of the accessories should agree with the record
ined in the field notes of the original survey, subject only to
changes as may reasonably be expected.

l. In case of material disagreement between the particular
nce in question and the record calls, the process of elimina-
of those features regarding which there may be doubt, after
ng due allowance for natural changes, will serve a most useful
se, as follows:

The character and dimensions of the monument in evidence
l not be widely different from the record;

The markings in evidence should not be inconsistent with
cord; and,

The nature of the accessories in evidence, including size,
on and markings, should not be greatly at variance with the
l.

ertain measure of allowance for ordinary discrepancies should
into the consideration of the evidence of a monument and its
ories, and no definite rule can be laid down as to what shall be
ent evidence in such cases. Much must be left to the skill,
y and good judgment of the surveyor in the performance of
ork, ever bearing in mind the relation of one monument to
er, and the relation of all to the recorded natural objects and
of topography.

. A corner will not be considered as lost if its position can be
ered satisfactorily by means of the testimony and acts of wit-
having positive knowledge of the precise location of the
al monument. The expert testimony of surveyors who may
identified the original monument prior to its destruction and
upon recorded new accessories or connections, etc., is by far
nost reliable, though landowners are often able to furnish
ble testimony. The greatest care is necessary in order to
lish the bona fide character of the record intervening after the
ction of an original monument. Full inquiry may often
to bring to light various records relating to the original corners,
memoranda of private markings, etc., and the surveyor should
use of all such sources of information. The matter of boundary
tes should be carefully looked into in so far as adverse claimants
base their contentions upon evidence of the original survey,
f such disputes have resulted in a boundary suit, the record
nony and the court's decision should be carefully examined.

relative to any information which may shed light upon the pos of an original monument.

The testimony of individuals may relate to knowledge of the inal monument or the accessories, prior to their destruction, any other marks fixing the locus of the original survey, and the of such testimony may be weighted in proportion to its complet and agreement with the calls of the field notes of the original su also upon the steps taken to preserve the location of the ori marks. All such evidence should be put to the severest pos tests by confirmation relating to known original corners and calls of the original field notes, particularly to line trees, bl lines and items of topography.

It is impossible to outline a definite rule for the acceptan non-acceptance of the testimony of individuals. Corroborative dence becomes necessary in direct proportion to the uncertain the particular statements advanced by the individual who test It will be well for the surveyor to bear in mind that confli statements and contrary views of interested parties are fruitf boundary disputes.

356. In those cases where witness corners were established i original survey, the true point for the corner will be controlle such witness corner, when the latter can be identified, by refer to the record in accordance with the general plan of the sur The usual diligent search will be made for witness corners, but w the same can not be identified the position of the true point fo corner will usually be of major importance, rather than the p for the witness corner, and in such instances the surveyor will ceed directly to the re-determination of the true corner posi adopting the particular methods which should govern the cas hand. Should it become necessary to restore a lost witness co the general principles hereinafter outlined will be observed.

357. In the absence of an original monument, a line tree, or a nite connection to natural objects, or to improvements, which be identified, may each fix a point of the original survey both latitude and departure. The mean position of a blazed l when identified as the original line, may sometimes help to f meridional line for departure, or a latitudinal line for latitude. O calls of the original field notes in relation to various items of topo phy may assist materially in the recovery of the locus of the orig survey. Such evidence may be developed in an infinite vari

ay be only such as to disprove other questionable features, may guide the surveyor in a general way in arriving at the diate vicinity of a line or corner, or in its best phases may be as to fix the position of a line or corner beyond any doubt.

3. A certain measure of allowance should be made for ordinary pancies in the calls relating to items of topography. Such nces should be considered more particularly in the aggregate, when they are found to be corroborative an average may be ed to control the final adjustment, which will be governed y by the evidences nearest the particular corner in question, g the greatest weight to those features which agree most har- ously with the record, and to such items as afford definite con- on. A careful analysis will generally reveal the merits of au- ic evidences as opposed to unreliable features bearing re- lance to the calls of the field notes, and in this matter the sur- will find an opportunity to exercise his skill to the fullest ity.

l. It is a matter of utmost importance to determine where an ified call of the original field notes shall operate to control for latitude and departure, or for either coördinate by itself, and y as to the necessity for applying the rules for proportionate urement where the distance between the identified points is derable.

RESTORATION OF LOST CORNERS.

0. A lost corner is a point of a survey whose position can not termined, beyond reasonable doubt, either from original traces m other reliable evidence relating to the position of the original ment, and whose restoration on the earth's surface can be nplished only by means of a suitable surveying process with ence to inter-dependent existent corners.

1. The surveyor is not prepared to consider the restoration of t corner until he has exhausted every other means of identifying riginal position, and at this stage of his work he should have mined upon an approximate position of the original monument d upon his findings resulting from retracements leading from m corners to the lost corner, from one, two, three or four direc- in accordance with the plan of the original survey. The prin- of proportionate measurement, which most nearly harmonizes eying practice with the legal and equitable considerations lved in controversies concerning lost land boundaries, enters

into the problem at this stage, and this plan of relocating a l corner will always be employed unless outweighed to the contr by physical evidence of the original survey. In cases where relocated corner can not be made to harmonize with all the c of the original field notes, due to unexplained discrepancy wh is made apparent by the retracement, the surveyor is required determine which calls will be given major control, and those wh must be subordinated.

862. The preliminary retracements furnish the only possi means of arriving at the discrepancies of the courses and distan of the original survey as compared with those derived in the pro of re-running the lines, and the whole problem of proportionate me urement is one involving the adjustment of said discrepancies. T restoration of the lost corners can not proceed until the retracem of the original survey has been completed. The retracement be based upon the courses and distances returned in the field n of the original survey, or the equivalent by calculation, initia and closed upon known original corners. Temporary stakes future use in the relocation of all lost corners may be set w making the retracements.

863. As has been observed, existing original corners can not disturbed; consequently discrepancies between the new and original record measurements of the line connecting the identi original corners will not in any manner affect measurements bey said corners, but the differences will be distributed proportion within the several intervals embraced in the line in question.

864. A proportionate measurement is one resulting in concord relation between all parts of an original record length of a line the new distances given to the several parts as determined by re-measurement, in such a manner that the new distance give any part of a line shall bear the same relation to the original rec length of that part of the line as the new measurement of the wh line bears to the original record length of said line. The ordin field problem consists in distributing the excess or deficie determined by comparing the new measurement with the rec distance between two original existent monuments, in such a m ner that the amount of excess or deficiency given to each inter shall bear the same proportion to the whole difference as the rec length of the interval bears to the whole record distance. Af having applied the proportionate difference to the record length

h interval the sum of the adjusted lengths will equal the new asurement of the whole distance.

365. The term "single proportionate measurement" is applied a new measurement made on a single line to determine the posi-n thereon for restoring a lost corner, for example, a quarter-section ner on line between two original section corners. The term ouble proportionate measurement" is employed to signify new asurements made between four original corners on intersecting ridional and latitudinal lines for the purpose of fixing by relation both lines the position of a lost corner, for example, a corner mon to four sections or four townships.

366. It will almost invariably happen that discrepancies will be eloped between the new measurements and the original measure-nts recorded in the field notes. When these differences occur the veyor will generally be required to adopt a proportionate asurement based upon a process conforming to the method bwed in the original survey. The principle of the preponder-e of one line over another of less importance is recognized, in er to determine upon the procedure relative to single or double portionate measurement, or other rule to be adopted in order imit the control and at the same time harmonize the restorative cess with the method followed in the original survey. Thus ndard parallels will be given precedence over other township eriors, and the latter will be given precedence over subdivisional s; section corners will be relocated before the position of lost rter-section corners can be determined.

PRIMARY METHODS.

(a) DOUBLE PROPORTIONATE MEASUREMENT.

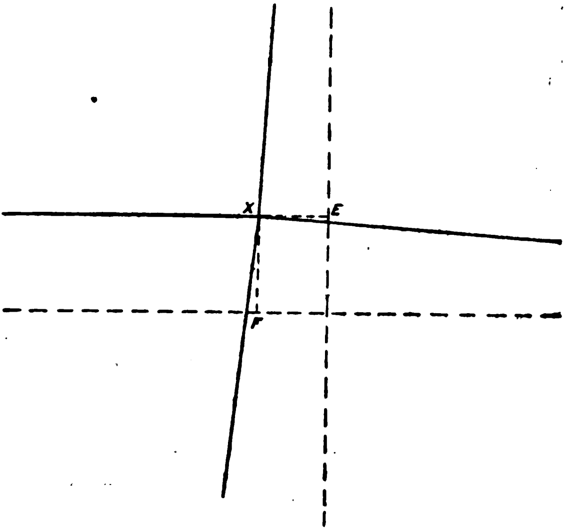
367. The method of double proportionate measurement is generally licable to the restoration of lost corners of four townships and of interior corners of four sections. It is the best example of the ic principle that monuments north and south should control the itudinal position of a lost corner, and monuments east and west uld control the longitudinal position of a lost corner, upon a plan which the influence of one identified original corner is balanced the control of a corresponding original corner upon the opposite e of a particular missing corner which is to be restored, each ntified original corner being given a controlling weight inversely portional to its distance from the lost corner.

368. In order to restore a lost corner of four townships whe of the connecting lines have been established in the field, a ret ment will first be made between the nearest identified ori corners on the meridional line, north and south of the missing co upon which line a temporary stake will be placed at the p proportionate distance. This will determine the latitude o lost corner. Next, the nearest original corners on the latitudina will be connected and a point thereon will be determined by portionate measurement in a similar manner, independent o temporary stake on the meridional line. The second temp point will determine the position of the lost corner in depa Then through the first temporary stake run a line east or west through the second temporary stake a line north or south, as rel situations may determine. The intersection of the two lines las will define the position of the restored corner by "double pr tionate measurement."

369. In the accompanying diagram the points "A," "B," and "D" (on the small scale) represent four original corners; (on the large scale) "E" represents the proportional point bet "A" and "B," for measurement only, and similarly, "F" repre the proportional point between "C" and "D." The point satisfies the first control for latitude, and the second contro departure.

370. The plan of double proportionate measurement wil applied to the restoration of lost corners of four townships whe the lines therefrom have been run. Lost interior corners of sections, where all the lines therefrom have been run, will als reestablished by double proportionate measurement, *after* relocating the required lost section corners on the township exte When a number of corners of four sections, and the interme quarter-section corners, are missing on all sides of the one so to be reestablished, the entire distance must, of course, be measured between the nearest identified corners both north south, and east and west, in accordance with the rule laid dow

371. Where one of the connecting lines has not been establi in one direction from the missing township or section corner, record distance to the nearest identified corner in the opp direction will prevail in lieu of a proportional measurement. T in the same diagram, if the latitudinal line in the directio the point "D" had not been established in the original survey,



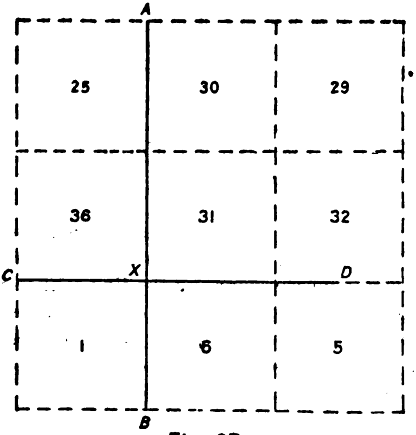


Fig. 67.

position of the point "F" in departure would have been d mined by reference to the record distance from the point " whereupon the point "X" would have been fixed by cardinal of from the points "E" and "F" as before. Again, in rare instar where the intersecting lines have been originally establishe only two of the directions, the record distances to the nearest i tified corners on the two lines will control the position of the t porary points from which the cardinal offsets are to be made.

(b) SINGLE PROPORTIONATE MEASUREMENT.

372. The method of single proportionate measurement is ge ally applicable to the restoration of lost corners on standard para and other lines established with reference to definite alinemen one direction only. Intermediate corners on township exte and other controlling boundary lines are to be included in this c

373. In order to restore a lost corner by single proportio measurement, a retracement will be made connecting the nea identified regular corners upon the particular line in question, record of which shows no deflection in alinement; a temporary st will be set on the preliminary line at the original record dista the total distance will be measured, also the falling at the objec corner. The temporary stake will then be adjusted for the portional part of the difference between the record distance the re-measurement, also for its proportional part of the fall Thus the adjusted position will fall on the true line connecting nearest identified corners, and at the same proportional inte from either as existed in the original survey. Any number of points, on the same straight line, may be recovered by the sa plan, setting a temporary corner for each at the time when mak the retracement. On the retracement of an east and west line, proper adjustments to secure the true latitudinal curve should allowed for as outlined in Chapter II.

374. Lost standard corners will be restored to their origi positions on a base line, standard parallel or correction line, single proportionate measurement on the line connecting the nea identified original standard corners on opposite sides of the miss corner or corners, as the case may be. The term "original stand corners" will be understood to designate standard township, sect and quarter-section corners, meander corners terminating t survey of a standard parallel, and closing corners in those ca where they were originally established during the survey of

ırd parallel as corners from which to project surveys to the
No other meander or closing corners along a standard par-
rill control the restoration of lost standard corners.

. All lost exterior section and quarter-section corners will be
ɔd by single proportionate measurement between the nearest
fied corners on opposite sides of the missing corner, north and
on a meridional line, or east and west on a latitudinal line,
he township corners have been identified or relocated. An
tion to this rule will be noted in the case of any exterior the
of which shows irregularities in alinement between the ter-
township corners. (See sec. 380.)

. All lost interior quarter-section corners will be restored by
proportionate measurement between the adjoining section
s, *after* the section corners have been identified or relocated.

. Lost meander corners, originally established on a line pro-
across the meanderable body of water and marked upon the
te side thereof will be relocated by single proportionate
rement, *after* the section or quarter-section corners upon the
te sides of the missing meander corner have been duly
fied or relocated.

(c) CLOSING CORNERS.

. In order to reestablish a lost closing corner on a standard
el or other controlling boundary, the line closed upon will be
ed, beginning at the corner on the standard parallel or other
lling boundary from which the connecting measurement was
ally made, itself properly identified or relocated; a temporary
will be set at the original record connecting distance, and the
listance and falling will be noted at the next regular corner on
posite side of the missing closing corner. The temporary stake
ıen be adjusted as in single proportionate measurement, i. e.,
osing corner will be reestablished on the true line closed upon
proper proportional interval between the nearest regular cor-
o the right and left. An identified closing corner not actually
d in the line closed upon will determine the direction of the
g line, but not its legal terminus; the latter is bound to fall at
ue point of intersection of the two lines. The position of a
ed closing corner should be verified by a retracement of the
whose terminus it was designed to mark. (See sec. 384.)

SECONDARY METHODS.

879. The following methods involve special applications of general rules of proportionate measurement for adoption in unu cases where the ordinary control can not be obtained.

(d) BROKEN BOUNDARIES.

880. In order to restore one or more lost corners on a broke irregular township exterior, or other controlling boundary, a retr

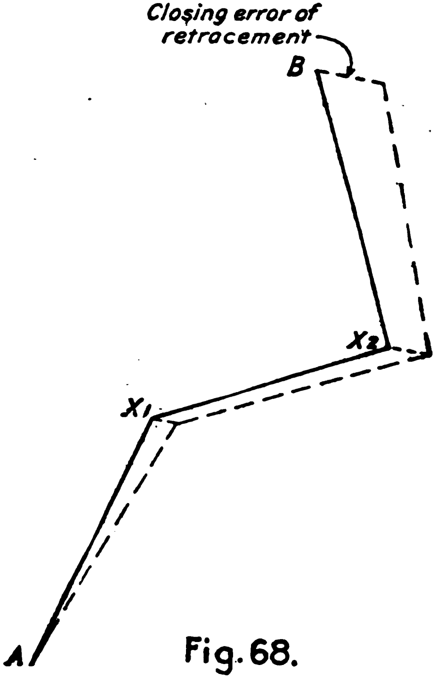


Fig. 68.

ment will be initiated at the nearest identified original corner on boundary, following out the record courses and distances, or equivalent by calculation, setting a temporary stake for each miss corner or angle point, until the next identified original corner been attained, where a final temporary stake will be set at the rec distance of the last course of the retracement. The closing error w be determined for course and distance from the last temporary to the objective original corner, and each temporary stake will ifter be adjusted on the bearing of the closing error, a propor- amount of the length of the closing error equal to the propor- part of the distance of the temporary stake from the initial of the retracement, i. e., the particular distance to be measured y temporary stake, on the bearing of the closing error, is to the length of the closing error as the distance of the particular orary stake from the initial original corner is to the whole ı of the retracement. Angle points and intermediate corners e treated alike.

(e) ORIGINAL CONTROL.

l. Where a line has been terminated with reference to a meas- ent in one direction only, a lost corner will be restored by refer- to the original record bearing and distance, counting from the st regular corner, the latter having been duly identified or ed. Examples will be found where lines have been discon- d at the intersection with large meanderable bodies of , or at the border of what was classed as impassable ground.

EX CORRECTION FOR AVERAGE ERROR IN ALINEMENT AND MEASUREMENT.

2. In unusual cases where a retracement has been made of miles of the original lines, between identified original corners, there has been developed a definite surplus or deficiency in urement, or a definite variation in alinement, characterizing riginal survey, it will be proper to make allowance for such ge "index error." Such adjustment will be taken care of natically in all cases where there exists a suitable basis for rtional measurement, but in any case where such control is ng, an index error, if conclusive, will be made use of by ying the determined correction to the record courses and dis- s. If there is not conclusive evidence of such index error the d courses and distances will be allowed to prevail.

SPECIAL CASES.

3. Examples of special cases could be set forth almost indefi- y, but without bringing out important new principles. In respects the treatment of a large number of special examples d serve to confuse the subject by seeming to warrant certain edure as a general rule which in fact would not be proper were

the conditions altered; the latter occur in an infinite varie
Ample provision has been made for the United States surveyor
call upon a supervising officer for advice in difficult cases, and wh
necessary the latter is in a position to direct the surveyor to proc
with additional retracements in order to develop any data wh
should be considered before a decision is rendered. In trials
boundary suits the court will generally consider many additio
questions besides those concerned in the technical problem, and
such instances an academic study of hypothetical examples mi
serve to cloud the real issue. It would be beyond the purpose
the Manual to invade the realm of non-technical matter wh
attempting to lay down the general principles involved in
restoration of lost corners.

384. In all unusual instances, where on account of mani
distortion, or through extensive obliteration resulting in gr
distances between existing corners, or otherwise, the evidence
survey can not be identified with sufficient certainty to enabl
suitable application of the various rules relating to the restorat
of lost corners, the surveyor is again advised to report the facts
the proper supervising officer. In the same connection, it is imp
tant that the surveyor should not be confused with the notion t
he is required, or has any authority, to revert to the princip
relating to the establishment of original surveys as an alternative
such cases. The methods incident to resurveys, as outlined in
next chapter, are designed to rectify unusual conditions which
widely at variance with the representations of the original approv
plat and field notes.

(g) MISCELLANEOUS CONTROL.

385. It will be apparent to the experienced surveyor that act
field conditions do not always furnish the basis for the applicat
of the rules heretofore set forth, and while developing a consist
theory to apply in unusual cases the surveyor will at once note t
the first consideration relates to a more or less arbitrary limitatio
the control to be adopted. No definite rule can be laid down, exc
that there should be the closest possible adherence to the basic exa
ples already given in the text. The methods heretofore outlin
readily harmonize surveying practice with legal decisions concerni
the restoration of lost corners. A strictly consistent mathemati
recovery of a lost corner, not based upon any known legal decisi
may be obtained by allowing every known corner within a reas

adius to enter into the control, each original corner being given ght inversely proportional to its distance from the missing ', and though the principle will lead to the same result in cases as by the methods previously outlined, it will yield a y different result under other regular circumstances. For the reason a miscellaneous control based upon such mathematical ple will not be adopted except as specifically approved by oper supervising officer after due consideration of the facts ard to the applicability of the method in the absence of a le basis for a regular control.

. Having thus safeguarded the application of the following d, the problem in the field will be developed by a series of re-ients each beginning at an accepted corner, thence following e record courses and distances, each retracement terminating mporary stake in the vicinity of the objective lost corner. take will be given a weight inversely proportional to the dis-from the accepted corner to which it is related. The several rary stakes will then be combined; the first two to be resolved point on the line between them, dividing the whole distance vo parts that will make the interval from either stake inversely tional to the weights previously assigned, and the latter point e given their combined weights. The last point will then be ited with the third temporary stake on a similar plan. Three e original corners will thus exercise their influence upon the esultant position for the corner which is to be restored. The will be the same no matter what the order of connecting the rary stakes may be, but the omission of any element of the l or the introduction of an additional original corner will alter ial position. The field of influence should accordingly be d with a view to obtaining a resultant balanced position which t be materially changed by the introduction of other known of control.

CHAPTER VI.

RESURVEYS.

JURISDICTION.

87. Certain important considerations are involved in the execu- 1 of Government resurveys of an entirely different character 1 those relating strictly to the making of original surveys; these siderations present matters not referred to in Chapter V. There twofold object of a resurvey: First, the adequate protection of sting rights acquired under the original survey in the matter of ir location on the earth's surface, and, second, the proper marking he boundaries of the remaining public lands.

88. As already noted in Chapter I, the Congress has authorized, ler certain conditions, the re-marking of the public-land surveys. e acts relating to resurveys contemplate a restoration of the ners of the original surveys in those townships, (*a*) where the iteration of the original monuments or other evidence of the ition of the original lines has become so advanced that the land indaries can be identified only through extensive retracements experienced surveyors of the General Land Office, and (*b*) where d investigation shows that conditions on the ground disagree with representations upon the original plat to such an extent that the d boundaries can not be identified positively in one position to exclusion of another, in consequence of which said plat should disqualified as a basis for the disposal of remaining public land. ile the Government may initiate a resurvey in the absence of any plication therefor, as a rule, the steps preliminary to the authori- ion of a resurvey will be taken by the settlers interested in the d, through a showing of facts made to the proper supervising cer, setting forth the existing conditions with respect to the ginal survey and status of ownership of the lands.[1]

[1] See current circular governing applications for resurveys.

389. The surveyor is advised to bear in mind the fact tha localities where resurveys are necessary the occasion for bound disputes is ever present; he should accordingly exercise the gre care in his technical work in the field and in the record thereo that the result of the resurvey shall relieve existing difficulti far as possible without introducing new complications. As in case of original surveys, the records of all resurveys must form enduring basis upon which depends the security of the title t lands acquired thereunder, and the field notes should be so prep that under the test of the closest possible scrutiny at all ti present and future, the record can be regarded as conclusive in matter of the location of such rights.

390. The General Land Office has exclusive jurisdiction all matters pertaining to surveys and resurveys affecting the pu lands; as between private owners of lands the title to which passed out of the United States, final determination in the ma of fixing the position of disputed land boundaries rests with the l court of competent jurisdiction. The rules of procedure laid d by the General Land Office to guide its surveyors in the re-mark of lines of previous surveys are intended to be in harmony with leading court decisions in suits involving boundary disputes, said rules should be so applied that the courts may, with secur accept without question the boundaries thus determined in so as they represent the true location of a particular tract inten to be conveyed by a patent. Government resurveys are un taken only by duly appointed United States surveyors act under the authority of the Secretary of the Interior through Commissioner of the General Land Office and under the immedi direction of subordinate supervising officers.

LIMIT OF AUTHORITY OF SURVEYOR.

391. There are certain questions of a purely judicial nat involved in resurveys of every description where the decision to be reserved to the General Land Office, particularly those relat to compliance with the general laws in respect to the entry of t public lands. Thus it comes within the realm of the survey process to identify and mark out on the ground the various le subdivisions of the public domain, but it is a judicial questi beyond the function of the surveyor to determine whether or n specified lands have been duly earned under a certain entry.

survey process the surveyor will determine whether or not embraced within a claim as occupied have been correctly d in position to the original survey, and where the demon-n of this question may be one involving more or less uncer-, as is often the case, the surveyor will examine and weigh idence relating strictly to the surveying problem involved, e will interpret the evidence in respect to its effect upon the er in which the resurvey shall be executed looking to the ction of the valid rights acquired under the original survey. urveyor has no authority to enter into any agreements looking exchange of one subdivision for another, or to bind the General Office in this particular.

BONA FIDE RIGHTS OF CLAIMANTS.

2. In order to carry out the provisions of the laws relating to rveys, the surveyor should understand fully the meaning of words "bona fide rights" and under what circumstances it will held that such rights have been impaired by a resurvey. In connection attention is again directed to the clause contained the act of March 3, 1909 (35 Stat., 845), as amended by joint lution approved June 25, 1910 (36 Stat., 884), which reads as ows:

'That no such resurvey or retracement shall be so executed as to air the bona fide rights or claims of any claimant, entryman, or er of lands affected by such resurvey or retracement."

he rights of claimants are to be given similar protection under provisions of the act of September 21, 1918 (40 Stat., 965).

93. It will be understood that bona fide rights are those acquired ood faith under the law. Rights of this character can be affected a resurvey only in the matter of POSITION OR LOCATION on the h's surface, and the surveyor will be concerned only with the stion as to whether lands covered by such rights have been ally LOCATED in good faith. Other questions of good faith, such riority of occupation, possession, continuous residence, value nprovements, and cultivation, when considered apart from the stion of the position of the original survey, do not in any manner t the problem of resurvey.

is evident that the resurvey must afford adequate protection ona fide rights vested in both improved and unimproved lands. he final determination of the true position of all lands, whether improved or unimproved, in the absence of original corners, necessity for more or less flexibility of method must be recogni: as the value of both of these classes of lands *may* be vitally affe by an arbitrary process of resurvey which is rigid in its applicat Unimproved lands, however, where no apparent attempt has b made on the part of the owner to identify the same under t original descriptions (and where the inherent value of the land question is the same), are not *necessarily* affected in the same man and such unimproved lands may be adjusted to a position fo by the surveyor to be conformable to adjoining or near-by tra where all may be held to qualify under the rule of acceptable l tion.

394. The question arises whether the technical rules for restoration of lost corners are to be rigidly applied in all cases reg less of their effect on the position of improvements, or whether position of all improvements is to be accepted without quest regardless of the relation or irrelation of such improvements to existing evidence of the original survey and to the descript contained in the entry. Manifestly these opposite extremes equally unacceptable. Somewhere between them, therefore, be found the basis for a determination of the question as to wl lands so improved are to be regarded as having been LOCATED good faith or otherwise. It is clear that no definite specific set rules can be laid down in advance for the determination of t question. This is a problem the solution of which must be fou on the ground by the surveyor; it is upon his judgment primar that the responsibility for a determination of the question of gc faith as to LOCATION must rest. The surveyor may err in his ju ment, but once this question is settled to his own satisfaction, t *procedure* to be adopted in the matter of the application of resurv rules is no longer in doubt.

395. It may be held generally that an entryman has located l lands in good faith (referred to herein as an acceptable location a claim or of a local point), when it is evident that his interpretati of the record of the original survey as related to the nearest existi corners at the time the lands were located (as defined by his fencin culture, or other improvements) is indicative of such a degree care and diligence upon his part, or that of his surveyor, in the asce tainment of his boundaries, as might be expected in the exercise ordinary intelligence under existing conditions. From this

lows that lack of good faith is not necessarily chargeable against entryman if he has not located himself according to a rigid appliation of the rules laid down for the restoration of lost corners, where mplicated conditions involve a double set of corners, both of hich may be regarded as authentic; or where the nearest existing rners in one or more directions are an excessive distance away; are improperly related to each other to an extraordinary degree: where all evidences of the original survey which had been adopted the entryman as a basis for his location have been lost before the survey is undertaken. Furthermore, the extent of recognition ven by neighboring claimants to a local point used for the control the location of claims very often carries with it the necessity for consideration by the surveyor of its influence in the matter of e acceptability of such locations under the foregoing rule of good ith.

396. In cases involving extensive obliteration at the date of try, the entryman or his successors in interest may be charged with e knowledge that the boundaries of the claim will probably be bject to more or less adjustment in the event of a resurvey, and at in the process of fixing the boundaries of groups of claims a neral control applied to all must be favored as far as possible in e interest of equal fairness to all and of simplicity of resurvey. ven in the presence of extensive obliteration of the original survey, claim which manifestly shows that no attempt has been made to late the same in some manner to the original survey can not generlly be regarded as having been located in good faith.

397. Cases will arise where it may be evident that lands have een OCCUPIED in good faith, but whose boundaries as occupied are learly in disagreement with the demonstrated position of the legal ubdivisions called for in the description. Obviously the rule of ood faith as to location can not apply, and relief must be sought hrough the process of amended entry (act of Feb. 24, 1909, 35 Stat., 45) to cover the legal subdivisions actually earned, rather than hrough an alteration of the position of established lines. This is a rocess of adjudication rather than one of resurvey. A case of this haracter should be regarded as an "erroneous location," in preisely 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 d mination, in the manner hereinafter stated, which would not n sarily agree with that resulting from a rigid application of arbi rules laid down for the restoration of lost corners.

GENERAL FIELD METHODS.

399. There are two recognized methods of making Govern resurveys—DEPENDENT and INDEPENDENT—and in general, field condition that may arise can be taken care of by the ap tion of one or the other method.

400. The DEPENDENT resurvey is designed to accomplish a re tion of what purports to be the original conditions according t record, based, first, upon identified existing corners of the ori survey and other recognized and acceptable points of control, second, upon the restoration of missing corners by proportionate r urement in harmony with the record of the original survey. type of resurvey is applicable to those cases showing fairly concor relation between conditions on the ground and the record of the nal survey. Titles, areas and descriptions should remain lutely unchanged in the typical dependent resurvey.

401. The INDEPENDENT resurvey provides methods adapted to siderable areas of public land where the original survey can no identified with any degree of certainty in accordance with the re sentations of the approved plat and field notes, and where the vailing conditions are such that strictly restorative processes, w applied as an inflexible rule between existing monuments or ado corner positions, are either inadequate or lead to unsatisfactory sults. This type of resurvey provides for the segregation of i vidual tracts when necessary, or a conformation of individual tr to the subdivisions of the resurvey if suitable. These processes found to be more flexible in their application than those of strictly dependent type, but at the same time they duly protec private rights which have been acquired upon the basis of the or nal approved survey and plat. With respect to the identification description of the public lands involved, the independent type of survey supersedes the record of the original survey. This will made apparent by the representations of the approved resurvey p

402. The basic principle, with respect to the protection of b fide rights, involved in one type of resurvey is identical with t of the other type, whether dependent or independent; they are b be regarded as a demonstration, on the part of the General Land ffice, in the light of the *best evidence available*, by means of the gal subdivisions of a dependent resurvey or by the tract segregans of an independent resurvey, of the *original* position of entered patented legal subdivisions or lots included in the *original* deiption when related to the *original* survey.

403. The necessity for both types of resurvey is encountered in e field; the applicability of one or the other method is altogether question depending upon local conditions, such as extent of oblitation, relative harmony of identified and recognized points, and tent of disposals by the Government. These questions should not judged in advance of a comprehensive field examination.

404. In general, a preliminary field examination will be required d authorized before the resurvey is to be undertaken.

The purpose of an investigation is to develop the extent of the literation of the evidence of the original survey, the extent of ttlement, the agricultural possibilities of the township, and any her information from which the necessity for, and the propriety , the proposed resurvey may be determined.

A second purpose to be subserved by an investigation is the sembling of sufficient data concerning the local survey conditions permit a proper type selection; and with this end in view the amining surveyor should investigate and report upon the relative sition of the evidence of the original survey; the degree to which entified points are concordant or the reverse; the extent to which orners discordantly related have been made the basis of claim ocations; the presence of one or more systems of unofficial local urveys which have been recognized and adopted by the claimants n fixing their boundaries; and the degree to which conflicts are to be anticipated.

405. The proper supervising officer will provide the examining surveyor 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 recommen tions concerning the type of resurvey which, in his judgment, sho properly be applied in view of the prevailing conditions.

When the report and recommendations of the examiner, w those of the supervising officer, have been received by the Gene Land Office, the situation will be considered, the appropriate t of resurvey will be determined, and the preparation of special instr tions for the resurvey will be authorized.

407. The special instructions, which must of necessity be ba largely upon the data provided by the examination, will indic the scope of the work, and, regardless of whether the lands are to dependently or independently resurveyed, the necessary retra ments will be made to fix the outboundaries of the township townships designated for resurvey. With the limiting boundar once restored so as to protect under the rules already laid down existing property rights in the adjoining lands not to be resurvey the plan of procedure outlined in the instructions should, und the known conditions, produce satisfactory results, and adheren thereto is expected. If, however, unforeseen conditions are dev oped in the progress of the resurvey, which may apparently rend the special instructions inapplicable or likely to produce inco sistent or unsatisfactory results, it is of the utmost importance th the surveyor suspend further monumentation of the corners; a after such additional retracement and investigation as may be nec sary to a proper understanding of the situation, he should report t facts to the proper supervising officer and request further instructio

408. During the progress of the resurvey the surveyor shou advise all interested parties, as occasion and opportunity may offe that the resurvey is not to be regarded as official or binding upon t United States until duly accepted by the Commissioner of the Ge eral Land Office, as provided by law, and that no contemplat alteration in the position of improvements or claim boundari should be made in advance of the official acceptance of the resurve

THE DEPENDENT RESURVEY.

GENERAL CONTROL.

409. A dependent resurvey is an official re-marking of the origin lines upon a plan whereby existing evidence of the original surve is given primary control over the position of the lines to be reestab lished. A certain amount of flexibility (as hereinafter described allowable in the dependent resurvey when necessary for the otection of bona fide rights of claimants, particularly in those ses where no objection is found to adopting a point acceptably ated under the rule of good faith already laid down, when only ightly at variance with the theoretical position of the same.

410. In theory the process consists, first, in the retracement and establishment of the township exteriors; second, the identificaon of all existing interior corners or other evidence of the original rvey; and, third, the determination, by a *suitable field procedure*, the theoretical position of all missing corners as indicated by a oper interpretation of the record of the original survey in relation such existing evidence. The actual field process may be varied some extent in order to meet local conditions or to suit the conience of the surveyor, but the theoretical position finally deterined must be identical with that which would result from a strict plication of the principles of proportional measurement. When is has been accomplished, attention should be given to the adopn, as an integral part of the resurvey system, of corner positions termined by the evidences, of whatever character, of acceptable aim location. Such evidences may, for convenience, be termed collateral evidence" as distinguished from direct evidence of the iginal survey.

411. The process of the dependent resurvey differs in scope from at applied for the usual restoration of one or more lost corners, d the rules governing a resurvey bring into consideration in a ore comprehensive manner the position of recognized land boundries, in the absence of evidence of the original corners. The sureyor has noted the detailed instructions set forth in Chapter V oking to the identification of existing evidence of the original urvey and the application of the rules of proportionate measurement or 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 identiication 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 ma based upon known corners, it being assumed that the exter boundaries of the township to be resurveyed have been identifi or restored under the rules already laid down in Chapter V, a under those relating to the acceptability of a local point or cla location. It is not usually possible to follow the method and or of procedure shown in the record of the original survey (owing missing corners), but the complete system of lines will be run out preliminary retracement, usually beginning with the meridio lines between known corners, followed by the latitudinal li between known corners, noting the intersections with the s meridional lines. The surveyor must be supplied with a compl copy of the record of the original survey, and temporary referen stakes may be set on the meridional lines at the record measurem for each corner point.

413. The preliminary retracements will lead at once to t identification of the prominent evidence of the original survey a a trial calculation will follow as to the latitudinal and longitudi adjustments at each missing corner, to suit the proportions wh may be derived when based upon these known corners. A seco and more exhaustive search will then follow within the zone of t probable location of each missing corner for the more obscure e dence of the original survey. At this stage of his field work t surveyor should exhaust every possible means of identifying t existent corners of the original survey. In many respects, t surveyor will be compelled to devise his own methods as the act field conditions seem to warrant, and his skill and judgment a surveyor should function to the fullest capacity.

If additional evidences of the original survey are found by t process, a second trial calculation will then be made as to the la tudinal and longitudinal adjustments of the temporary referen stakes previously set at each missing corner, to suit the proportio measurements derived from all of the known original corner exactly as outlined in Chapter V. These calculated adjustme will determine the theoretical location of each lost corner w reference to all existing evidence of the original survey.

In the absence of other considerations, the theoretical points th determined by proportionate measurement, based upon existi original corners, are fixed to a mathematical certainty, and wh these points have been determined, the evidence of the origi urvey and the record thereof have served their primary purpose. Then, and not until that time, is the surveyor 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 surveyor may proceed with ful 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 surveyor that it is better to accept a position based upon local improvements rather than to disturb satisfactory existing conditions. The surveyor 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 surveyor 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 aforestated, 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 necessarily to be adopted 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 surveyor 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 surveyor confers upon the nt a significance similar to that of an original corner position, l thus avoids disturbing satisfactory local adjustments. Chief ong this class of evidence forming the basis of the recognized ition of land boundaries are recorded monuments established local surveyors, duly agreed upon by the interested property ners; the position of boundary fences determined in the same nner; and the center lines of public roads and drainage or irriga- ı ditches, when intended to be located on the subdivisional es of the public-land surveys. The local record in these cases, en available, may furnish the connecting link to the previously ntified evidence of the original survey, but even in the absence conclusive record, if a point qualifies as above outlined, the sumption is strong that its position bears satisfactory relation he original survey and that its correctness can not be success- y disputed. Points which actually qualify as aforestated may accepted as the best available evidence of the true position of original survey.

20. The technical record of the resurvey should clearly set h the reasons for the acceptance of a local point, where unofficial erminations of the above character do not represent actual marks he original survey. Such recognized and acceptable local marks l be preserved, and described in the record of the resurvey. New numents will be established as required, in addition to, but with- destroying the evidence of, the local marks.

REESTABLISHMENT OF TRUE LINES.

21. As already stated, with the combined control of the depend- resurvey fully determined, the final calculation will be made o the latitudinal and longitudinal adjustments of the temporary erence stakes previously set at the remaining missing corners. e final calculations will be based upon the known position of the ners of the general control as thus adopted, upon the plan of portionate measurement, all as provided in Chapter V. The ult of this process balances in regular proportion the differences ween the measurements shown in the record of the original sur- and those derived in the retracement. Thus the true lines of dependent resurvey are finally determined through the influ- e exercised by the identified existent corners of the original vey and every other identified call of the record thereof.

such other collateral evidence of the position of recognized la boundaries as may be properly adopted for such influence.

422. The field procedure incident to the running and measu ment of the true lines of the dependent resurvey will conform the requirements of Chapter II, while the marking of lines betwe corners and the notation of objects to be recorded will conform the provisions of Chapter III, and the monumentation of the surv will comply with Chapter IV. The technical record of the res vey will be broadened to show the relationship between the origi survey and its reestablished lines.

423. The field note description of an identified or accepted cor will be introduced into the technical record of the resurvey at t place in the true line notes where the position for the corner is in cated as having been attained. The record will embrace:

(*a*) A complete description of the remaining evidence of the ori nal monument;

(*b*) A complete description of the new monument;

(*c*) A complete description of the original accessories as identifie

(*d*) A complete description of the new accessories;

(*e*) A concise statement relating to the recovery of a corner bas upon identified line trees, blazed lines, items of topography, other calls of the field notes of the original survey, in the absen of evidence of the monument or its accessories; and,

(*f*) A statement of fact relating to the relocation of an obliterat monument; or a statement of the determining features leading the acceptance of a recognized local corner.

424. General titles (in addition to the regular page heading) wi be inserted in the field notes of dependent resurveys to indicate th character of the resurvey, the technical record of which follow Such titles will be inserted in the body of the field notes, as appro priate, and will show the name of the original surveyor and the yea 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, explana tory of the method of control adopted in the restoration of one o more lost corners.

425. In addition to the usual showing of data upon the townshi plat, the plat of a dependent resurvey should carry a memorandum r the information of the public to the effect (modified as special rcumstances 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 pon the plat approved ——— (date), in their true original position ccording to the best available evidence of the position of the original corners; all differences between the measurements shown on e original plat and those derived in the retracement have been stributed proportionally between accepted corners in accordance ith surveying rules; reference will be made to the original plat r the showing of the areas and more detailed descriptions of the rious smaller subdivisions."

DDITIONAL METHODS FOR THE PROTECTION OF BONA FIDE RIGHTS.

426. Referring to those cases where locally recognized corners e discordantly related to the original survey, it will be apparent at such corners can be employed only for the determination of e boundaries of claims where bona fide rights have been duly tablished which would otherwise be impaired by the resurvey nder the same rule of good faith in the matter of location. Cases f this kind are found to be decidedly exceptional in the townships here dependent resurveys have been made, and such situations will e given particular attention in the preliminary examination and pecial instructions. In those instances when encountered, provision will be made in the special instructions for a "metes-and-bounds" survey, as hereinafter outlined under the general subject f "independent" resurveys, unless an amendment of entry in conformity with the lines of the resurvey will answer the particular requirements of the situation. In either case the surveyor will note the Manual text relating to metes-and-bounds surveys and amendment of entries (see secs. 434 to 452, inclusive).

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 conformable.

The surveyor will proceed with the complete retracement of interior section lines. In this process he will employ instrumen methods and make the measurements as provided in Chapter He will be guided by the suggestions given in Chapter V in rega to the search for evidence of the original survey, and beyond th he will devise his own methods in the search as the actual fie conditions seem to warrant. Temporary reference stakes will set where the original corners are not at once identified (thou the use of local reference points will be unobjectionable). It w be assumed that a single system of reference stakes has been emplo ed, as this scheme lends itself more readily to theoretical discussio as well as practical utility in the field, and allows the utmost freedo as to the order in which the retracements are made.

Having completed the reestablishment of the township exterio and the retracement of the interior lines, the surveyor will be co cerned with the two primary considerations, heretofore discusse which it is his duty to harmonize: First, the restoration of what th record purports to be original conditions; and, second, the protectio of the bona fide rights of claimants in the matter of location. Th first requirement must be fulfilled with reference to the evidenc of the original survey, and the discovery and identification of actu original corners is paramount, bearing in mind that the developmen of a single additional original corner adds manifest conclusivenes to the work. These identified points when combined with thos acceptably located constitute the general control. The secon item, which does not directly affect the technical procedure, ha 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.

Same as E.
Position determined by location of improvements; point agrees approximately the theoretical position and it is recognized by adjoining claimants; improvements would be adversely affected by change of point.
Same as E.
and W. Same as T.

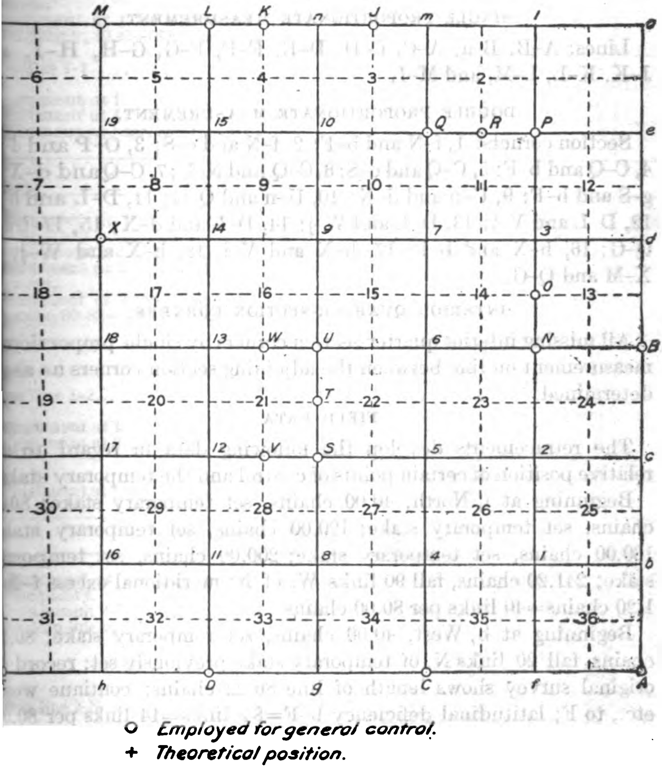


Fig. 69.

X. Identified original corner.
a. Duly restored by double porportionate measurement and thereafter employed r general control on an equality with an identified original corner.
b–n, inclusive. Theoretical true line position, duly restored by single proportionate easurement.

METHOD.

After completing all retracements and having determined upon general control to be adopted, as indicated in the diagram and acc panying key, the true lines of the dependent resurvey, beginnin the southeast corner of the township, will be reestablished as follc

SINGLE PROPORTIONATE MEASUREMENT.

Lines: A–B, B–a, A–C, C–D, D–E, E–F, F–G, G–H, H–I, a 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- 4, C–Q and b–F; 5, C–Q and c–S; 6, C–Q and N–U; 7, C–Q and d–X g–S and b–F; 9, U–n and d–X; 10, U–n and Q–G; 11, D–L and b- 12, D–L and V–i; 13, D–L and W–j; 14, D–L and d–X; 15, D–L a Q–G; 16, h–X and b–F; 17, h–X and V–i; 18, h–X and W–j; X–M and Q–G.

INTERIOR QUARTER-SECTION CORNERS.

All missing interior quarter-section corners by single proportion measurement on line between the adjoining section corners as abc determined.

FIELD DATA.

The retracements develop the following data in regard to t relative position of certain points of control and the temporary stak

Beginning at f, North, 40.00 chains, set temporary stake; 80. chains, set temporary stake; 120.00 chains, set temporary stak 160.00 chains, set temporary stake; 200.00 chains, set tempora 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. chains, fall 20 links N. of temporary stake previously set; record original survey shows length of line 80.22 chains; continue wes etc., to F; latitudinal deficiency b–F=84 links=14 links per 80.(chains.

Beginning at 2 (temporary stake), East, 40.00 chains, set temp rary stake; 80.82 chains, fall 44 links S. of c; record of original su vey shows length of line 79.90 chains; run west from temporary stak at 2 on similar plan; latitudinal excess c–S=66 links=22 links p 80.00 chains.

CALCULATIONS.

The adjustments of the temporary stakes to true line positior and the determination of the bearings and lengths of the reestat lished true lines, are calculated as follows:

BETWEEN SECTIONS 35 AND 36.

Memo.	Course.	Distance.	N.	S.	E.	W.
etracement f-1	North.	80.00	80.00	......	......	......
djustment at 1 for meridional excess.	......	......	.40	......	......	......
djustment at 1 for latitudinal deficiency, 80.46—(80.22-0.14).	......	......	......	......	0.38	......
ue line f-1	N. 0° 16′ E.	80.40	80.40	......	.38	......
djustment at f	......	......	.00	......	.00	......
djustment at 1	......	......	.40	......	.38	......
djustment at ¼ sec. cor. (mean)	......	......	.20	......	.19	......

BETWEEN SECTIONS 25 AND 26.

Memo.	Course.	Distance.	N.	S.	E.	W.
djustment at 1 from true to temporary.	......	......	......	0.40	......	0.38
etracement 1-2	North.	80.00	80.00	......	......	......
djustment at 2 for meridional excess.	......	......	.80	......	......	......
djustment at 2 for latitudinal excess, 80.82—(79.90 +0.22).	......	......	......	......	0.70	......
		......	80.80	.40	.70	.38
		......	.40	......	.38	......
ue line 1-2	N. 0° 14′ E.	80.40	80.40	......	.32	......
djustment at 1	......	......	.40	......	.38	......
djustment at 2	......	......	.80	......	.70	......
		......	1.20	......	1.08	......
djustment at ¼ sec. cor. (mean)	......	......	.60	......	.54	......

BETWEEN SECTIONS 23 AND 24.

Memo.	Course.	Distance.	N.	S.	E.	W.
djustment at 2 from true to temporary.	......	......	......	0.80	......	0.70
etracement 2-N	North.	81.20	81.20	......	......	......
andom 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	......
		......	2.00	......	1.60	......
Adjustment at ¼ sec. cor. (mean)	......	......	1.00	......	.80	......

BETWEEN SECTIONS 25 AND 36.

Memo.	Course.	Distance.	N.	S.	E.	W.
Retracement b–1	West.	80.46				8[illegible]
Random line to temporary stake at 1.				0.20		
Adjustment at 1 temporary to true.			0.40		0.38	
			.40	.20	.38	8[illegible]
			.20			
True line b–1	N. 89° 51′ W.	80.08	.20			8[illegible]
Adjustment at b				.00		
Adjustment from 80.00 ch. point on random to temporary stake at 1.				.20		
Adjustment at 1 temporary to true.			.40		.38	
			.40	.20	.38	
			.20			
			.20			
Adjustment at ¼ sec. cor. (mean)			.10			

BETWEEN SECTIONS 24 AND 25.

Memo.	Course.	Distance.	N.	S.	E.	W.
c to random line				0.44		[illegible]
Retracement c–2 (reversed)	West.	80.82				[illegible]
Adjustment at 2 temporary to true.			0.80		0.70	
			.80	.44	.70	[illegible]
			.44			
True line c–2	N. 89° 45′ W.	80.12	.36			[illegible]
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 ¼ sec. cor. (mean)			.62		.76	

THE INDEPENDENT RESURVEY.

428. An independent resurvey is an official re-subdivision of th public lands distinct from the original survey which it is designe to supersede. The independent resurvey is accomplished by thre distinct steps:

(*a*) The reestablishment of the outboundaries of the lands subjec to resurvey, following the method of a dependent resurvey;

(*b*) The segregation of lands embraced in any valid claim where e initial steps have been taken looking to the disposal of the title the United States based upon the former approved plat; and,

(*c*) New exterior, subdivisional and meander lines as necessary, tablished upon a new regular plan, which, for every purpose of entification and description of the public lands involved, becomes e prevailing survey.

REESTABLISHMENT OF OUTBOUNDARIES.

429. The limiting boundaries of the lands subject to independent urvey must agree with the previously established and identified terior or subdivisional lines of the approved original surveys. In ler to qualify as a suitable limiting boundary as aforementioned, ine of the accepted established surveys will be selected which be conclusively identified (by existing original or properly re-red corners) in one position to the exclusion of all others and ich by its known position adequately protects all rights (located good faith as hereinbefore defined) based upon any township plat wing subdivisions of the public lands adjacent to said boundary. h outboundaries of the lands to be resurveyed by the independent cess must necessarily be retraced and reestablished in their true ginal position. The lands upon one side of such outboundary are be re-subdivided upon a new plan, while upon the opposite side of h line the original subdivisions are to be strictly maintained and e of the original conditions are to be disturbed.

430. The outboundaries are generally selected along the locus of previously established township exteriors where the existing idence gives positive proof of the location of the original survey, d where conditions on the ground are harmoniously related to the ord of said original survey. In special cases certain section lines y fully qualify as suitable lines to mark the limit of the inde-ndent resurvey; such section lines will then be duly retraced and stablished in their true original position. Particular attention ll be given to this very important subject at the time when the d examination is made with a view to maintaining the original rvey as far as consistent.

431. In those cases where a proper limiting boundary can not be ured without involving the necessity for the inclusion in the up of a greater number of townships than administratively prac-able to execute in one assignment, the necessity may arise for the

extension of tract segregations (as hereinafter outlined) into a tow ship ungrouped for resurvey. In such cases, under speci authority of the General Land Office, any tract found to exte across such group outboundary will be segregated in full, wheth or not the tract was originally described as in the township to resurveyed, and the necessary steps will thereupon be taken by General Land Office in the matter of suspension of the lands in adjoining township from further disposal and of additional inves gations with a view to a resurvey of all or a portion of the sa adjoining township. (See second rule, sec. 445.)

432. The special instructions will show specifically what li have been selected to limit the independent resurvey, and the s veyor engaged in the execution of such resurvey will proceed w the retracement and reestablishment of said outboundaries as a c dition precedent to beginning the independent resurvey.

433. Where the new lines of the independent resurvey are not be initiated or closed upon the restored original corners of the re tablished outboundaries of the independent resurvey, said resto corners will be marked only with reference to the township, ra and section to which they will thenceforth relate, and new regu corners of minimum control will be established as necessary to gove the lines of the independent resurvey, all as provided in sec. 1 Chapter III. During the preliminary stages of the resurvey th will often be more or less doubt as to whether an old corner will ret its former control or will have to be altered, and until this unc tainty has been removed the marking of a corner and its accessor should be deferred. The monumentation will follow the final det mination of the future significance of each point. Where an o point is to be perpetuated merely to control the former alineme but not the corner of a subdivision, its future significance will be th of an "angle point" only and the monument and its accessories w be marked accordingly.

METES-AND-BOUNDS SURVEY OF PRIVATE CLAIMS.

434. After the reestablishment of the outboundaries of the lan subject to independent resurvey has been accomplished in accor ance with the requirements of the special instructions, the surveyo attention will be directed to the segregation or marking out of all du entered, selected, reserved (in certain cases), granted, or patente whose description may be based upon the former approved plat, ·hich can not be conformed to the lines of the resurvey.

›. A status diagram will be furnished to the surveyor showing ıtented lands, valid entries, school sections, and other land s, and all other disposals, reservations, or selections of lands ȝ position and description are based upon the original survey ›lat, and whose boundaries can not legally be disturbed. In · case the various tracts shown upon the status diagram will otected either by individual "metes-and-bounds" survey or ıe assignment of appropriate subdivisions of the resurvey in the latter lines (new section lines, or center lines of sections arter sections) are found to coincide or approximately agree the boundaries of said tracts.

6. It is not to be understood that the metes-and-bounds survey .vate claims must be completed before beginning the projection e new lines of the independent resurvey. It has merely been ıed logical to consider the subject of the tract segregations in nce of the question of the establishment of new lines. The fact ıt surveyors will find it expedient to carry both branches of the ey along together in the locality of the camp or other field headters.

:7. The jurisdiction of the General Land Office, the limit of the .ority of the surveyor, and the bona fide rights of claimants, re entered or patented lands are involved, remain absolutely the ȝ whether the resurvey is to be made upon the dependent or pendent plan. Thus where the independent type of resurvey been adopted as more feasible, identified corners of the original ·ey in the immediate vicinity of lands to be segregated will be iloyed for the control of the location of such lands. The question he good faith of the entryman will in every case be fully conred, as previously outlined in this chapter, and where the evice of the original survey is so obliterated that a charge of a lack ood faith can not be brought against an entryman whose claim ndaries may differ from a theoretical location determined by e rigid surveying rules, the position of the improvements is to be rded as the best available evidence of the original position of claim, and the same will be employed as far as consistent for the trol of the location of the boundaries of such claim.

:88. Where there is sufficient evidence of the original survey, the ntification of the areas to be segregated, resulting from the subdivision of the original sections, will proceed in accordance with provisions of Chapters III and V, and every corner or angle p of each tract as thus located will be marked upon the ground.

439. Where the surveyor can not point out, by suitable ide fication of the original surveys, the definite location of an e based upon the former approved plat, the claimant or owner of s lands will be consulted as to the position of his boundary lines. ' boundaries of the private claim, so determined, will be fixed between the private and public lands, subject to the official acc ance of the resurvey. Where dispute is encountered in regard the adjustment of the line between adjoining patented tracts, e acceptably located under the rules already laid down, which not be reconciled or suitably disposed of by surveying process, tracts will be surveyed in conflict, as hereinafter provided, and shown on the resurvey plat; the questions arising out of such conf will be given administrative review with the field notes of resurvey.

440. The owner of an unidentified claim will be called upon indicate the boundary lines thereof if possible, and in this conn tion, should occasion arise, the surveyor will explain the manne adjusting differences between adjoining claims and what will c stitute an acceptable location of a claim. The latter condit demands a form agreeing with the original entry, approximat regular boundaries, an area not widely inconsistent with that sho upon the original plat, and a location as nearly correct as may expected from the existing evidence of the original survey, with overlapping into an adjoining township not subject to resurv except as provided in sec. 431. In every case where the o boundaries of the lands subject to "independent resurvey" ha been reestablished by the "dependent" or "restorative" plan, t subdivisions of a tract situated and originally described as along upon the opposite sides of such outboundary must agree with t line reestablished and harmonize in relative position.

441. In the execution of an independent resurvey, therefo the identity of each tract to be segregated therein or indicat by conformation to the lines of the resurvey, whether patent or unpatented, must be maintained, and the surveyor will not allowed to change materially the configuration of a tract as sho by its original description in order to indemnify the owner there against deficiencies in area, to eliminate conflicts between entri

r any other purpose. If improvements have been located in faith, the segregation survey should be so executed, or the ormation to the lines of the resurvey so indicated, as to cover early as possible these improvements and at the same time ntain substantially the form of the entry as originally described. leparture from this rule will be allowed.

2. The question of amendment of entries for the purpose of nitting adjustments in terms of the resurvey involving lands included within the original tract is a matter for the adjudica- of the General Land Office after the resurvey has been accepted the plats thereof filed in the local land office.

3. In case of absentee owners an attempt should be made to blish communication, if necessary, in order that the claimant point out the lands subject to a metes-and-bounds survey. If owner can not be found and there is no visible indication, such boundary fence, of the location of the limits of a claim, the eyor will exercise the alternative of locating the claim from nearest original point of control or from a point of a neighboring m, or of assigning to the entered or patented lands the appropri- subdivisions of the resurvey, all subject to the principles here- efore set forth. The controlling factors in such locations will be ed upon the individual and neighborhood improvements (such uildings, wells, springs of water, cultivated lands, public roads, ees, corners of recognized private surveys, etc.) which may indi- the evident intention of the entryman or patentee as to the ition of his land.

44. Each non-conformable valid claim in a township will be en a serial tract number, commencing with No. 37 in the smallest nbered and entered section of the original plat, progressing ough the township in the order in which lots and sections are nbered. A tract number will be used but once in a township, l if any tract lies partly in two or more townships subject to urvey the number applied to the tract in the first township arveyed will not be used for other tracts in the adjoining town- p.

145. The following rules will be observed in the execution of the tes-and-bounds survey of all specially designated tracts:

1st. Each claim, acceptably located, but at variance with the lines the resurvey, will be surveyed and monumented at each angle int.

2d. Where a portion of a claim is originally described as in a tow ship not subject to resurvey, such portion of the claim will not surveyed by metes and bounds, provided the limiting boundary found to qualify as set forth in sec. 429. The portion of the cla originally described as in the township to be resurveyed shou ordinarily be defined in a position (either by segregation or conf mation to the lines of the resurvey) which is properly related to t identified or restored corners on the limiting boundary. (S sec. 431.)

3d. Where the boundaries of a claim are unacceptably located pointed out by the claimant, the surveyor will proceed with a prop survey of the tract in accordance with rules already stated whi will result in a suitable relation to the original survey, and the corn of the tract as thus located will be monumented. If the claima protests against such location, the surveyor will request that the pr test be made in writing (to be submitted with the returns of the r survey), and will thereupon make an accurate connection with t corners of the claim as unacceptably located, to be made the subje of a complete report by the surveyor in his field notes, reviewi the facts with reference to the question of location. As a furth protection to an entryman thus unacceptably located see sec. 45

4th. Where, through a compliance by the surveyor with the gene rules above laid down, the metes-and-bounds segregation of a clai (or the conformation thereof to the lines of the resurvey) within t field of an independent resurvey (or the related subdivisions with the field of a dependent resurvey) fails to cover any or all of t lands, occupied, improved or claimed by the entryman, patent or present owner, and the latter indicates a desire to amend h entry, a full report will be made by the surveyor in his field note describing therein the subdivisions actually occupied and sought be acquired under the amended entry, but which are not cover by the tract as surveyed, all looking to the protection of the title the lands actually earned.[1]

5th. Where it so happens that the regular quarter-quarter sectio embraced within a claim fall in approximately the same position the regular quarter-quarter sections of the resurvey, and the entr man or patentee indicates a desire to conform his claim to the r survey, and no apparent objection is found by the surveyor, t facts will be stated in the field notes, and the claim will be so ind

[1] See current circular relating to amendment of entries.

located 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.

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 TR 38	AP 3 TR 37
AP 1 TR 45	AP 2 TR 46

1919

T 26 N R 17 E
S 14

AP 1 TR 38	AP 2 TR 37

1919

T 26 N R 17 E

AP 1 TR 37	S 14

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 surveyor 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 surveyor, 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 improvements alone, 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-d-bounds survey and the technical record in respect to the same ill conform to the usual practice in regular surveys. While the apping of important items of topography and valuable permanent provements will be given attention with regard to this feature of e resurvey plat, yet it will be apparent that the amount of data to shown in connection with the metes-and-bounds surveys makes impossible, at the usual scale, to show objects of little relative portance. This class of memoranda taken during the progress of e work will *not* be required in the field notes of metes-and-bounds rveys.

452. At least one angle point of each tract survey will be definitely nnected with one of the regular corners of the resurvey, and where es of claims are intersected by lines of the resurvey a connection ill be made from the point of intersection to the nearest claim cor-r and recorded in the field notes of the regular section line. The tter will be considered a satisfactory connection to all adjoining aims located within the interior of either section. Where an ex-nsive system of tract segregations has been surveyed, the interior acts of the block will not require individual reference connections. he establishment of closing corners on the regular line when entering leaving public land will conform to the general practice in this spect as provided in sec. 191, Chapter III.

THE PROJECTION OF NEW LINES.

453. The peculiar conditions of the situation which necessitate n independent resurvey render it impossible to formulate general ules suited to all cases. Experience has demonstrated the neces-ity for giving deliberate attention to the unique problems of subdi-ision which are to be found in each definite example. The general ractice is to secure a surveyor's report of the actual conditions nvolved in a particular independent resurvey, upon consideration f which there may be devised the best plan for a re-subdivision of he vacant public lands, and the latter will be set forth in the special nstructions. The possibility of placing the regular lines of the ndependent resurvey so as to obtain maximum agreement with the osition of the boundaries of conformable claims will be fully con-idered with a view to eliminating or reducing the necessity for ract 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 responsi to his special advantages in the opportunity of working out the tec nical problem while on the ground.

454. A problem involving the re-subdivision of vacant pub lands, as in an independent resurvey, should be approached in t same way as practically all problems in fragmentary subdivisio though the independent resurvey may at times involve the re-su division of a group of many townships wherein all conditions, exce perhaps with relation to the tract segregation surveys, may comparatively regular. First attention will be given to completi the new township exteriors which are to be independently resu veyed after having reestablished the outboundaries of the group the dependent plan. The new exteriors will be carried forward a completed in harmony with the rules set forth in Chapter III f the establishment of original surveys. The new section lines w be run out and marked as in regular or fragmentary subdivision the situation may be and new meander lines will be run as require The new exterior and subdivisional lines will usually be extend across small blocks of tract segregation surveys, noting connectio as previously stated, and in such cases the new lines and corne will be fully monumented regardless of the fact that some poin will fall within the tract segregation surveys. The latter poin are required in their usual function to determine the subdivisio of the public lands affected.

455. A general exception to the rule of extending the lines the independent resurvey across the tract segregations will be mad in those townships or portions thereof so densely covered by priva claims that the remaining parcels of public lands may be as well better identified and described for expediency with reference isolated tract numbers. In such cases closing corners will be r quired on the regular lines when entering or leaving public lan The regular lines may or may not be extended as blank lines acro the tract segregations, according to the plan of running the ne section lines of the resurvey. Where this method is employed will be necessary to assign tract numbers to the vacant parcels public land and to mark the angle points thereof accordingly. Whe a parcel of vacant public land is to be identified on this plan, suc vacant tracts will be surveyed by metes and bounds in accordanc with the usual rules. Rare cases may arise where it will be deeme expedient to segregate by metes-and-bounds survey certain quarte 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 surveyor 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.

O