

*Manual of*  
Instructions for the Survey of the  
Public Lands of the United States

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UNITED STATES  
DEPARTMENT OF THE INTERIOR

**KEY TO CITATION OF AUTHORITIES, BY VOLUME AND  
PAGE OR SECTION**

**Stat.**—United States Statutes at Large.

**R.S.**—Revised Statutes of the United States; citation includes section number.

**U.S.C.**—United States Code (The Code of the Laws of the United States).

**L.D.**—Decisions of the Department of the Interior relating to the public lands through 1929, Vols. 1 to 52.

**I.D.**—Decisions of the Department of the Interior, 1930 and later, beginning with Vol. 53.

**CFR**—Code of Federal Regulations of the United States of America. Title 43—Public Lands: Interior.

**U.S.**—United States Reports. Decisions of the Supreme Court of the United States.

**Fed.**—Federal Reporter. Decisions of the United States Courts of Appeals.

**F. 2d**—Federal Reporter, second series.

Section numbers cited in this Manual without other designation indicate the chapter and chapter section of the Manual.

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# The General Plan

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## THE MANUAL

### Purpose and Scope of the Manual

1-1. The Manual of Surveying Instructions describes how cadastral surveys of the public lands are made in conformance to statutory law and its judicial interpretation. This chapter summarizes the various Acts and the general plan of surveying based on them. Previous editions of the Manual were issued in 1855 (reprinted as the Manual of 1871), 1881, 1890, 1894, 1902, 1930, and 1947.

1-2. Surveying, in general, is the art of measuring and locating lines, angles, and elevations on the surface of the earth, within underground workings, and on the beds of bodies of water. A "cadastral survey" creates (or re-establishes), marks, and defines boundaries of tracts of land. In the general plan this includes a field-note record of the observations, measurements, and monuments descriptive of the work performed and a plat that represents the cadastral survey, all subject to approval of the Director, Bureau of Land Management.

1-3. Details of the plan and its methods go beyond the scope of textbooks on surveying. The application to large-scale areas requires an understanding of the stellar and solar methods for making observations to determine the true meridian, the treatment of the convergency of meridians, the running of the true parallels of latitude, and the conversion in the direction of lines so that at any point the angular value will be referred to the true north at that place. These subjects are therefore explained and examples given with specific relation to the approved surveying practice. The use, care and adjustments of the solar transit are fully treated because of its wide use in public land

surveying. The applications of photogrammetry and electronic instrumentation to public land surveying are covered for the first time in this edition of the Manual.

1-4. Extended treatment is given to subdivision of sections, restoration of lost or obliterated corners, resurveys, and special surveys of many kinds. These now make up the major part of the surveying program of the Bureau of Land Management. Stress is placed on thoroughness in the identification and perpetuation of the surveys already completed.

### Development of the Manual

1-5. The surveys of public lands have been conducted since 1785, when a beginning point was established where the west boundary of Pennsylvania crosses the north bank of the Ohio River. The first surveys, covering parts of Ohio, were made under supervision of the Geographer of the United States in compliance with the Ordinance of May 20, 1785. Detailed instructions were not needed in these initial surveys, because only the exterior lines of the townships were surveyed, and only mile corners were established. Township plats were marked by subdivisions into sections or "lots" one mile square, numbered from 1 to 36, commencing with No. 1 in the southeast corner of the township and running from south to north in each sequence to No. 36 in the northwest corner of the township.

1-6. The Act of May 18, 1796, provided for the appointment of a Surveyor General, whose duty was to survey the public lands northwest of the Ohio River. Half of the townships were to be subdivided into two-mile blocks, and the rule for numbering of sections within the town-



ship was changed to that practiced today. Subsequent laws called for additional subdivision, and the system of surveys was gradually refined to its present form. In the early period advice and general instructions were given the Surveyor General by the Secretary of the Treasury, then in charge of land sales, and later by the Commissioner of the General Land Office. Instructions to deputy surveyors were issued by the Surveyor General. A Surveyor of the Lands of the United States South of Tennessee was appointed in 1803 with the same duties as the Surveyor General, and eventually a surveyor general was appointed for each of many public-land States and Territories.

1-7. In 1831 the Commissioner of the General Land Office issued detailed instructions to the surveyors general concerning surveys and plats. The applicable parts were incorporated by individual surveyors general in bound volumes of instructions suitable for use in the field by deputy surveyors. From these directions evolved the Manual of Surveying Instructions. The Act of July 4, 1836, placed the overall direction of the public land surveys under the principal clerk of surveys in the General Land Office. The immediate forerunner of the Manual series was printed in 1851 as "Instructions to the Surveyor General of Oregon; Being a Manual for Field Operations." Its use was at once extended to California, Minnesota, Kansas, Nebraska, and New Mexico. In a slightly revised version these instructions were issued as the Manual of 1855.

### The Manual Supplements

1-8. The following supplements to this Manual are for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., 20402:

(1) *Standard Field Tables and Trigonometric Formulas*. Semi-hard cover, pocket-size, 4½ x 7, 245 pages. First published by the General Land Office in 1910, eighth edition published in 1956. The tables and data are designed for use by cadastral surveyors in the field and office.

(2) *The Ephemeris of the Sun, Polaris and Other Selected Stars with Companion Data and Tables*. Paper cover, 6 x 9, 30 pages and a star chart. Published annually in advance since 1910.

Data for the sun are given in terms of Greenwich *apparent noon* for ready use with the solar transit. Data for all stellar positions are given in terms of the Greenwich meridian, *mean time* and *mean time intervals*. The data are prepared by the Nautical Almanac Office of the United States Naval Observatory.

(3) *Restoration of Lost or Obliterated Corners and Subdivision of Sections, a Guide for Surveyors*. Paper cover, 6 x 9, 40 pages, illus. The subject matter under this title first appeared in the decisions of the Department of the Interior, 1 L.D. 339; 2d ed., 1 L.D. 671 (1883). There have been several revisions and extensions, the latest in 1973. Providing an introduction to the rectangular system of public land surveying and resurveying, with a compendium of basic laws relating to the system, it answers many common questions arising in practical work. Although intended especially for surveyors outside the Bureau of Land Management, it is also of interest to attorneys, title insurance company personnel, and others who have professional interests in former or present public lands.

## THE PUBLIC LANDS

### Definition

1-9. The original public domain included the lands that were turned over to the Federal Government by the Colonial States and the areas acquired later from the native Indians or foreign powers. Insofar as public land surveys are concerned, "public lands" are those which, after inuring to the United States, have remained in public ownership, or, after private acquisition, have been returned to public ownership and the status of public land by law.

### Administration

1-10. After admission of the States into the Union, the Federal Government has continued to hold title to and administer the unappropriated lands. Various enabling acts expressly provide that the title to unappropriated lands within these States shall be retained by the United States. Moreover, lands in the territories not appropriated by competent authority be-

fore they were acquired are in the first instance the exclusive property of the United States, to be administered, or for disposal to such persons, at such time, 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.

1-11. It is within the province of the Director of the Bureau of Land Management to determine what are public lands, what lands have been surveyed, what are to be surveyed, what have been disposed of, what remains to be disposed of, and what are reserved. By a well settled principle of law the United States, through the Department of the Interior, has the authority and duty to extend the surveys as may be necessary to include lands erroneously omitted from earlier surveys.

### Navigable Waters

1-12. Beds of navigable bodies of water are not public domain and are not subject to survey and disposal by the United States. Sovereignty is in the individual states. Under the laws of the United States the navigable waters have always been and shall forever remain common highways. This includes all tidewater streams and other important permanent bodies of water whose natural and normal condition at the date of the admission of a State into the Union was such as to classify it as navigable water. Tidelands which are covered by the normal daily overflow are not subject to survey as public land. (See discussion in chapter VII on Special Surveys.)

### Swamp and Overflowed Lands

1-13. In Alabama, California, Florida, Illinois, Indiana, Iowa, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Ohio, Oregon, and Wisconsin, the swamp and overflowed lands, though public domain, pass to the States upon identification by public land survey, and approved selection, the title being subject to the disposal by the States.

1-14. The Act of March 2, 1849 (9 Stat. 352), granted to the State of Louisiana all its swamp and overflowed lands for the purpose of aiding in their reclamation. The Act of September 28, 1850 (9 Stat. 519), extended the grant to other public land States then in the Union. The grant was also extended to Minnesota and Oregon by the Act of March 12, 1860 (12 Stat. 3). These various grants were carried over into R.S. 2479 (43 U.S.C. 982). A notable exception to the swamp land laws is found in the Arkansas Compromise Act of April 29, 1898 (30 Stat. 367; 43 U.S.C. 991), by which all right, title, and interest to the remaining unappropriated swamp and overflowed lands reverted to the United States.

1-15. The provisions of the grants apply to elevations below the uplands where, without the construction of levees or drainage canals, the areas would be unfit for agriculture. The grants apply to all swamp and overflowed lands unappropriated at the dates of the granting acts, whose character *at that time* would bring them within the provisions of the grant. Discussion of swamp and overflowed lands in connection with field examinations and surveys is found in chapter VII on Special Surveys.

## LAWS RELATING TO SURVEYS

### Early Laws

1-16. Principal early laws are found in:

(1) "An ordinance for ascertaining the mode of locating and disposing of lands in the western territory, and for other purposes therein mentioned," passed by the Continental Congress on the 20th of May 1785.

(2) The Acts of May 18, 1796 (1 Stat. 464); May 10, 1800 (2 Stat. 73); February 11, 1805 (2 Stat. 313); April 25, 1812 (2 Stat. 716); April 24, 1820 (3 Stat. 566); April 5, 1832 (4 Stat. 503); July 4, 1836 (5 Stat. 107); and March 3, 1849 (9 Stat. 395).

1-17. Based on these early laws, that part of the Northwest Territory which became the State of Ohio was the experimental area for the development of the rectangular system. Here the plans and methods were tested in a practical way. Notable revisions of the rules

were made as the surveys progressed westward until the general plan was complete.

Adoption of the rectangular system marked an important transition from the surveying practice that generally prevailed in the Colonial States where lands were described by irregular metes and bounds, each parcel depending more or less on the description of its neighbors.

### Revised Statutes and United States Code

1-18. The surveying system developed under the early laws was incorporated in the Revised Statutes and the United States Code:

*Duties of Director.* The Secretary of the Interior, or such officer as he may designate, shall perform all executive duties appertaining to the surveying and sale of the public lands of the United States, or in any wise respecting such public lands, and, also, such as relate to private claims of land, and the issuing of patents for all grants of land under the authority of the Government. (R.S. 453; 43 U.S.C. 2.)

The Secretary of the Interior, or such officer as he may designate, is authorized to enforce and carry into execution, by appropriate regulations, every part of the provisions of this title not otherwise specially provided for. (R.S. 2478; 43 U.S.C. 1201).

*Rules of Survey.* The public lands shall be divided by north and south lines run according to the true meridian, and by others crossing them at right angles, so as to form townships of six miles square, unless where the line of an Indian reservation, or of tracts of land surveyed or patented prior to May 18, 1796, or the course of navigable rivers, may render this impracticable; and in that case this rule must be departed from no further than such particular circumstances require.

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

Third. The township shall be subdivided into sections, containing, as nearly as may be, six hundred and forty acres each, by running parallel lines through the same from east to west and from south to north at the distance of

one mile<sup>1</sup> from each other, and marking corners at the distance of each half mile. The sections shall be numbered, respectively, beginning with the number one in the northeast section and proceeding west and east alternately through the township with progressive numbers, until the thirty-six be completed.

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

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

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

Seventh. Every surveyor shall note in his field book the true situations of all mines, salt

<sup>1</sup> As amended. Authority for the establishment of section lines at intervals of one mile was contained in the Act of May 10, 1800 (2 Stat. 73), cited in the text. The "one mile line" provision, which was not carried into the Revised Statutes, apparently inadvertently, nevertheless has been included in all printed Manuals issued before and after the adoption of the Revised Statutes. The omission was corrected by the Act of April 29, 1950 (64 Stat. 92).

<sup>2</sup> The superior results obtained by the use of steel ribbon tapes led to the abandonment of the obsolete link chain, except that the "chain unit," which is peculiarly adapted to land surveying, has continued in use.

licks, salt springs, and mill seats which come to his knowledge; all watercourses over which the line he runs may pass; and also the quality of the lands.

Eighth. These field books shall be returned to the Secretary of the Interior or such officer as he may designate, who shall cause therefrom a description of the whole lands surveyed to be made out and transmitted to the officers who may superintend the sales. He shall also cause a fair plat to be made of the townships and fractional parts of townships contained in the lands, describing the subdivisions thereof, and the marks of the corners. This plat shall be recorded in books to be kept for that purpose; and a copy thereof shall be kept open at the office of the Secretary of the Interior or of such agency as he may designate for public information, and other copies shall be sent to the places of the sale, and to the Bureau of Land Management. (R.S. 2395; March 3, 1925, 43 Stat. 1144; 43 U.S.C. 751.)

*Boundaries and Contents of Public Lands; How Ascertained.* 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 Secretary of the Interior or such agency as he may designate, 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 Secretary of the Interior or such agency as he may designate, 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 watercourse, 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 Secretary of the Interior or such agency as he may designate, 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. (R.S. 2396; March 3, 1925, 43 Stat. 1144; 43 U.S.C. 752).

*Lines of Division of Half-Quarter Sections, How Run.* 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; 43 U.S.C. 753).

*Rivers and Streams.* All navigable rivers, within the territory occupied by the public

lands, shall remain and be deemed public highways; and, in all cases where the opposite banks of any stream not navigable belong to different persons, the stream and the bed thereof shall become common to both. (R.S. 2476; 43 U.S.C. 931).

*Extension of Public Surveys Over Mineral Lands.* 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; 43 U.S.C. 766).

*Survey of Private Land Claims.* The Secretary of the Interior or such officer as he may designate shall cause to be surveyed all private land claims after they have been confirmed by authority of Congress, so far as may be necessary to complete the survey of the public lands. (R.S. 2223; March 3, 1925, 43 Stat. 1144; 43 U.S.C. 52).

*Penalty for Interrupting Surveys.* Whoever, by threats 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 Director of the Bureau of Land Management, shall be fined not more than \$3,000 or imprisoned not more than three years, or both. (R.S. 2412; June 25, 1948, ch. 645, 62 Stat. 789; May 24, 1949, ch. 139, sec. 42, 63 Stat. 95; 18 U.S.C. 1859).

*Protection of Surveyor by Marshall of District.* 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 marshall 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; March 3, 1925, 43 Stat. 1144; 43 U.S.C. 774).

## SUBSEQUENT LEGISLATION AND ESTABLISHMENT OF THE BUREAU OF LAND MANAGEMENT

1-19. Additional legislation and orders pertinent to the survey of the public lands:

*Purchase of Metal Monuments.* The Act of May 27, 1908 (35 Stat. 347) provided "for the purchase of metal monuments to be used for public land survey corners wherever practicable."

*Penalty for the Destruction of Survey Monuments.* Section 57 of the Criminal Code of 1909 provided a penalty for the unauthorized alteration or removal of any Government survey monument or marked trees. The wording was slightly modified June 25, 1948, in ch. 645, 62 Stat. 789; 18 U.S.C. 1858, to read: "Whoever willfully destroys, defaces, changes, or removes to another place any section corner, quarter-section corner, or meander post, on any Government line of survey, or willfully cuts down any witness tree or any tree blazed to mark the line of a Government survey, or willfully defaces, changes, or removes 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."

*Resurvey of Public Lands.* The Act of March 3, 1909 (35 Stat. 845) as amended June 25, 1910 (36 Stat. 884; 43 U.S.C. 772), provides that: "The Secretary of the Interior may, as of March 3, 1909, in his discretion, cause to be made, as he may deem wise under the rectangular system on that date 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, . . ."

*Selection of Surveyors.* The Interior Department appropriation Act of 1911 (June 25, 1910, 36 Stat. 703, 740), provided, under "Surveying the Public Lands": "The surveys and resurveys to be made by such competent surveyors as the Secretary of the Interior may select, . . ."

This provision of law brought to a close the practice of letting contracts for the making of surveys of public lands.

*Further Authority for Resurveys.* The Act of September 21, 1918 (40 Stat. 965; 43 U.S.C. 773), provides authority for the resurvey, by the Government, of townships in which the disposals exceed 50 percent of the total area. Such resurveys will be undertaken only upon application of the owners of at least three-fourths of the privately owned land in the township, and upon deposit of the estimated costs of the resurvey.

*Acceptance of Contributions for Surveys.* The Act of July 14, 1960 (74 Stat. 506; 43 U.S.C. 1364), provides that the Secretary of the Interior may accept contributions for cadastral surveying performed on federally controlled or intermingled lands.

*The National Environmental Policy Act of 1969.* The Act effective January 1, 1970 (83 Stat. 852; 42 U.S.C. 4321), states in part that "The purposes of this chapter are: To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere. . . ." The Act was implemented by Executive Order No. 11514, March 5, 1970, which provided, under "Responsibilities of Federal agencies," that ". . . Agencies shall develop programs and measures to protect and enhance environmental quality. . . ."

*Establishment of the Bureau of Land Management.* On July 16, 1946, the Bureau of Land Management was established in the Department of the Interior in accordance with the President's Reorganization Plan No. 3 of 1946. Under that plan the General Land Office was abolished and its functions transferred to the Secretary.

Order No. 2225, July 15, 1946, by the Secretary of the Interior, provided that the functions and powers of the General Land Office, and the United States Supervisor of Surveys, together with the field surveying service, be exercised by the Director of the Bureau of Land Management, subject to the direction and control of the Secretary, through such officers or units of the bureau as might be designated.

In the organization of the Bureau of Land Management, the Division of Cadastral Survey is located in the headquarters office. This division has technical supervision, through state and service center directors, of surveying the public lands. The chief of the division acts as consultant to the Director in the formulation of policies, programs, standards, and procedures of cadastral surveys.

## GENERAL RULES

1-20. From the foregoing synopsis of congressional legislation it is evident:

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

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

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

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

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

other boundary of such fractional section, as due parallelism with section lines will permit.

Sixth. That lost or obliterated corners of the approved surveys must be restored to their original locations whenever this is possible.

1-21. The basic provisions require that the public lands "shall be divided by north and south lines run according to the true meridian, and by others crossing them at right angles, so as to form townships six miles square;" that "the townships shall be subdivided into sections, containing as nearly as may be, six hundred and forty acres each;" and that "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 system of rectangular surveys fits the basic requirements to the curved surface of the globe.

In this rectangular plan the township boundaries are intended to be due north and south or due east and west. The boundaries running north and south are termed "range lines." The boundaries running east and west are called "township lines."

The range lines are great circles of the earth that, if extended, would intersect at the north pole. This convergency becomes apparent in the measurement of the township lines. The con-

vergency is taken up at intervals by the running of standard parallels, on which the measurements are again made full. On the standard parallels (first named "correction lines") there are offsets in the range lines and two sets of corners, standard corners for the lines to the north and closing corners for lines to the south. The usual interval between the standard parallels is 24 miles, but there were many exceptions in the older surveys.

In order to make the sections represent "square miles" as nearly as may be, the meridional lines are run from south to north and parallel to the east boundary of the township for a distance of five miles from the south boundary. These are run and monumented as true lines. The remainder of the section lines are all run by random and true between the established section corners. This produces the rectangular sections, 25 of which contain 640 acres each, within allowable limit. The sections along the north and west boundaries are subdivided on a plan for certain lottings to absorb the convergency and the excess or deficiency in the measurements. These sections provide a maximum number of aliquot parts (160-, 80-, and 40-acre units) or regular subdivisions of a section, the remainder being shown as lots whose contents are computed according to the field measurements.

**ORGANIZATION**

1-22. The public land surveys are conducted by cadastral survey branches of the Bureau of Land Management's service center and state offices. The authority over field operations is limited by instructions issued by the Director to the directors of the field offices. The service center is located in Denver, Colorado. The state offices, with locations, are:

- Alaska State Office at Anchorage, Alaska.*
- Arizona State Office at Phoenix, Arizona.*
- California State Office at Sacramento, California.*
- Colorado State Office at Denver, Colorado.*
- Idaho State Office at Boise, Idaho.*
- Montana State Office at Billings, Montana.*  
(Administers public lands in Montana, North Dakota, and South Dakota.)

TOWNSHIP LINE

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

RANGE LINE

FIGURE 2.—A regular township.

*Nevada* State Office at Reno, Nevada.

*New Mexico* State Office at Santa Fe, New Mexico. (Administers public lands in New Mexico and Oklahoma.)

*Oregon* State Office at Portland, Oregon. (Administers public lands in Oregon and Washington.)

*Utah* State Office at Salt Lake City, Utah.

*Wyoming* State Office at Cheyenne, Wyoming. (Administers public lands in Wyoming, Kansas, and Nebraska.)

Headquarters for surveys in the remaining States are at the Eastern States Office, Silver Spring, Maryland.

### THE PUBLIC LAND STATES

1-23. Thirty States have been created out of the public domain. In those where the public land surveys have been substantially completed, excepting Oklahoma, the original records have been transferred to the States. In most cases duplicate copies are on file in Washington, D.C. The Director of the Bureau of Land Management has administrative authority in questions relating to the remaining public land in those States, including resurvey and the extension of surveys to include parcels of public land omitted from the official surveys.

The following list of the States formed from the public domain gives the date of admission, a citation of the enabling act in the United States Statutes at Large, and the present location of the original records of public land surveys.

*Alabama*. Included in the territory of the original 13 States and admitted into the Union December 14, 1819 (3 Stat. 608); records with the Secretary of State at Montgomery.

*Alaska*. Purchased from Russia in 1867; admitted into the Union January 3, 1959 (72 Stat. 339); records in the State Office of the Bureau of Land Management at Anchorage.

*Arizona*. Included in the lands ceded by Mexico in 1848 and the Gadsden purchase in 1853; admitted into the Union February 14, 1912 (36 Stat. 557; 37 Stat. 1728); records in the State Office of the Bureau of Land Management at Phoenix.

*Arkansas*. Acquired under the Louisiana Purchase in 1803 and admitted into the Union June 15, 1836 (5 Stat. 50); records with the Department of State Lands at Little Rock.

*California*. Ceded by Mexico in 1848 and admitted into the Union September 9, 1850 (9 Stat. 452); records in the State Office of the Bureau of Land Management in Sacramento.

*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; admitted into the Union August 1, 1876 (18 Stat. 474; 19 Stat. 665); records in the State Office of the Bureau of Land Management in Denver.

*Florida*. Ceded by Spain in 1819 and admitted into the Union March 3, 1845 (5 Stat. 742); records with the Board of Trustees of the Internal Improvement Trust Fund 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); records in the State Office of the Bureau of Land Management in Boise.

*Illinois*. Included in the territory of the original 13 States and admitted into the Union December 3, 1818 (3 Stat. 536); records in the Illinois State Archives, Secretary of State, at Springfield.

*Indiana*. Included in the territory of the original 13 States and admitted into the Union December 11, 1816 (3 Stat. 399); records with the Archivist, Indiana State Library, at Indianapolis.

*Iowa*. Acquired under the Louisiana Purchase in 1803 and admitted into the Union December 28, 1846 (9 Stat. 117); records with the Secretary of State at Des Moines.

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

*Louisiana*. Included in the Louisiana Purchase in 1803; boundary extended to include

additional lands, title to which was quieted through treaty with Spain in 1819; admitted into the Union April 30, 1812 (2 Stat. 701); records with the Register, State Land Office, at Baton Rouge.

*Michigan.* Included in the territory of the original 13 States and admitted into the Union January 26, 1837 (5 Stat. 144); records with the State Department of Treasury at Lansing.

*Minnesota.* Included in the territory of the original 13 States (additional lands acquired under the Louisiana Purchase in 1803); admitted into the Union May 11, 1858 (11 Stat. 285) records with the Department of Conservation at Saint Paul.

*Mississippi.* Included in the territory of the original 13 States and admitted into the Union December 10, 1817 (3 Stat. 472); records with the State Land Commissioner at Jackson.

*Missouri.* Acquired under the Louisiana Purchase in 1803 and admitted into the Union August 10, 1821 (3 Stat. 645, 3 Stat. Appendix II); records with the State Land Survey Authority at Rolla.

*Montana.* Acquired under the Louisiana Purchase in 1803 and with the Oregon Territory, title to which was established in 1846; admitted into the Union November 8, 1889 (25 Stat. 676, 26 Stat. 1551); records in the State Office of the Bureau of Land Management at Billings.

*Nebraska.* Acquired under the Louisiana Purchase in 1803 and admitted into the Union March 1, 1867 (14 Stat. 391, 820); records with the State Surveyor at Lincoln.

*Nevada.* Ceded by Mexico in 1848 and admitted into the Union October 31, 1864 (13 Stat. 30, 749); records in the State Office of the Bureau of Land Management at Reno.

*New Mexico.* Included in the lands annexed with Texas in 1845, with lands ceded by Mexico in 1848, and the Gadsden Purchase in 1853; admitted into the Union January 6, 1912 (36 Stat. 557, 37 Stat. 1723); records in the State Office of the Bureau of Land Management at Santa Fe.

*North Dakota.* Included in the territory of the original 13 States and with lands acquired under the Louisiana Purchase in 1803; admitted into the Union November 2, 1889 (25 Stat. 676; 26 Stat. 1548); records with the State Water Conservation Commission at Bismarck.

*Oklahoma.* Acquired under the Louisiana Purchase in 1803 and with lands annexed with Texas in 1845; admitted into the Union November 16, 1907 (34 Stat. 267; 35 Stat. 2160); records in the New Mexico State Office of the Bureau of Land Management at Santa Fe, New Mexico.

*Ohio.* Included in the territory of the original 13 States and admitted into the Union November 29, 1802 (2 Stat. 173); records with the Auditor of State at Columbus.

*Oregon.* Included in the Oregon Territory, title to which was established in 1846; admitted into the Union February 14, 1859 (11 Stat. 383); records in the State Office of the Bureau of Land Management at Portland.

*South Dakota.* Included in the territory of the original 13 States and with lands acquired under the Louisiana Purchase in 1803; admitted into the Union November 2, 1889 (25 Stat. 676; 26 Stat. 1549); records with the Commissioner of Schools and Public Lands at Pierre. The plats of mineral patent surveys of South Dakota are filed in the Montana State Office of the Bureau of Land Management at Billings, Montana, and the necessary mineral surveys are directed from that office.

*Utah.* Ceded by Mexico in 1848 and admitted into the Union January 4, 1896 (28 Stat. 107, 29 Stat. 876); records in the State Office of the Bureau of Land Management at Salt Lake City.

*Washington.* Included in the Oregon Territory, title to which was established in 1846; admitted into the Union November 11, 1889 (25 Stat. 676, 26 Stat. 1552); records in the Oregon State Office of the Bureau of Land Management at Portland, Oregon.

*Wisconsin.* Included in the territory of the original 13 States and admitted into the Union May 29, 1848 (9 Stat. 233); records with the Department of Natural Resources 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; admitted into the Union July 10, 1890 (26 Stat. 222); records in the State Office of the Bureau of Land Management at Cheyenne.

## Methods of Survey

The methods described in this chapter comprise the specifications for determining the length and direction of lines.

### DISTANCE MEASUREMENT

#### Units

2-1. The law prescribes the chain as the unit of linear measure for the survey of the public lands. All returns of measurements in the rectangular system are made in the true horizontal distance in miles, chains, and links. (Exceptions are special requirements for measurement in feet in townsite surveys, chapter VII, and mineral surveys, chapter X.)

#### *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

The chain unit, devised in the seventeenth century by Edmund Gunter, an English astronomer, is so designed that 10 square chains are equivalent to one acre. In the English colonial area of the United States the boundaries of land were usually measured in the chain unit, but lengths of lines were frequently expressed in poles. One pole is equal to 25 links, and four poles equal one chain. The field notes of some early rectangular surveys in the southern States show the distance in "perches," equivalent to poles. The term now commonly used for the same distance is the rod.

Land grants by the French crown were made

in arpents. The arpent is a unit of area, but the side of a square arpent came to be used for linear description. The Spanish crown and the Mexican Government granted lands which were usually described in linear varas. Both the arpent and the vara have slightly different values in different States. The conversions most often needed are shown in the Standard Field Tables.

#### Tapes

2-2. Use of the steel tape is the commonly accepted method of measurement. The tapes used vary in length from one to eight chains, the appropriate length depending upon the topography and the nature of the survey. Graduation is to chains and links, and in some instances to tenths of links. For measurements on the slope the vertical angles are determined by use of a clinometer or a transit. The measured slope distances are then reduced to horizontal equivalents by reference to tables or by multiplying the slope distance by the cosine of the vertical angle.

Each tape should be compared with a standard steel tape before being used in the field.

#### Stadia

2-3. The stadia method is a fast way of making reconnaissance surveys for such purposes as obtaining topography or searching for original corners. Its use is not permitted for measurement of lines. Most transits used by the Bureau of Land Management have a stadia interval with a ratio of 1:132 for use with the chain unit, rather than the standard ratio of 1:100. Data for the reduction of stadia meas-

urements are found in the Standard Field Tables.

### Subtense Bar

2-4. The subtense bar may be used provided that no measurement is over ten chains and that the instrument used in connection with it is capable of measuring in single seconds.

### Traversing

2-5. Traverses may be run where the terrain is too precipitous for chaining and the intervisible points required for triangulation cannot be practicably obtained. Traversing should be kept to a minimum.

### Triangulation

2-6. Triangulation may be used in measuring distances across water or over precipitous slopes. The measured base should be laid out so as to adopt the best possible geometric proportions of the sides and angles of the triangle. If it is necessary to determine the value of an angle with a precision of less than the least reading of the vernier, the method of repetition should be employed.

A complete record of the measurement of the base, the determination of the angles, the location and direction of the sides, and other essential details is entered in the field tablets, together with a small diagram to represent the triangulation.

In the longer and more important triangulations all of the stations should be occupied, if possible, and the angles should be repeated and checked to a satisfactory closure; the latter may be kept within  $0' 20''$  by careful use of the one-minute transit.

In line practice the chainmen are frequently sent through for taped measurement over extremely difficult terrain, but with the length of the interval verified by triangulation. This is done to ensure the most exact determination of the length of the line while also noting the intervening topographic data.

### Electronic Telemetry

2-7. The measurement of lines by use of electronic telemetry fully meets the require-

ments for accuracy. Determining factors in its use are the terrain, ground cover, and availability of the proper instruments. Some types are adapted to the measurement of long distances, others to measurement of intermediate distances. Transport and maintenance must be considered in determining whether the use of telemetry will expedite a particular survey. Provision must be made for measuring distances to important items of topography.

The variety of electronic distance-measuring devices, the rapid development of combinations with optical theodolites, and modifications of the instruments make it impracticable to describe the methods of use in this manual. The surveyor should consult the manufacturer's operating manual for calibration, use, care, and adjustments.

A special kind of triangulation is used when it is desired to locate on the ground a point for which the geographic position has been determined in advance. Two intervisible triangulation stations are occupied simultaneously with optical theodolites and electronic measuring devices. A mobile party sets a temporary point at the approximate position of the desired point by reference to a topographic map or aerial photographs. The position of the temporary point is then determined by triangulation or trilateration and the true point is monumented.

The system is made more adaptable by use of the hoversight developed by the United States Geological Survey. This instrument is fixed in a helicopter. The airborne observer is able to identify a point on the ground perpendicularly beneath a flashing target mounted outside the helicopter. The position of the flashing target is then determined by triangulation. Full utilization of the system requires ready contact with computers by telephone or radio. The Airborne Control Survey, as it is called, is carefully planned to coordinate ground crews, helicopter, and computers. Its use has been successful in surveys over extensive areas in Alaska, and experiment is being made in resurveys and in connection with photogrammetric surveys at the present time.

## PHOTOGRAMMETRY<sup>1</sup>

2-8. The earliest uses of aerial photography by the cadastral surveyor were for terrain studies, locating himself on the ground, and as an aid in the search for corners. As methodology improved, simple photogrammetric processes enabled the surveyor to delineate topographic features, determine the meanders of water bodies, compute areas of erroneously omitted lands, and lay out townsites as they actually exist. Photogrammetric projects involving both distance measurements and the direction of lines have been completed for both original surveys and resurveys of extensive areas of public lands.

### Aerial Camera

2-9. The aerial camera is a high-precision instrument designed for making photographs on which reliable measurements can be made after resolvable errors have been analyzed and removed. The camera must be maintained in calibration at all times. To insure this the calibration should be checked periodically by a competent testing agency such as the Bureau of Standards. The aerial camera used for cadastral surveys should include the following features:

- (1) A distortion-free lens with a high resolving power
- (2) A between-the-lens shutter
- (3) A precision-ground platen
- (4) A method of flattening film at the time of exposure
- (5) A system of fiducial marks which appear on each photograph and define the lens axis.

### Aerial Photography

2-10. An aerial photograph is not a map with a uniform scale throughout, but merely a pictorial representation of the terrain. Geometrically speaking, an aerial photograph is a perspective projection of an area as viewed from a single point above the ground. Relief displacement, lens characteristics, film and paper dis-

tortion, and tilt of the camera preclude its having a uniform scale.

Topographic maps may be compiled either by the use of stereoplotting instruments or by making measurements directly upon the photograph. Elements which may affect the accuracy are camera calibration, height of the aircraft above the terrain being mapped, the density and accuracy of ground control, the tip or tilt of the camera at the moment of exposure, film distortion, and the instruments used in making the measurements.

An approximate scale for a vertical aerial photograph is stated by the equation  $S = \frac{f}{H-h}$

where:

- f = the focal length of the camera
- H = the flying height above sea level
- h = the average elevation of the terrain above sea level

*Stereophotogrammetry* utilizes a stereoscopic plotting instrument (optical-mechanical device) to compile data from aerial photographs. These data, usually in the form of a map, vary in accuracy according to the design of the instrument. Often the instrument embodies a higher degree of accuracy than the photography. By use of a first-order plotting instrument a complete solution of the geometry of the photogrammetric problem may be obtained. All relative displacements of images such as those due to perspective, difference of flying height, lens distortion, and photographic material distortion are resolved.

Several instruments have been designed for aerotriangulation, a method of adjusting consecutive photographs in a strip bridging from one set of control points to another.

*Resolution* in photography pertains to the sharpness of recording images of two or more light sources, which are close together, so that the images are recognized and distinct. Depending on the characteristics of the lens-film combination, the final resolving power may be enhanced or degraded.

Other factors that affect the quality of the final photograph are aperture opening, distance to the subject, exposure time, atmospheric conditions of haze and brightness of the sun, con-

<sup>1</sup> A complete discussion of the subject in its broad application is contained in the Manual of Photogrammetry, published by the American Society of Photogrammetry.

trast of the subject, vibration, size of the subject, and the processing of the film after exposure.

### Field Control

2-11. A network of control points of known position is used as a reference to fix the detail of aerial photographs by photogrammetric processes. The density and distribution of field control points to be photo-identified are determined primarily by the characteristics of the photography, the type of photogrammetric equipment and computer programs to be used, and the accuracy required. Ground control surveys are usually necessary to identify the existing basic control and to provide additional control points.

The basic control into which the supplemental surveys are tied, the supplemental surveys themselves, and the photo-identification of points must in toto provide the degree of accuracy required of the resultant cadastral survey. The survey methods used in the control survey have to be of equal or higher order accuracy than is specified for the results. The classification and standards of accuracy of geodetic control surveys are outlined in Bureau of Budget (now Office of Management and Budget) Circular A-16. The density, spacing, accuracy, and manner of marking of photo-identified points must conform to the criteria established by the responsible photogrammetrist.

*Datum.* A basic network of high-order geodetic control has been established throughout the United States. This network has been developed by combining a number of separate geodetic datums into a single datum known as the North American Datum of 1927. All horizontal control stations established for photogrammetric projects should use this datum as the base for computing values for the control stations. (section 2-82.)

Vertical control in the United States is referred to an arbitrary level for the entire nation which was based on mean sea level as determined by observations made over a period of years at tidal stations on the Atlantic, Pacific, and Gulf Coasts. Several adjustments

have been made of the basic network, the most recent in 1929.

Basic vertical control bench marks within or adjacent to a photogrammetric project should be used to expand the vertical control over the project area. When there is no basic vertical control near the project area, an arbitrary datum may be assumed and expanded to control the project.

*State Plane Coordinates.* State plane coordinate systems are used extensively for photogrammetric plotting. (section 2-83.) Formulas and tables for computing values for these systems have been prepared by the United States Coast and Geodetic Survey (now the National Geodetic Survey) for each individual State. The computations involve corrections for grid lengths, sea level factors, and grid azimuths.

*Horizontal Control.* Basic horizontal control is that which has been established by the National Geodetic Survey to form the National Network; this should be the origin for all supplemental control on each photogrammetric project.

The supplemental control should be of sufficient density to permit an efficient control of all the photographs at the time of the analytical phototriangulation. The density of control will vary with the size of the project, but generally horizontal control should be located in every six to eight models in a bridge with never fewer than four control points in a flight strip.

The supplemental control may be established by triangulation, trilateration, or traverse using transit and tape or theodolite and electronic distance-measuring instruments. In all applications the control thus established should be executed using second-order methods and meet second-order accuracy.

*Vertical Control.* The basic vertical control network is that established by the National Geodetic Survey by spirit leveling; when such control is within the project area, it should be used to establish supplemental vertical control.

The supplemental vertical control may be established on an assumed datum where no basic control network is near the project.

The supplemental control may be established by spirit leveling or trigonometric leveling.

Both the horizontal and vertical control

points are normally targeted prior to the aerial photography. The targets are centered over the respective stations and have a symmetrical design easily identified on the photography. Care should be taken when selecting the size, shape, color, and material to be used for the targets.

In cases where targeted points have been destroyed prior to photography it may be necessary to substitute "natural targets" to supplement the control. Such points are selected in the field and referenced into the control scheme. The identification should be made only while viewing the photography stereoscopically and at the site of the feature. A photograph showing the feature and its relationship with the destroyed station should be furnished the operator of the comparator at the time of the analytical phototriangulation.

#### Mechanical Phototriangulation

2-12. The mechanical (known also as analogue or instrumental) method of phototriangulation establishes positions and elevations by use of an instrument viewing a spatial model. Precise connections are made between successive models which in turn are tied to vertical and horizontal control. After adjustment, an accurately scaled representation of the project area can be depicted. This method has been used for several successful cadastral survey projects.

#### Analytical Phototriangulation

2-13. Analytical phototriangulation is a mathematical determination of ground positions of panelled points observed in a strip or block of aerial photographs. The positions are determined by use of electronic computers and are based on coordinate measurements of the image positions in each photograph. The method considers such factors as camera calibration, film distortion, atmospheric refraction, and earth curvature during the computations.

The instruments used to determine photographic coordinates, from which the ground positions are established, are the comparator (either monocular or stereoscopic), point-marking and transfer devices, and computers. The

advent of the electronic computer made it practicable to use analytical methods in phototriangulation. The basic foundation for analytical photogrammetry had been established by Sebastian Finsterwalder about 1900.

The accuracy of the data obtained by use of the analytical process is usually of a higher order than that obtained by the mechanical methods. The Bureau of Land Management has therefore adopted it for use in photogrammetric cadastral surveys.

#### Photogrammetry in Original Surveys and Resurveys

2-14. Pilot projects employing photogrammetric methods for making original surveys and resurveys have led to standardization of methods and equipment. As new equipment and refinements in methods are developed they will be tested and employed as warranted.

*Protraction Diagrams.* A diagram representing the plan for the extension of the rectangular system over unsurveyed public lands, based upon computed values for the corner positions, is termed a protraction diagram. Such diagrams have been prepared for substantially all unsurveyed areas of public lands except the Aleutian Islands and southeastern Alaska.

A successful photogrammetric project requires a good plan and coordination between the cadastral surveyor and the photogrammetrist. As in any cadastral survey, all pertinent data must be reviewed, including maps, aerial photographs, geodetic surveys, cadastral surveys, and protraction diagrams.

Certain basic steps are always required to complete a photogrammetric survey:

#### *Original Surveys*

*Corner Positions.* The theoretical corner points are first plotted upon a map or on existing aerial photographs at the coordinate positions of the protraction diagram or other plan. The transfer may be accomplished by scaling on the map, or the positions may be located by using plotting instruments such as the Kelsh plotter. The more accurately these values can be plotted, the smaller the moves will be from the panel points when permanent corner monuments are established.

*Control.* The plan of geodetic control depends on the number of flight lines and the number of models in each flight line. It should be based on triangulation or traverse stations established to second-order accuracy. It is advisable that electronic distance-measuring instruments and theodolites be used in establishing new stations. Final values for such stations should be given as state plane coordinates.

*Panels.* The theoretical position of each corner, as plotted on maps or existing photographs, as well as each original or new control station, is marked on the ground by a systematically designed panel. Care should be taken to center the panel over the monument or survey stake.

The panels should be of such a design and size as to be conspicuous in the subsequent aerial photographs. The photography is undertaken immediately following the control and paneling operation in order to assure the least disturbance to panelled points. If a panel is destroyed before the photography can be accomplished, the photogrammetrist should select a natural object near the destroyed panel to serve as a substitute during the remaining operations.

*Aerial Photography.* Complete stereoscopic coverage of the area to be surveyed is essential. The photography should have a minimum of 55% forward lap and 30% side lap between flight lines. With a photoscale of 1:20,000, it is possible to perform surveys having a root-mean-square horizontal error of plus or minus one foot.

In certain areas it is advisable to use several types of aerial negatives—color, panchromatic, and infrared false color—for positive identification of panelled points. Experiments are being conducted to determine the best film-filter-background combination to give maximum clarity in delineating panelled points.

*Analytical Bridge.* An analytical bridge, a form of phototriangulation, establishes coordinate values for the panelled points and also natural objects. The photographic coordinates are transformed into State plane coordinates, which are used in computing corner moves.

In addition to panelled points, it is necessary to obtain positions of houses, windmills, or other features that require ties to complete the cadastral survey. The cadastral surveyor must

work closely with the photogrammetrist to assure that the necessary ties to such items are made.

Once the corners are monumented at the protracted positions, the cadastral surveyor prepares his plats in the normal manner, prefacing his notes with a statement concerning the method of procedure.

### *Execution of Resurveys*

As in the making of original surveys, planning and cooperation between the cadastral surveyor and the photogrammetrist are essential to success.

*Corner Positions.* From the original survey notes and plats the theoretical position of each previously established corner is plotted upon existing aerial photography. Where suitable maps do not exist, a cursory search for the exterior boundaries of the townships to be resurveyed should be made. Any corners found are identified upon existing aerial photography and the interior corners plotted in accordance with the record of the original survey.

A careful search is made for the corners in the positions plotted on the photographs. When a corner is recovered, it is rehabilitated or re-monumented. In the event that no positive evidence of the corner is recovered, a temporary stake is set at the theoretical position. In either case a State plane-coordinate value is established to be used in control for further search or in computing subsequent corner moves.

Geodetic control, aerial photography, and analytical bridge methods and procedures are the same as for original surveys.

### *Meanders*

The sinuosities of a shoreline may be produced on a manuscript base by use of a stereo-plotting instrument. The plotting scale is usually five times that of the photography. Angle points are selected along the shore, and the coordinate values of both meander corners and angle points are determined by scaling. Courses and distances of the meanders are computed from the coordinate values. The accuracy of the results depends on the accuracy with which the meander corners are photo-identified,

the precision with which the sinuosities of the shoreline are drawn, and the correctness of scaling from the manuscript.

In areas of little relief single photographs can be used as the displacement of features is at a minimum. Distortion caused by camera tilt is small enough to be removed by adjustment. Either contact prints projected by a reflecting projector and enlarged to convenient scale or enlargements made from the original film may be used.

Whether the stereoplottting instrument or the single print is used, it is desirable that the field man verify the shoreline and perhaps delineate it on the photographs with colored ink.

### Accuracy Checks

2-15. In both the original survey and the resurvey it is advisable to establish the coordinate position for a number of corners selected at random, being sure that there are several check positions in each flight line. It is preferable that these check positions fall in the overlap area between flight lines, this being one of the weak points in a photogrammetric bridge.

The values of the check points should be withheld from the original bridge and used as a check. If they fall within the allowable tolerance for accuracy, they will have served their purpose. If they do not meet the accuracy tolerance, the bridge may be strengthened by using them as control. In such a case additional accuracy checks will be required to assure that the survey meets the necessary standard.

Where photogrammetry is used as a means of establishing the position of section corners, accuracy is necessarily stated as a radius of error rather than a ratio of closure, since any position established is independent of monuments preceding or following along a boundary. Errors of position are not accumulative, and a stated radius of error means that any monument's position may differ from the protracted value by the full radius of error and in any direction from the protracted point. Since the acceptable radius of error is the same for each bridged point, the error in bearing and the percentage error in distance between two survey monu-

ments will vary inversely as the length of the course.

### Accuracy

2-16. The accuracy obtainable in photogrammetric surveys depends on the scale and type of photography, the instruments used, the skill of the compiler, the density of ground control, the amount of relief, and the nature of the vegetative cover. These factors relate to the data taken from the photographs. If markers are positioned by relationship to nearby photo-identifiable objects, the precision of the field methods used also affects the final accuracy. If meanders are recorded, the reliability of their delineation on the photography is a factor in the accuracy of the work.

It is axiomatic that "the greater the accuracy, the greater the cost." The scale of the photography for each project, therefore, should be commensurate with the accuracy required. The amount of topographic relief may affect the choice of methods. In flat terrain, with photography nearly vertical, measurements for some purposes may be made on a photographic print. As the relief or the tilt increases, rectification and adjustment are necessary.

If precision is not required, a tube magnifier, which can be carried in the pocket, will measure 0.005 inch. A precision comparator has a least measurement of one micromillimeter. At a photo scale of 1:20,000, 0.005 inch represents eight feet, while one micromillimeter represents 0.06 foot. These figures are cited to illustrate how methods and instruments can be selected to give desired precision in results.

### THE DIRECTION OF LINES

2-17. The direction of each line of the public land surveys is determined with reference to the true meridian as defined by the axis of the earth's rotation. Bearings are stated in terms of angular measure referred to the true north or south.

2-18. *The Magnetic Needle.* The Manual of 1890 prohibited the use of the magnetic needle except in subdividing and meandering, and then only in localities free from local attraction. The

Manual of 1894 required that all classes of lines be surveyed with reference to the true meridian independent of the magnetic needle.

A field note record is required of the average magnetic declination over the area of each survey. The value is shown on the plat and in the field notes. The principal purpose of this record is to provide an approximate value for use in local surveys and retracements, where a start is to be made by the angular value of the magnetic north in relation to the true north.

### Methods of Establishing Direction

2-19. Current practice is to determine true azimuth by one of the following methods:

- (1) Direct observations of the sun, Polaris, or other stars
- (2) Observations with a solar attachment
- (3) The turning of angles from triangulation stations of the horizontal control network.

At remote locations, if these methods are made impracticable for long periods by thick cloud cover, angles may be turned from identifiable lines of an adjacent Bureau of Land Management survey. Use may also be made of a gyro-theodolite, properly calibrated and previously checked on an established meridian.

### Observations—General Considerations

2-20. *Sequence of Observations.* A small error in latitude or azimuth has only a slight effect in time. When all three are unknown, the order of sequence in their determination should be (1) time, (2) latitude, and (3) azimuth.

2-21. *Geographic Position.* The longitudes that are shown upon maps refer to the zero meridian of the Royal Observatory at Greenwich, England. The map values for longitude scaled from the topographic maps of the United States Geological Survey may be accepted for use in making any of the calculations incident to the observations for time, latitude, and azimuth that are required with Manual practice. Where these maps are not available, it is probable the surveyor will be able to find others that will show longitude within the degree of accuracy required. Precision in both latitude and longitude may be secured wherever geodetic stations have been established.

The showing of latitude and longitude on the plat of the cadastral survey should be extended to seconds if ties to a geodetic station warrant that refinement.

2-22. *Precision of Observations.* The methods that are set out in the Manual for a well balanced observing program are good for results within  $\pm 6$  seconds of time and  $\pm 15''$  in latitude and azimuth, when estimated vernier readings are made to the nearest  $30''$ .

2-23. *Astronomy in the Manual.* The basic astronomy needed for understanding of the observations described in the Manual is well covered in college courses in applied astronomy. The theory relating to the observations and the derivation of formulas is not repeated in the Manual. The subjects are treated with a view to securing the most direct practical results. The methods are not difficult when coupled with practice in making the observations. Until the steps become familiar it is helpful to record for an experienced observer and to assist in making the reductions.

The methods applied principally in observations upon Polaris and the sun are arranged to facilitate the work under most conditions encountered in the field. The tables and formulas that are published in the Standard Field Tables and in the Ephemeris are designed for the convenience of the cadastral surveyor in the field.

The bright stars in the equatorial belt may be observed to secure refinements and to verify results secured by observations on the sun and Polaris. These stars may be selected for favorable position in declination at any date when the sun is either too low or too high for the desired observation. The south declination stars are needed for certain observations in Florida, the higher north declination stars in Alaska. The stellar methods are indispensable to a well balanced observing program whenever high precision is required.

### 2-24. Symbols.

$\neq$ : The symbol for inequality, which is here used to show a relation that approaches equality.

$v$ : Observed vertical angle. In altitude observations on the sun the reductions to the sun's center both vertically and horizontally, as well as instrument errors, are compensated by tak-



local mean time, one hour for  $15^\circ$  difference in longitude.

2-30. *The equation of time* is the amount to be added to, or subtracted from apparent time to convert over into local mean time. The equation of time is changing constantly. Its value for apparent noon each day, on the Greenwich meridian, is tabulated in the Ephemeris. The equation of time reaches a maximum of about 16 minutes early in November.

2-31. *Standard time* is identical with local mean time on the central meridian of each time belt, as Eastern Standard Time on the 75th meridian; Central Standard Time on the 90th meridian; Mountain Standard Time on the 105th meridian; Pacific Standard Time on the 120th meridian; Yukon Standard Time on the 135th meridian; Alaska Standard Time on the 150th meridian; Bering Standard Time on the 165th meridian of longitude. Correction for longitude is all that is required for converting over into local mean time, additive when east of the central meridian, subtractive when west. An additional correction of one hour is necessary when "daylight saving" time is in effect.

2-32. If an observation is to be made of Polaris on a different meridian than that of the preliminary observation for time, it is important to adjust the local mean time to the new station. This adjustment amounts to 23 seconds across one township at Cape Sable, Florida; 60 seconds at Point Barrow, Alaska. It is 30 seconds across one township in latitude  $46^\circ$ . For example, a Polaris observation is to be made at a station in latitude  $46^\circ$ ; the adjustment in local mean time, for longitude, for the time observation that may not be made in that same meridian will be at the rate of 5 seconds per mile. A watch that reads correct local mean time at the point of time observation will be  $0^m 5^s$  slow of local mean time in the meridian one mile to the east, or the same amount fast for the meridian one mile to the west. This adjustment may be allowed for when the time observation is made somewhere on the line of the survey and the Polaris observation is made at field party headquarters.

The unit of sidereal time is measured by one revolution of the earth on its axis, the 24-hour period of which is equivalent to 23 hours 56

minutes 4.091 seconds in mean solar time. There are  $366\frac{1}{4}$  sidereal 24-hour periods in the solar year of  $365\frac{1}{4}$  days.

The mathematical equations that are employed in the observations upon the equatorial stars, for time and altitudes, and for the azimuths and altitudes of Polaris at various hour angles, are based upon the sidereal time rate. The same equations are applicable in the reduction of observations upon the sun for time, the moment of the observation being expressed in apparent time.

Assume that a star and *mean sun* cross the Greenwich meridian at the same instant. The star would cross each succeeding meridian ahead of the sun by an increasing time interval proportionate to the longitude west of Greenwich. These time intervals, called *sidereal conversions*, are listed for increasing longitudes in both the Ephemeris and the Standard Field Tables. Sidereal conversions are applied to the mean solar time to obtain sidereal time and vice versa.

Sidereal time is not employed directly in the Manual methods. It is avoided through the plan of the tabulations that are published in the Ephemeris for the upper culmination and elongation of Polaris, and for the transit (meridian passage) of the equatorial stars, which are given in terms of mean solar time, Greenwich meridian, for the ordinary civil date, a.m. or p.m. The azimuths and altitudes of Polaris are tabulated in terms of mean time hour angle.

2-33. In the entry of the record of an observation, the watch time is the reading at that moment. The watch may be set to read the approximate local mean time, or it may be set to carry the approximate standard time. In either case the "watch error" is the difference between the actual reading and what would be the exact local mean time or standard time as intended. The watch error in standard time may be determined by comparison with a clock that reads the correct standard time controlled electrically, or the comparison may be made with the radio time signals.

There is usually a personal preference as to the setting of a watch. Many prefer to set to standard time. Others on extensive field work

find it convenient to change over to local mean time, or to carry a substitute watch set to local mean time. On solar transit orientation, the time circle reads apparent time. If the solar unit is being used constantly, as is nearly always the case where the line runs through heavy forest cover or dense undergrowth, many surveyors like to use a watch set to apparent time.

The record entry should therefore be explicit (1) as to the setting of the watch to approximate standard, local mean, or apparent time; (2) the conversion, if from standard to local mean time; and (3) the method of ascertaining the watch error in terms of local mean time in every case when making an hour angle observation on Polaris. Many Polaris observations are made during the season, sometimes daily. It is for this purpose that the Manual devotes so much attention to the practical field observations for time.

2-34. The element of time enters into all azimuth determinations, apparent time for all observations upon the sun, local mean time for all observations on Polaris and other stars. The sun's declination varies with the apparent time and the longitude west from Greenwich. The declination enters into all observations on the sun for azimuth. Thus the apparent time and longitude should be known to a degree of accuracy commensurate with the refinement necessary in computing the sun's declination. The azimuth of Polaris varies with local mean time of observation, which must be known to a degree of accuracy consistent with the result wanted in the determination of the true meridian.

2-35. In observations on Polaris at elongation, precision in local mean time is unnecessary, but in hour angle observations upon Polaris it will be noted that at upper or lower culmination, in latitude  $40^\circ$  for example, Polaris varies  $1'$  in azimuth in about three minutes of time. This interval of time slowly increases toward elongation, and in the latter position more than 30 minutes of time are required for a change of  $1'$  in azimuth.

#### Examples of Time Conversions

2-36. *Standard time into local mean time:*  
Watch reading  $\pm$  watch error in standard time

$\pm$  correction for longitude. The correction for longitude is additive east and subtractive west of the standard meridian of the time belt. The conversion table, "degrees to time," Standard Field Tables, is convenient in this reduction. For example, in longitude  $77^\circ 01' 37.5''$  W.:

Watch time of observation .....	=	$6^h 26^m 40^s$ p. m.
Watch slow of 75th meridian standard time by comparison with a standard clock .....	=	$+1^m 22^s$
Correction for longitude of station ( $77^\circ 01' 37.5''$ W. or $5^h 08^m 06.5^s$ ) .....	=	$-8^m 06^s$
Local mean time of observation .....	=	$6^h 19^m 56^s$ p. m.

2-37. *Apparent time into local mean time:*  
Apparent time of observation  $\pm$  the equation of time. The equation of time is taken from the Ephemeris for the date of observation and corrected for the longitude and time of observation, conveniently interpolated as the interval from Greenwich noon to the time of observation. The watch error in local mean time is then found by taking the difference between the watch reading at the instant of the observation and the reduced mean time of observation. For example, in longitude  $77^\circ 01' 37.5''$  W.:

Mar. 18, 1970, apparent time of altitude observation upon sun .....	=	$3^h 42^m 11^s$ p. m.
Equation of time, Greenwich apparent noon .....	+ $8^m 12.5^s$	
Interpolation for longitude of station $5^h 08^m$ W., and time of observation $3^h 42^m$ , p.m., $8^h 50^m$ after Greenwich noon, or $8.83/24$ of change ( $17.64^s$ ) in 24 hours .....	=	$-6.5^s$
Equation of time .....	+ $8^m 06.0^s$	+ $8^m 06^s$
Local mean time of observation .....	=	$3^h 50^m 17^s$
Watch time of observation .....	=	$3^h 57^m 53^s$
Watch fast of local mean time .....	=	$7^m 36^s$

This reduction is made when the apparent time has been determined by solar observation as in section 2-63. If the correct watch time is known, a reverse process is used to convert local mean time to apparent time when computing the declination of the sun at the time of an observation.

**Polaris**

2-38. Polaris, the North Star, occupies a position in the northern heavens about  $1^\circ$  from a line defined by the axis of the earth's rotation. Being a star of the second magnitude and near the polar axis, it ranks as the most useful circumpolar star. It will be assumed that the surveyor has learned how to identify Polaris in the clear night sky by reference to the "pointers" in the constellation of the "Great Bear," popularly called the "Dipper." Polaris,  $\alpha$  Ursae Minoris, is nearly on a line (or great circle) determined by the pole and the star  $\delta$  Cassiopeiae. Both stars are located in the same direction from the pole. The same line, or great circle, passes near the star  $\zeta$  Ursae Majoris, another star of the "Dipper." The latter star is located on the *opposite* side of the pole. The relative position of the three stars gives an immediate indication of the approximate position of Polaris in its diurnal circle at that time. The three stars are all of about the same brightness. Instructions will follow regarding the identification of Polaris by instrumental methods during the twilight period, before the star is visible to the naked eye. The same method may be used for verification of a night observation if the neighboring constellations are obscured by clouds.

An experienced surveyor can readily observe Polaris at sunrise or sunset, reading the measurements without artificial illumination, and with a very clear atmosphere can make the observation when the sun is as much as 20 or 30 minutes above the horizon.

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

The pointings of the arrows on the circle (at right) indicate the direction of the apparent motion of Polaris in its diurnal path. The point-

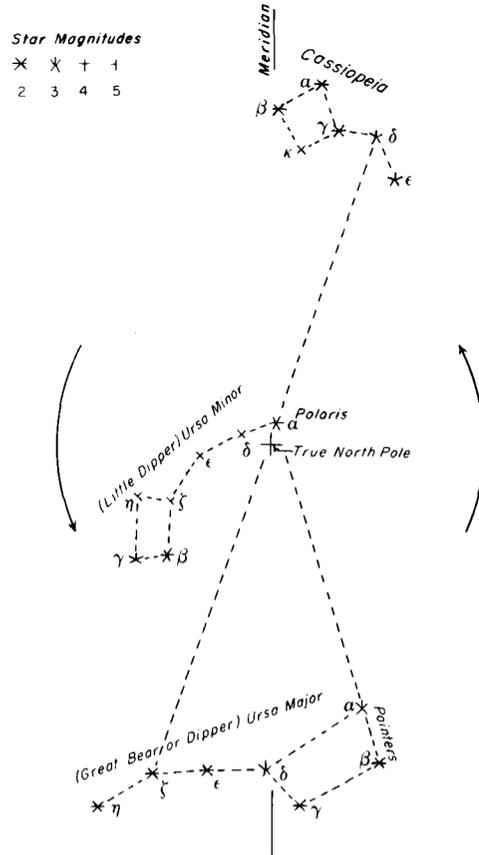


FIGURE 4.—Naked-eye identification of Polaris.  
 About noon March 23d.  
 About 6 a.m. June 22d.  
 About midnight September 22d.  
 About 6 p.m. December 22d.

ings of the arrows on the lines tangent to the circle show the direction of travel at the epochs of culmination and elongation. If the surveyor has any doubt in regard to the quadrant occupied by Polaris in its diurnal circle at the

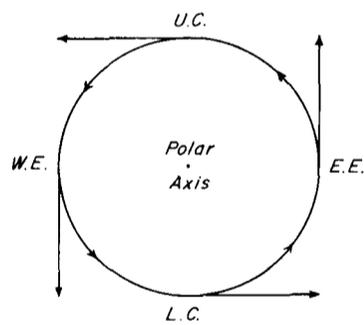


FIGURE 5.

time of an observation, he may set the intersection of the telescope cross-wires exactly on the star, then, without moving the instrument, note the direction of the star's motion and compare with the diagram.

The motion of Polaris at western elongation is vertically downward; at eastern elongation the motion is vertically upward. At western or eastern elongation the motion in azimuth is zero.

At the equator, if Polaris could be observed, the hour angle of Polaris at elongation would be  $90^{\circ}0'0''$  or  $6^{\text{h}}0^{\text{m}}0^{\text{s}}$  sidereal hour angle or  $5^{\text{h}}59^{\text{m}}-1.02^{\text{s}}$  mean time hour angle, but as stations of observation are occupied in the higher latitudes the hour angle of Polaris at elongation decreases progressively. The reason for this is 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 higher latitudes, giving increasing azimuths at elongation with the more northern latitudes.

2-39. The position of Polaris in its diurnal circle at any time may be determined by reference to the mean time interval from upper culmination to any observed position west of the meridian, or by reference to the mean time interval from any observed position east of the meridian to the succeeding upper culmination.

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

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

Example of reduction from the Greenwich mean time of upper culmination of Polaris to

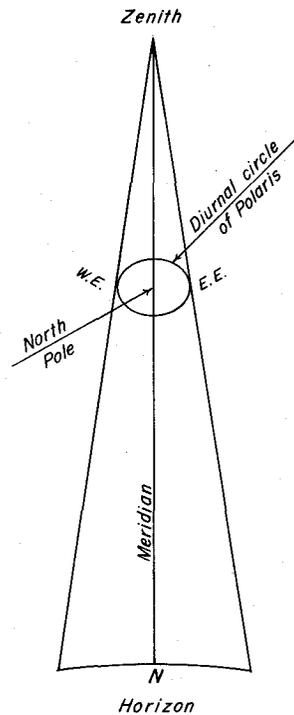


FIGURE 6.—The meridian and vertical planes tangent to the diurnal circle of Polaris as viewed from inside the celestial sphere.

the local mean time of upper culmination of Polaris, longitude  $111^{\circ}15' \text{ W.}$ :

Aug. 16, 1972, Gr. U. C. of Polaris.....	= $4^{\text{h}}27.3^{\text{m}}$ a.m.
Red. to long. $111^{\circ}15' \text{ W.}, 1^{\text{m}}13^{\text{s}}$ .....	= $-1.2$
L. M. T. of U. C. of Polaris.....	= $4^{\text{h}}26.1^{\text{m}}$ a.m.

The local mean time of the meridian passage of any other star is reduced in the same way from the time for the Greenwich meridian to the longitude of the station. It should be noted that this conversion is at the rate of approximately 10 seconds of time for each  $15^{\circ}$  (or one hour) of longitude, subtractive to the west. Also, the meridian passage of each star comes approximately four minutes earlier each succeeding day in terms of local mean time. On one calendar day each year a star will have a double meridian passage.

2-40. The Greenwich mean time of elongation of Polaris, latitude  $40^{\circ}$ , is tabulated in the Ephemeris for every day in the year, arranged for the ordinary civil date, a.m. or p.m. This is reduced to the local mean time for the position of the station, in two steps: first, for longitude; second, for latitude.

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

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

*Eastern Elongation*

Sept. 14, 1972, Gr. E. E. of Polaris,	
lat. 40° .....	= 8 <sup>h</sup> 33.8 <sup>m</sup> p.m.
Red. to long. 146°30' W., 1 <sup>m</sup> 36 <sup>s</sup> .....	= -1.6
Red. to lat. 64°30' N. ....	= +4.3
L. M. T. of E. E. of Polaris .....	= 8 <sup>h</sup> 36.5 <sup>m</sup> p.m.

*Western Elongation, same station*

Oct. 31, 1972, Gr. W. E. of Polaris,	
lat. 40° .....	= 5 <sup>h</sup> 25.7 <sup>m</sup> a.m.
Red. to long. 146°30' W., 1 <sup>m</sup> 36 <sup>s</sup> .....	= -1.6
Red. to lat. 64°30' N. ....	= -4.3
L. M. T. of W. E. of Polaris .....	= 5 <sup>h</sup> 19.8 <sup>m</sup> a.m.

**2-41. Hour Angles.** The interval between the time of a star's meridian passage (or transit) and other position in its diurnal circle is termed the star's hour angle. This is measured in sidereal time, or the equivalent in angular measure in degrees, minutes, and seconds. The hour angle may count either to the east or to the west of the meridian. As the ordinary watch is rated in mean solar time, the observation for time, and the reductions, require the conversions from the one rate to the other. The Ephemeris and the Standard Field Tables both include a table of sidereal conversions. The conversion increment is to be subtracted from a sidereal interval, or added to a mean time inter-

val, to obtain the equivalent. The conversion is required in the reduction of an altitude observation upon a star for time, as the observed hour angle is in the sidereal interval.

*Conversion of a mean time interval into a sidereal time interval, or vice versa:* The amount to apply to one time interval to obtain the other time interval is found in the table of sidereal conversions without computation.

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

Mean time hour angle of Polaris for an assumed observation in Alaska		
= 7 <sup>h</sup> 32.6 <sup>m</sup> .....		= 7 <sup>h</sup> 32 <sup>m</sup> 36 <sup>s</sup>
Conversion into equivalent sidereal hour angle .....	= +1 14	
Sidereal hour angle .....		= 7 <sup>h</sup> 33 <sup>m</sup> 50 <sup>s</sup>
		<hr/>
		7 <sup>h</sup> = 105°
		33 <sup>m</sup> = 8° 15'
		50 <sup>s</sup> = 12'30"
		<hr/>
Sidereal hour angle converted to degrees..		113°27'30"

The conversion from a mean time interval to the equivalent sidereal hour angle is required in the analytical reduction of the hour angle observation upon Polaris for azimuth or latitude, whenever the reduction is made by the equations in place of, or as a check upon, taking the values from the tables of azimuths and altitudes that are published in the Ephemeris. The conversion is not required if the tables are employed, as the values are tabulated in mean time hour angle.

**2-42. Hour angles of Polaris:** a mean time hour angle of Polaris *west* of the meridian is the mean time interval *from* the local mean time of the last preceding upper culmination *to* the local mean time of observation of Polaris. A mean time hour angle of Polaris *east* of the meridian is the mean time interval *from* the local mean time of observation *to* the local mean time of the next succeeding upper culmination of Polaris.

The above application of the term "hour angle" is a departure from conventional usage, which is employed in order to simplify the steps. One step relating to hour angles for positions east of the meridian is avoided. Polaris crosses the meridian at lower culmination at an hour angle of 11<sup>h</sup>58<sup>m</sup>02<sup>s</sup>. In the arrangement of the various examples, the observations west

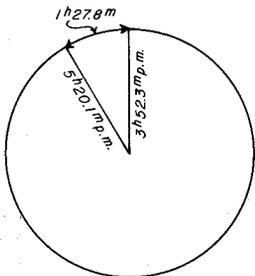
of the meridian have been referred to the last preceding upper culmination, those east of the meridian have been referred to the next succeeding upper culmination, thus avoiding any hour angles exceeding  $11^{\text{h}}58^{\text{m}}02^{\text{s}}$ .

*Hour angles of Polaris: verification by the star chart:* a simple check on the approximate value of the hour angle at any moment, any date, and of the position west or east of the meridian, may be secured by use of the star chart in the Ephemeris. First, scale a line for the date, then place the overlay scale on the chart making the date line agree with the scale for the time of observation, a.m. or p.m., lower set of figures. In this position, note where Polaris will be found with respect to the meridian line of the overlay scale. Finally, read the scale for hour angle, upper set of figures, star west or star east of the meridian. The reduction values

should of course be taken from the tabulated daily position of Polaris.

The tables of the azimuths of Polaris at all hour angles, that are published in the Ephemeris, are tabulated with the argument in *mean time hour angle*, counting from upper culmination. Therefore, for an observation west of the meridian the hour angle is referred to the preceding upper culmination; for one east of the meridian the reference is to the next succeeding upper culmination. The hour angle at lower culmination is the half ( $11^{\text{h}}58^{\text{m}}$ ) of the sidereal day ( $23^{\text{h}}56.1^{\text{m}}$ ). That position is a good one for a latitude observation. It should be understood that hour angle observations for azimuth are not referred to the point of lower culmination. The equations for the azimuth and altitude observations count strictly from upper culmination.

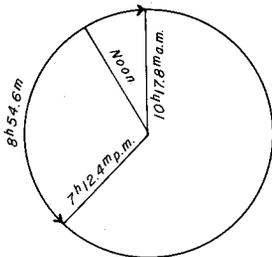
Examples of computing hour angles of Polaris, all for long.  $117^{\circ}15' \text{ W.}$ :



(1)

*West of the meridian, p.m. observation, U.C. in p.m.*

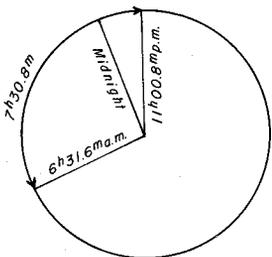
Feb. 23, 1972, l.m.t. of observation	.....	=	$5^{\text{h}}20.1^{\text{m}}$ p.m.
Gr. U.C., same date	.....	=	$3^{\text{h}}53.6^{\text{m}}$ p.m.
Red. for long. (sidereal conversion)	.....	=	$-1.3$
Hour angle, west	.....	=	$3^{\text{h}}52.3^{\text{m}}$ p.m.
			$1^{\text{h}}27.8^{\text{m}}$



(2)

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

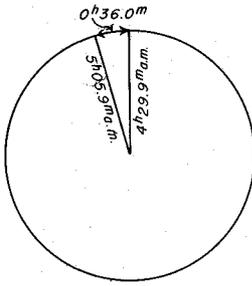
May 18, 1972, l.m.t. of observation	.....	=	$\left\{ \begin{array}{l} +12 \\ 7^{\text{h}}12.4^{\text{m}} \text{ p.m.} \end{array} \right.$
Gr. U.C., same date	.....	=	$10^{\text{h}}19.1^{\text{m}}$ a.m.
Red. for long.	.....	=	$-1.3$
Hour angle, west	.....	=	$10^{\text{h}}17.8^{\text{m}}$ a.m.
			$8^{\text{h}}54.6^{\text{m}}$



(3)

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

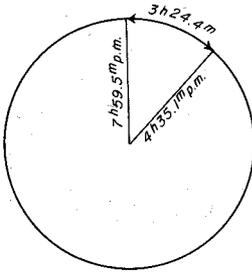
Nov. 7, 1972, l.m.t. of observation	.....	=	$\left\{ \begin{array}{l} +12 \\ 6^{\text{h}}31.6^{\text{m}} \text{ a.m.} \end{array} \right.$
Gr. U.C., Nov. 6	.....	=	$11^{\text{h}}02.1^{\text{m}}$ p.m.
Red. for long.	.....	=	$-1.3$
Hour angle, west	.....	=	$11^{\text{h}}00.8^{\text{m}}$ p.m.
			$7^{\text{h}}30.8^{\text{m}}$



(4)

*West of the meridian, a.m. observation, U.C. in a.m.*

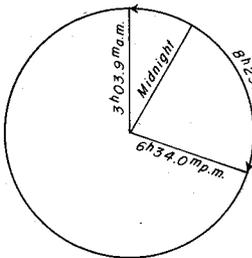
Aug. 15, 1972, l.m.t. of observation	.....	=	5 <sup>h</sup> 05.9 <sup>m</sup> a.m.
Gr. U.C., same date	.....	=	4 <sup>h</sup> 31.2 <sup>m</sup> a.m.
Red. for long.	.....	=	-1.3
Hour angle, west	.....	=	0 <sup>h</sup> 36.0 <sup>m</sup>



(5)

*East of the meridian, p.m. observation, U.C. in p.m.*

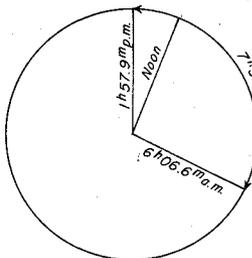
Gr. U.C., Dec. 22, 1972	.....	=	8 <sup>h</sup> 00.8 <sup>m</sup> p.m.
Red. for long.	.....	=	-1.3
L.m.t. of U.C., Dec. 22	.....	=	7 59.5 p.m.
L.m.t. of observation, same date	.....	=	4 35.1 p.m.
Hour angle, east	.....	=	3 <sup>h</sup> 24.4 <sup>m</sup>



(6)

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

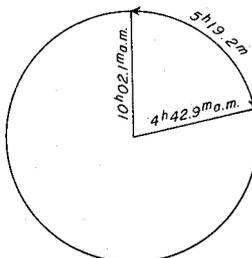
Gr. U.C., Sept. 6, 1972	.....	=	3 <sup>h</sup> 05.2 <sup>m</sup> a.m.
Red. for long.	.....	=	-1.3
L.m.t. of U.C., Sept. 6	.....	=	3 03.9 a.m.
L.m.t. of observation, Sept. 5	.....	=	6 34.0 p.m.
Hour angle, east	.....	=	8 <sup>h</sup> 29.9 <sup>m</sup>



(7)

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

Gr. U.C., Mar. 23, 1972	.....	=	1 <sup>h</sup> 59.2 <sup>m</sup> p.m.
Red. for long.	.....	=	-1.3
L.m.t. of U.C., Mar. 23	.....	=	1 57.9 p.m.
L.m.t. of observation, same date	.....	=	6 06.6 a.m.
Hour angle, east	.....	=	7 <sup>h</sup> 51.3 <sup>m</sup>



(8)

*East of the meridian, a.m. observation, U.C. in a.m.*

Gr. U.C., May 22, 1972	.....	=	10 <sup>h</sup> 03.4 <sup>m</sup> a.m.
Red. for long.	.....	=	-1.3
L.m.t. of U.C., May 22	.....	=	10 02.1 a.m.
L.m.t. of observation, same date	.....	=	4 42.9 a.m.
Hour angle, east	.....	=	5 <sup>h</sup> 19.2 <sup>m</sup>

2-43. Mean time hour angle of Polaris at elongation:  $t$  = the sidereal hour angle in angular measure. This is converted first into the sidereal time interval and then into the mean time interval, which is the mean time hour angle of Polaris at elongation.

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

Example of computing the mean time hour angle of Polaris at elongation, April 3, 1970, in latitude  $48^{\circ}00' N.$ , on which date the declination of Polaris is  $89^{\circ}07'50.3'' N.$ :

$$\begin{aligned} \phi &= 48^{\circ}00'; & \tan \phi &= 1.11061 \\ \delta &= 89^{\circ}07'50.3''; & \cotan \delta &= 0.01518 \\ \cos t &= (0.01518)(1.11061) & &= 0.01686 \end{aligned}$$

Sidereal hour angle =  $89^{\circ}02'02''$   
 $89^{\circ} = 5^h56^m$   
 $2' = 0^m08^s$   
 $2'' =$  (negligible)

$$\begin{aligned} \text{Reduction to mean time hour angle} &= -0\ 58 \text{ (sidereal conversion)} \\ \text{Mean time hour angle at elongation} &= \underline{\underline{5^h55^m10^s}} \end{aligned}$$

2-44. Altitude observation of Polaris at upper culmination for latitude:

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

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

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

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

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

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

Compute the local mean time and watch time of culmination.

Thoroughly level the transit.

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

Reverse the transit and observe the altitude of Polaris.

Again level the transit.

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

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

Take a mean observed altitude to use in the reduction.

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

September 5, 1972, in approximate latitude  $33^{\circ}23' N.$ , and longitude  $107^{\circ}11'38'' W.$ , at approximate tempera-

ture  $50^{\circ} F.$ , and approximate altitude above sea level 3,600 ft., I make an altitude observation of Polaris at upper culmination for latitude, making four observations, two each with the telescope in direct and reversed positions.

*Summary of results*

Watch correct for 105th meridian time by comparison with radio signals.  
 Mean watch time of observation ..... =  $3^h16^m31^s$  a.m.  
 Mean observed vertical angle ..... =  $34^{\circ}16'23''$   
 Reduced latitude ..... =  $33^{\circ}23'22'' N.$

*Field notation*

Setting:  $90^{\circ}00'$   
 $\delta \neq 89^{\circ}08'$   
 $90^{\circ} - \delta \neq 0^{\circ}52'$   
 $\phi \neq 33^{\circ}23'$   
 $v \neq 34^{\circ}15' = \phi + (90^{\circ} - \delta)$

U.C. of Polaris, Gr.m.t., Sept. 5, 1972 =  $3^h09.1^m$  a.m.  
 Red. to long.  $107^{\circ}11.6' W.$  (sidereal conversion) ..... =  $-1.2$

$$\underline{\underline{3^h07.9^m \text{ a.m.}}}$$

L.m.t. of U.C., Sept. 5, 1972 ..... =  $3^h07^m54^s$  a.m.  
 Correction for longitude ( $2^{\circ}11'38''$ ) ..... =  $+8\ 47$   
 Computed watch time of U.C. .... =  $3^h16^m41^s$  a.m.

Telescope	Watch time	Vertical angle
Direct .....	$3^h12^m33^s$	$34^{\circ}15'30''$
Reversed .....	$3\ 14\ 31$	$34\ 17\ 30$
Reversed .....	$3\ 18\ 30$	$34\ 18\ 00$
Direct .....	$3\ 20\ 30$	$34\ 14\ 30$
Mean .....	$3^h16^m31^s$	$34^{\circ}16'23''$
Refraction ( $1'24'' \times .89 = 1'15''$ ) .....		= $-1\ 15$
		$h = 34^{\circ}15'08''$
$\delta = 89^{\circ}08'14''; 90^{\circ} - \delta$ .....		= $-51\ 46$
$\phi = 33^{\circ}23'22'' N. = h - (90^{\circ} - \delta)$ .....		= $33^{\circ}23'22''$

**Hour Angle Observation of Polaris for Latitude**

2-45. The latitude may be determined by an altitude observation of Polaris at any hour angle. By this method the vertical angles are read in pairs, or double pairs, with reversals of the position of the telescope, and watch time noted at each setting. A watch correction is required, which will be applied to the mean (or average) of the watch readings to obtain the correct local mean time of observation for the pair or double pair of settings. The mean time hour angle of Polaris at the epoch of observation is then taken out as in observations for azimuth, and the declination of Polaris for the date is ascertained in the Ephemeris.

With the two values, mean time hour angle and declination, the latitude may be computed or there may be derived from the table in the Ephemeris the vertical angle equivalent for the position of Polaris above or below the earth's polar axis at the epoch of observation. The latter value is applied to the observed vertical angle, corrected for refraction, to secure the true elevation of the pole, or the *latitude* of the station. The method may be combined with the observation for azimuth, or it may be used independently.

The vertical angle reduction is tabulated in the Ephemeris in a simplified form in which the two principal arguments are employed to secure a primary adjustment to the elevation of the pole, subtractive when Polaris is above the pole and additive below. Since the primary adjustments have been computed for a station in latitude 45° north, a small supplemental correction must then be taken from the table for altitudes other than 45°, the arguments being mean time hour angle and observed altitude.

If an analytical reduction is made, it is convenient to begin with an angle  $\alpha$ , computed from the equation:

$$\tan \alpha = \frac{\tan \delta}{\cos t}$$

in which equation the factor "cos t" becomes negative for hour angles exceeding 90°, whereupon  $\alpha$  will exceed 90°. Remember that "t" is the *sidereal* hour angle.

The latitude may then be derived from the equation:

$$\cos (\phi - \alpha) = \frac{\sin \alpha \sin h}{\sin \delta}$$

Example of hour angle observation of Polaris for latitude, making use of the table given in the Ephemeris:

June 28, 1972, in approximate latitude 41°20' N., and longitude 111°37' W., at approximate temperature 50° F., and elevation above sea level 6,800 ft., I make an hour angle observation of Polaris for latitude, making four observations, two each with the telescope in direct and reversed positions.

*Summary of results*

Mean observed vertical angle .....	= 41°55'00"
Mean watch time of observation .....	= 4 <sup>h</sup> 46 <sup>m</sup> 38 <sup>s</sup> a.m.
Watch fast of local mean time, by comparison with radio time signal corrected for longitude .....	= 26 <sup>m</sup> 28 <sup>s</sup>
Reduced latitude .....	= 41°20'37" N.

*Field notation*

Telescope	Vertical angle	Watch time
Direct .....	41°53'00"	4 <sup>h</sup> 44 <sup>m</sup> 45 <sup>s</sup> a.m.
Reversed .....	41 54 00	4 45 50
Reversed .....	41 56 00	4 47 20
Direct .....	41 57 00	4 48 37
Mean .....	41°55'00"	4 <sup>h</sup> 46 <sup>m</sup> 38 <sup>s</sup> a.m.
Watch fast of local mean time .....		-26 28
L.m.t. of observation, June 28, 1972 .....		= 4 <sup>h</sup> 20 <sup>m</sup> 10 <sup>s</sup> a.m. = 4 <sup>h</sup> 20.2 <sup>m</sup> a.m.
Gr. U.C. of Polaris, same date .....		= 7 <sup>h</sup> 38.7 <sup>m</sup> a.m.
Red. to long. 111°37' W. ....	= -1.2	= 7 <sup>h</sup> 37.5 <sup>m</sup> a.m.
Hour angle of Polaris east of meridian .....		= 3 <sup>h</sup> 17.3 <sup>m</sup>

Declination of Polaris ..... 89°08'06"

Mean time hour angle	Primary adjustment, subtractive, Polaris above the pole		
	Declination		
	89°08'00"	89°08'06"	89°08'20"
3 <sup>h</sup> 11.5 <sup>m</sup> .....	0°34'35"	0°34'31"	0°34'22"
3 17.3 .....	0 33 35	0 33 31	0 33 22
3 17.5 .....	0 33 33	0 33 29	0 33 20
Mean observed vertical angle, v .....		v = 41°55'00"	
Refraction, 64" × 0.79 .....		= -0 51	
		h = 41°54'09"	
Primary adjustment to elevation of pole .....		= -33 31	
Supplemental correction .....		= -1	
Latitude of station .....		= 41°20'37" N.	

**Polaris at Elongation**

2-46. Of the various methods of observation to establish the true meridian, the simplest is the observation upon Polaris at eastern or western elongation.

Azimuth of Polaris at elongation:

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

Example of computing the azimuth of Polaris at elongation, October 20, 1970, in latitude 46°20' N., on which date the declination of Polaris is 89°07'54" N.:

$$\begin{aligned} \cos \delta &= 0.015155 \\ \cos \phi &= 0.690462 \\ \sin A &= 0.015155 \div 0.690462 = 0.021949 \end{aligned}$$

A = Azimuth of Polaris at elongation = 1°15'28".

A table of azimuths of Polaris at elongation for latitudes from 10° to 70° N. appears in the Ephemeris, arguments: declination of Polaris and latitude of station.

Example in the use of the table of azimuths

of Polaris at elongation, same date and station as above, showing the method of interpolation:

Latitude	Declination		
	89°07'50"	89°07'54"	89°08'00"
	Azimuths elongation		
46°00'.....	1°15'06"	1°15'00"	1°14'52"
46°20'.....		1°15'28"	
47°00'.....	1°16'30"	1°16'24"	1°16'15"

By interpolation in the table the required azimuth of Polaris at elongation is therefore found to be 1°15'28".

**Azimuth of Polaris at Any Hour Angle**

2-47. While there is no better method for the establishment of the true meridian than the observation upon Polaris at elongation, for most of the year this requires nighttime observations. Moreover, should Polaris be obscured by clouds at the time of elongation, the observation must fail.

The "hour angle" method admits of observa-

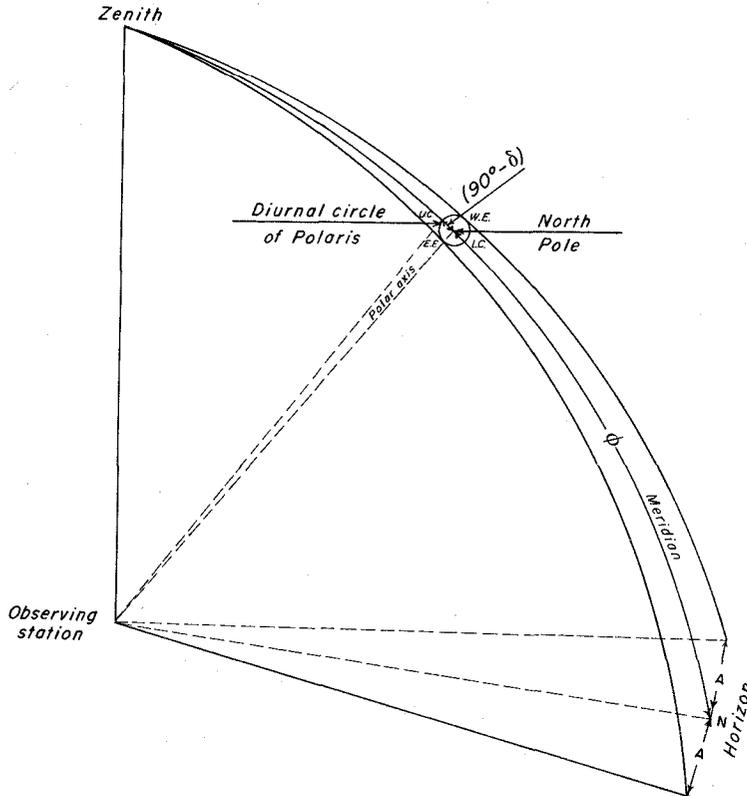


FIGURE 7.—The meridian and vertical planes tangent to the diurnal circle of Polaris as viewed from outside the celestial sphere.

tion upon Polaris for azimuth at any time that the star is visible; the precise watch error in local mean time must be known, but if this has been determined, the hour angle method becomes at once the most convenient. The possible accuracy of the result compares favorably in every way with the refinement obtained in an observation at elongation.

2-48. *Azimuth of Polaris at any hour angle:*  $t$  = sidereal hour angle in angular measure; in hour angles exceeding  $90^\circ$  the function “ $-\sin \phi \cos t$ ” becomes positive by virtue of the cosine of an angle between  $90^\circ$  and  $270^\circ$  being treated as negative in analytical reductions:

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

A table of azimuths of Polaris at all hour angles, for latitudes from  $10^\circ$  to  $65^\circ$  N., appears in the Ephemeris, arguments: declination of Polaris, mean time hour angle, and latitude of station. For other than the latitudes given in the table, and for greater accuracy in terms of seconds of azimuth, the surveyor will be required to solve the above equation.

Example of computing the azimuth of Polaris, February 21, 1972, at a mean time hour angle of  $2^h37.4^m$ , in latitude  $33^\circ20'$  N., on which date the declination of Polaris =  $89^\circ08'36''$  N.:

Mean time hour angle.....	= $2^h37.4^m$		
	= $2^h37^m24^s$	$2^h = 30^\circ$	
		$37^m = 9^\circ15'$	
Red. to sidereal hour angle .....	= $26^\circ 50'$	= $12^\circ30''$	
Sidereal hour angle .....	= $2^h37^m50^s$	= $39^\circ27'30''$	
$\log \cos \phi$ .....	= 9.921940	$\log \sin \phi$ .....	= 9.739975
$\log \tan \delta$ .....	= 1.825278	$\log \cos t$ .....	= 9.887666
$\log \cos \phi \tan \delta$ = <u>1.747218</u>		$\log \sin \phi \cos t$ = <u>9.627641</u>	
$\text{nat} \cos \phi \tan \delta$ = 55.875		$\text{nat} \sin \phi \cos t$ = <u>0.424</u>	
$\text{nat} \sin \phi \cos t$ = <u>0.424(-)</u>			
Algebraic sum .....	= 55.451	$\log \sin t$ .....	= 9.803127
		$\log 55.451$ .....	= 1.743910
		$\log \tan A$ .....	= <u>8.059217</u>
Azimuth of Polaris at above hour angle, A = <u><u><math>0^\circ39'24''</math></u></u>			

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

Mean time hour angle	Azimuth of Polaris			Correction subtractive for declination + $89^\circ08'40''$
	Mean declination + $89^\circ08'30''$			
	Latitude			
	$32^\circ$	$33^\circ20'$	$34^\circ$	
$2^h29.6^m$ .....	37.2'	37.8'	38.1'	0.1'
37.4 .....		39.4		0.1
39.6 .....	39.3	39.9	40.2	0.1

By interpolation in the table the required azimuth of Polaris is therefore found to be  $0^\circ39.4' - 0.1' = 0^\circ39.3'$  or  $0^\circ39'18''$ .

**Polaris at Sunset or Sunrise**

2-49. If the sky is clear Polaris may be most conveniently observed by the hour angle method at sunset or sunrise without artificial illumination. The preparation for the observation consists in computing in advance the approximate settings in azimuth and altitude in order to find Polaris. The plan contemplates an approximate reference meridian. With the time of sunset or sunrise assumed as the time of observation, the hour angle “ $t$ ” and azimuth “ $A$ ” are ascertained in order to find the position of Polaris in azimuth. The vertical angle will be equal to the latitude of the station *plus* the primary adjustment when Polaris is above the pole, or *minus* when below, taking the value from the tabulation given in the Ephemeris.

The “settings” for finding position are approximations, to bring Polaris reasonably near the center of the field of the telescope where the star should be found in plain view. The telescope must be focused upon a distant object, otherwise, though Polaris may be practically at the center of the field, it might be out of focus and therefore may not be noticed during daylight. When Polaris has been found the observation may follow the hour angle method, the reductions to be based upon the data derived in the observation. The settings should be made each time for the several sightings. The daylight hour angle method is particularly desirable because the observation, including all instrumental work, marking of points upon the ground, etc., is accomplished without artificial illumination, and sunset is usually a convenient time to devote to this field duty.

Example of the computation of the position of

Polaris at sunset, May 6, 1972, at a station in latitude  $47^{\circ}20' N.$ , and longitude  $102^{\circ}40' W.$ :

From the Ephemeris the declination of the sun adjusted to approximate sunset is found to be  $16^{\circ}48' N.$ ; the equation of time  $3^m$ , to be subtracted from apparent time; upper culmination of Polaris, Greenwich meridian  $11^h06.2^m$  a.m.; the declination of Polaris  $+ 89^{\circ}08'16''$ . From the Standard Field Tables, the apparent time of sunset is found to be  $7^h17^m$  p.m.

May 6, 1972:

Sunset .....	=	$7^h17^m$ p.m., app. t.
Equation of time .....	=	$-3$
Anticipated time of observation .....	=	$7^h14^m$ p.m., l.m.t.
		$+12$

Gr. U.C. of Polaris ..... =  $11^h06.2^m$  a.m.  
 Red. to long.  $102^{\circ}40'$  ..... =  $-1.1$        $11\ 05$  a.m., l.m.t.  
 Hour angle of Polaris, west of meridian .....  $\neq$   $8^h09^m$  A  $\neq 1^{\circ}03' W.$   
 Latitude of station ..... =  $47^{\circ}20'$   
 Vertical angle adjustment, Polaris below the pole ..... =  $-28$        $v \neq 46^{\circ}52''$

Example of the computation of the position of Polaris at sunset, November 6, 1972, same station:

Declination of the sun adjusted to approximate sunset  $16^{\circ}14' S.$ ; equation of time  $16^m$  to be subtracted from apparent time; upper culmination of Polaris, Greenwich meridian  $11^h02.1^m$  p.m.; declination of Polaris  $+ 89^{\circ}08'35''$ .

November 6, 1972:

Sunset .....	=	$4^h46^m$ p.m., app. t.
Equation of time .....	=	$-16$
Anticipated time of observation .....	=	$4^h30^m$ p.m., l.m.t.
Gr. U.C. of Polaris .....	=	$11^h02.1^m$ p.m.
Red. to long. $102^{\circ}40'$ .....	=	$-1.1$ $11\ 01$ p.m., l.m.t.
Hour angle of Polaris, east of meridian .....	=	$6^h31^m$ A $\neq 1^{\circ}15' E.$
Latitude of station .....	=	$47^{\circ}20'$
Vertical angle adjustment, Polaris below the pole .....	=	$-08$ $v \neq 47^{\circ}12'$

Example of the computation of the position of Polaris at sunrise, November 7, 1972, same station:

Declination of the sun adjusted to approximate sunrise  $16^{\circ}25' S.$ ; equation of time  $16^m$  to be subtracted from apparent time; upper culmination of Polaris and declination of Polaris same as above.

November 7, 1972:

Sunrise .....	=	$7^h15^m$ a.m., app. t.
Equation of time .....	=	$-16$
Anticipated time of observation .....	=	$6^h59^m$ a.m., l.m.t.
		$+12$
Upper culmination of Polaris, November 6 .....	=	$11\ 01$ p.m., l.m.t.
Hour angle of Polaris, west of meridian .....	$\neq$	$7^h58^m$ A $\neq 1^{\circ}05' W.$
Latitude of station .....	=	$47^{\circ}20'$
Vertical angle adjustment, Polaris below the pole .....	=	$-26$ $v \neq 46^{\circ}54'$

### Stellar Observations, Equatorial Belt

2-50. There are two customary methods of star identification. First, the brighter stars may be found individually by naked eye during starlight, each by means of its position within its own constellation and with the aid of a chart that shows the outline of that and the neighboring constellations; second, using the transit, any star may be found by reference to vertical angle and horizontal angle from the meridian, both values related to an anticipated time of observation, and to an approximate north and south line. The second method is frequently more certain, especially if there are clouds that obscure some of the stars and is a necessity for twilight or daylight observations.

The charts of the constellations are interesting and useful, but they are not employed as an accessory to the Manual methods.

The location of any one of the selected bright stars, in favorable position for observation, on any date and at any moment within the 24-hour period, may be found most readily by reference to the diagram insert of the Ephemeris; an explanation of its use is given on the diagram. The simple steps are these: first interpolate for the date, and place the meridian line of the overlay scale on the date line; this shows the field as it will be at the noon of that date. Next, move the overlay scale to the left for p.m. periods, or to the right for a.m. periods, as shown by the lower set of figures, to the anticipated time of an observation. Then read the upper set of figures for hour angle for any selected star at that anticipated time, to the east or to the west of the meridian.

Having selected the star to be observed and the anticipated time of observation, the time of the meridian passage of the star for that date is then taken from the Ephemeris. The hour angle for the position is the *time interval* between the anticipated time of observation and the time of the meridian passage.

Use the following equation to find the vertical angle of the star at the anticipated moment of observation:

$$\sin h = \cos t \cos \phi \cos \delta + \sin \phi \sin \delta$$

(If  $\sin h$  is negative the star is below the horizon.)

Then use the companion equation to find the horizontal angle from the meridian, as follows:

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

The product " $\sin \phi \sin \delta$ " and the fraction  $\frac{\sin \delta}{\cos \phi \cos h}$  are negative for south declinations.

The product " $\cos t \cos \phi \cos \delta$ " is negative for hour angles exceeding 6 hours or  $90^\circ$ .

If the result for " $\cos A$ " is  $\left\{ \begin{array}{l} \text{positive} \\ \text{negative} \end{array} \right\}$  the angle counts from the  $\left\{ \begin{array}{l} \text{north.} \\ \text{south.} \end{array} \right\}$

The vertical angle setting (" $v$ " for this purpose) for the meridian passage of a star south of the zenith is:

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

An approximate north and south line, the approximate latitude, and the approximate watch correction to local mean time are used in computing the approximate angular settings for " $A$ " and " $v$ ". The objective lens should be set carefully to *celestial focus*. The computed direction will be sufficiently precise to bring the selected star into the field of the telescope at the anticipated time of observation. An explanation of preparing for an observation is also given in the Ephemeris.

For *daylight observations*, and referring especially to stars of first magnitude or brighter that would naturally be selected, the initial or approximate values, and the settings for horizontal and vertical angles, should be such as to bring the star within the middle-third of the field, or roughly within  $10'$  of the cross-wire intersection.

2-51. A first magnitude star is rated as 1.0;

second magnitude 2.0; etc. Brighter than first magnitude is rated, as Capella, 0.2; slightly brighter, as Vega, 0.1; much brighter, as Canopus, -0.9; or still brighter, as Sirius, -1.6; on this scale a magnitude of 2.1 is rated for Polaris. This detail is an important feature of identification.

As an additional aid in star identification, it is helpful to note the positions of the bright planets Venus, Mars, Jupiter, and Saturn. The times of their transits, and their approximate declinations, are tabulated in the Ephemeris for the first and sixteenth day of each month. The planets are "wanderers" (very changeable in position) so that the interpolations between the tabulated dates will be rough, although close enough for identification, and the varying positions will become more readily noted on continued acquaintance. The proximities of the planets to the selected stars, up to about 40 minutes in time of transit and  $10^\circ$  difference in declination, are shown in the tabulations by footnote-reference.

The planets appear different in the telescope, Venus very bright and slightly crescent when farthest from the sun, and not so bright, but decidedly crescent when near the sun. Mars is always a dull red, brightest when its transit is near midnight, but scarcely noticeable when the transit is within two or three hours of noon. Jupiter, when passing the meridian between 9 p.m. and 3 a.m., is very bright with some of its several moons always in evidence clearly seen on sharp focus. Saturn, similarly, though not so bright, has its "rings," but no moons. As in the case of Mars, Jupiter and Saturn are scarcely noticeable when their meridian passage occurs between 9 a.m. and 3 p.m., their positions then being so far distant from the earth.

If a star identification is to be made naked-eye from the constellations, then the nearby planet or planets should be noted, and accounted for by appearance. If the star is identified instrumentally, by settings in horizontal and vertical angle, then the noting of the relation to the nearby planet, or planets, is one of the best ways in which to become acquainted with the latter.

2-52. The stellar observation is useful any time of year, particularly when the sun reaches a meridian altitude exceeding  $60^\circ$  or  $65^\circ$ .

There is no difficulty in picking up the meridian passage of a star when the conditions for visibility are good. Most of the selected stars are brighter than Polaris; some of them can be observed throughout any day that is clear and free from haze.

After the initial preparations have been made for a Polaris observation, including the marking of a meridian reference by solar transit orientation, or by reference to lines previously determined, it is good practice to include the meridian passage of a star in the observing program. In this manner the watch correction for local mean time is obtained just when needed and on the most direct plan under the usual field conditions.

The Greenwich mean times of the meridian transit of the selected bright stars of the equatorial belt are tabulated in the Ephemeris for the 1st and 16th day each month; the reductions to the other days of the month are indicated on each page of the stellar tabulations. This data must be converted to the local mean time of transit.

Example of the computation of the finding positions of an equatorial star:

March 10, 1971, on a meridian previously established, at a station in latitude  $42^\circ 15' N.$ , and longitude  $121^\circ 47' W.$ , preparing to observe the star No. 15/26,  $\alpha$  Leonis (Regulus), declination  $+ 12^\circ 06' 24''$ , Mag. 1.3, anticipated time of observation  $6^h 30^m$  p.m., l.m.t.

Star's transit, Gr.m.t., March 1	$11^h 30.4^m$ p.m.
Reduction to March 10	$-35.4$
Sidereal conversion, long. $121^\circ 47' W.$	$-1.3$
Star's transit, l.m.t.	$10^h 53.7^m$ p.m.
Anticipated time of observation, l.m.t.	$6\ 30$ p.m.
Hour angle SE. ( $t = 65^\circ 55'$ )	$4^h 23.7^m$

For the purpose of computing the *finding* positions, the mean time hour angle need not be converted to a sidereal time hour angle, since the actual time of the observation will probably vary somewhat from the anticipated time.

$$\begin{aligned} \sin h &= \cos t \cos \phi \cos \delta + \sin \phi \sin \delta \\ \cos t &= 0.4081 \\ \cos \phi &= 0.7402 & \sin \phi &= 0.6724 \\ \cos \delta &= 0.9778 & \sin \delta &= 0.2097 \\ \text{Product} &= 0.2954 & \text{Product} &= 0.1410 \\ \sin h &= 0.2954 + 0.1410 = 0.4364 \\ h &= \underline{25^\circ 53'} \end{aligned}$$

$$\begin{aligned} \cos A &= \frac{\sin \delta}{\cos \phi \cos h} - \tan \phi \tan h \\ \sin \delta &= 0.2097 \\ \cos \phi &= 0.7402 & \tan \phi &= 0.9083 \\ \cos h &= 0.8997 & \tan h &= 0.4852 \\ \frac{\sin \delta}{\cos \phi \cos h} &= 0.3149 & \tan \phi \tan h &= 0.4407 \\ & & & -0.4407 \\ \cos A &= -0.1258 \text{ (Negative indicates horizontal} \\ & & & \text{angle counts from south.)} \\ A &= \underline{S. 82^\circ 46' E.} \end{aligned}$$

Using the finding positions of the star ( $h = 25^\circ 53'$ ,  $A = S. 82^\circ 46' E.$ ), four observations are made, two each with the telescope in direct and reversed positions. The *true* values for time and azimuth are obtained by a more precise reduction of the observations by use of the above formulas. Keep in mind that in all stellar observations the true vertical angle ( $h$ ) is equal to the observed vertical angle ( $v$ ) minus the refraction ( $r$ ) in zenith distance. There is no correction for parallax. In solving for time, the hour angle ( $t$ ) obtained by use of the formula is in terms of the *sidereal* rate. A subtraction of 10 seconds per hour (sidereal conversion) will give the equivalent mean time hour angle.

### Direct Solar Observations

2-53. *Declination.* The declination of the sun is corrected in hourly difference to the longitude of the station and to the time of observation. North declinations are treated as positive, south declinations as negative. A northerly hourly motion is treated as positive, a southerly hourly motion is treated as negative.

Example of computation of the sun's declination:

It is desired to compute the value of the sun's declination at a station in longitude  $5^h 08^m$  west of Greenwich; apparent time of observation  $3^h 42^m$  p.m.; Mar. 18, 1970:

Declination of the sun at Greenwich apparent noon	$= 1^\circ 00' 04'' S.$
Difference in time from Greenwich apparent noon to apparent time of observation:	
For longitude $5^h 08^m$	
For time, p.m. $= +3^h 42^m$	
$8.83^h = \frac{8^h 50^m}{8^h 50^m}$	
Hourly difference in declination	$= +59.28''$
Difference in declination from Greenwich apparent noon to apparent time of observation:	
$8.83 \times 59.28'' = 523''$	$= 8' 43'' N.$
True declination of the sun	$\underline{0^\circ 51' 21'' S.}$

2-54. *Meridian Observation of the Sun for Apparent Noon.* With the telescope on the meridian elevated to the sun's altitude, the watch times of transit of the sun's west and east limbs are noted, the mean of which is the watch time of apparent noon. If the observation fails for either limb the reduction to the sun's center is accomplished by adding or subtracting 68 seconds; a refinement in the amount of this interval is had by referring to the Ephemeris for the time of the sun's semi-diameter passing the meridian for the date of observation.

The setting for the approximate altitude of the sun's center is:

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

#### OBSERVING PROGRAM

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

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

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

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

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

The refinement in this observation depends mostly on the direction of the sighting for meridian. A small discrepancy in direction is scarcely appreciable for ordinary requirements, such as to establish a watch correction in local mean time with necessary accuracy for making the Polaris observations for azimuth and latitude by the hour angle method.

Example of meridian observation of the sun for apparent noon, and reduction to watch correction local mean time:

September 9, 1971, in latitude  $42^\circ 32' 24''$  N., and longitude  $119^\circ 46' 30''$  W. ( $7^h 59^m 06^s$ ), with the telescope in the meridian and elevated to the sun's altitude, I observe the sun's transit for time, noting the watch time of transit of each limb.

$$\begin{array}{r} \text{Setting:} \quad 90^\circ 00' \\ \phi \neq (-) 42^\circ 32' \\ \delta \neq (+) 5^\circ 20' \quad (\text{corrected for longitude}) \\ \hline v \neq \quad \underline{\underline{52^\circ 48'}} \end{array}$$

⊕	Watch time of transit, W. limb.....	= $11^h 54^m 48^s$
⊖	Watch time of transit, E. limb.....	= $11\ 56\ 56$
	Watch time of apparent noon .....	= $11^h 55^m 52^s$
	Apparent noon .....	= $12^h 00^m 00^s$
	Eq. of time ad-justed to time of observation ... =	$-2\ 37$
	Local mean time of apparent noon...	= $11\ 57\ 23$
	Watch slow of local mean time.....	= $\underline{\underline{1^m 31^s}}$

2-55. *Meridian Altitude Observation of the Sun for Latitude.*—Reverse the sign of  $\delta$  for south declinations:

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

The following observing program is recommended:

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

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

Reverse the transit.

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

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

The important factor in this observation is exactness in vertical angle. The observation may be duplicated by vertical angle readings on stars within the equatorial belt at meridian passage, using the same equation:

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

The resulting values in latitude should agree within the limits of the precision of the instrument. The uncertain factor is the value of the observed vertical angle. This may be compensated by balancing an observation within the equatorial belt by an observation on Polaris at upper or lower culmination, or by a latitude observation on Polaris by the hour angle method.

Example of meridian altitude observation of the sun for latitude:

September 25, 1971, in approximate latitude  $48^\circ 10'$  N., and longitude  $109^\circ 10'$  W. ( $7^h 16^m 40^s$ ), temperature  $70^\circ$  F., elevation above sea level 2,500 ft., I make an observation of the sun for latitude, observing the altitude of the sun's lower limb with the telescope in direct position, reversing the telescope and observing the sun's upper limb.

Settings:

	90°00'
$\phi \neq (-) 48^{\circ}10' N.$	$\phi \neq (-) 48^{\circ}10' N.$
$\delta \neq (-) 0^{\circ}49' S.$	$\delta \neq (-) 0^{\circ}49' S.$
$v \neq$	$v \neq 41^{\circ}01'$
Sun's semi-diameter $\neq 16'$	
Lower limb ( $41^{\circ}01' - 16'$ )	40°45'
Upper limb ( $41^{\circ}01' + 16'$ )	41°17'
$\ominus$ Observed alt., lower limb, telescope dir.	= 40°46'30"
$\oplus$ Observed alt., upper limb, telescope rev.	= 41°18'30"
Mean observed altitude, $v$	= 41°02'30"
Refraction	= -0 59
Parallax	= +0 06
	$h = 41^{\circ}01'37''$

Declination, Gr.

app. noon	= 0°42'01.0" S.
Red. to longitude 109°10' W.,	
$7.278 \times 58.45'' = 7'05.4'' S.$	$7'05.4'' S.$
	$0^{\circ}49'06.4'' S.$
	$\delta = 0^{\circ}49'06'' S.$
$\phi = 90^{\circ} - \delta - h$	= 48°09'17" N.

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

September 10, 1969, in approximate latitude  $41^{\circ}35' N.$ , and longitude  $109^{\circ}58' W.$ , at temperature  $50^{\circ} F.$ , and elevation above sea level 6,500 ft., I make a meridian observation of the sun for time and latitude, observing simultaneously the altitude of the sun's lower limb and the transit of the sun's west limb, reversing the telescope and observing simultaneously the altitude of the sun's upper limb and the transit of the sun's east limb.

Setting:

	90°00'
$\phi \neq (-) 41^{\circ}35' N.$	$\phi \neq (-) 41^{\circ}35' N.$
$\delta \neq (+) 4^{\circ}47' N.$	$\delta \neq (+) 4^{\circ}47' N.$
$v \neq$	$v \neq 53^{\circ}12'$
Sun's semi-diameter $\neq 16'$	
Lower limb ( $53^{\circ}12' - 16'$ )	52°56'
Upper limb ( $53^{\circ}12' + 16'$ )	53°28'

Telescope	Sun	Watch time transit	Observed vertical angle
Direct	$\ominus$	11 <sup>h</sup> 56 <sup>m</sup> 18 <sup>s</sup>	52°56'30"
Reversed	$\oplus$	11 58 26	53 29 00
Mean		11 <sup>h</sup> 57 <sup>m</sup> 22 <sup>s</sup>	53°12'45"
Refraction ( $43'' \times 0.8$ )			= -34
Parallax			= +05
$h$			= 53°12'16"
$\delta = 4^{\circ}47'18'' N.; 90^{\circ} + \delta$			= 94°47'18"
$\phi = 90^{\circ} + \delta - h$			= 41°35'02"

Watch time of apparent noon	= 11 <sup>h</sup> 57 <sup>m</sup> 22 <sup>s</sup>
Apparent noon	= 12 <sup>h</sup> 00 <sup>m</sup> 00 <sup>s</sup>
Equation of time, Gr. noon sub- tractive from app. t	= 3 <sup>m</sup> 01 <sup>s</sup>
Red. to long. 109°58' W.	= 7
	3 <sup>m</sup> 08 <sup>s</sup> -3 08
Local mean time of apparent noon	11 <sup>h</sup> 56 <sup>m</sup> 52 <sup>s</sup> = 11 56 52
Watch fast of local mean time	= 30 <sup>s</sup>

The accuracy of the reduced latitude is directly related to the refinement of the value of the observed vertical angle. A better determination of the latitude by this method is possible only by making a series of observations on successive days, or the observation may be duplicated by vertical angle readings on stars within the equatorial belt at meridian passage, and by combining the result with Polaris observations for latitude.

*Altitude Observation of the Sun for Azimuth*

2-56. While observations of Polaris for azimuth are used extensively, there are situations where a direct altitude observation on the sun will expedite the survey. The bright stars within the equatorial belt may also be substituted when the sun is not in favorable position. In general these observations are supplemental to the normal running of the lines by solar transit orientation in order to improve and verify the line work.

The altitude observation will frequently permit a prompt start on the survey in advance of an opportunity for the usual Polaris observation. Also, at stations far removed from field headquarters, the solar transit orientation should be verified in this manner. Direct observations on the lines as run will help to show that the solar unit is performing well or that it needs adjustment.

Some of the stars are always in favorable position, both in hour angle and declination. The brighter stars may be picked up during the daylight hours if not obscured by haze or clouds. The stellar altitude observations are particularly useful when the sun is not in favorable position. In the southern States, during the summer months, the sun is too high for the

noon observation for time and latitude. In the northern States, from late October until late February, the sun is too low for the best observing for time and azimuth. The bright north declination stars are especially helpful for the observing in Alaska, the southern declination stars for the meridian time-and-latitude observations in Florida.

The trigonometric elements of the altitude observation for time and azimuth are vertical angle, latitude, and declination of the sun or the star.

Accuracy in latitude is essential to good observing for azimuth by the altitude method. If the latitude has not been well determined previously, an azimuth observation on the sun southeasterly should be balanced by one southwesterly at about the same vertical angle. Averaging the results will eliminate the effect of an unknown discrepancy in latitude.

The precision with which the azimuth may be determined by the altitude observation of the sun or a star is dependent on the correctness of the vertical angle. The error in azimuth that results from a discrepancy in vertical angle increases rapidly when the angular elevation is large, when the hour angle is small, or with the southerly declinations. Presuming careful observing with the instrument in good adjust-

ment, but with an error in the readings of vertical angles, the error in azimuth is multiplied one, two, or three times, depending on the sun's position in altitude, hour angle, and declination. The effect is shown graphically in figure 8. By balancing an observation southeasterly with one southwesterly at about the same vertical angle, the error in azimuth will be compensated.

The altitude observation calls for accuracy in the instrumental adjustments and for good judgment in the selection of a well formed polezenith-sun triangle. Vertical angles from 20° to 50° are to be preferred, not less than three hours from meridian passage, and north declination. A bright star in north declination is much better than the sun when the south declination of the sun exceeds 10°.

In order to balance the altitude observation for azimuth, to compensate for uncertainties in vertical angle, the sun may be observed *southeasterly and southwesterly*; or the sun in one position and a star in the companion position; or two north declination stars may be selected, especially when the sun is in southerly declination; etc.; the purpose being to balance the observation in nearly the same vertical angle, and to secure well-shaped celestial-triangles.

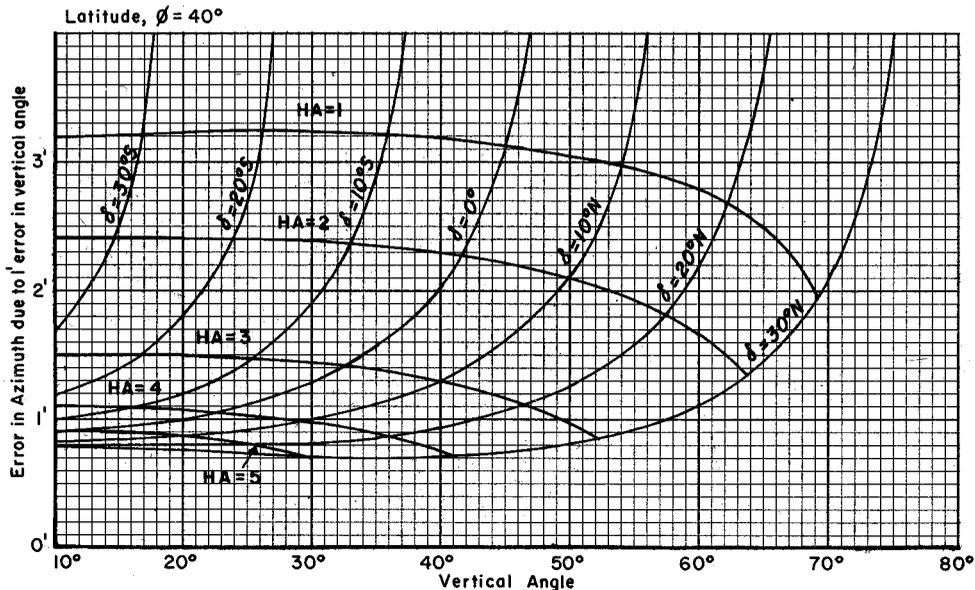


FIGURE 8.—Errors in azimuth caused by one minute error in vertical angle at various angular elevations, computed for observations in latitude 40°, for declinations within the equatorial belt.

The solar transit is equipped with a full vertical circle, a neutral-tint colored glass in the dust shutter of the eyepiece, a removable prismatic eyepiece, and a removable reflector for illuminating the cross wires. These are essential to rapid and accurate altitude observations, and for the night observing. The latest model features a solar circle on the reticle of the transit telescope; this gives the horizontal and vertical angle sightings to the sun's center (instead of to the limbs). Double lines are provided for half of each the vertical and horizontal cross wires; this spacing is to improve the *stellar* observation for exact centering, avoiding the complete covering of the star by the wire (as the latter may obscure the star in the daylight observation). See section 2-64.

There are a number of equations for solving the altitude observation for *azimuth*, in which the elements are vertical angle, latitude, and declination of the sun or the star. These are companion equations to those employed in solving the altitude observation for *time*, using the same elements. Some of the equations are adapted to the use of natural trigonometric functions and the computing machine; the same equations may be employed by logarithmic reduction in combination with the natural functions; some are adapted to strictly logarithmic reduction. These equations are given in the Standard Field Tables. Occasionally, for a check against a possible error, if the results do not come out as expected, a second reduction may be made, using another equation.

The same equations are employed for the stellar observations as for the altitude observation of the sun. With the stars there is no reduction to center, no correction for parallax, and no hourly change in declination. The sun and the stars have the same corrections for *refraction in zenith distance*, the latter subject to temperature change and to differences in barometric pressure.

Under the Manual rules, a series of three altitude observations upon the sun, each with the telescope in direct and reversed position, are required. Each pair of direct and reversed sightings are combined and reduced as one observation. This will give three results for the indicated bearing of the reference mark. The

separate results will vary somewhat, much the same as separate orientations of the solar unit. When desired, in order to guard against error, or to check a discrepancy, any of the sightings may be reduced to the sun's center and solved separately.

For the *stellar* altitude observation four sightings are required, two each with the telescope in direct and reversed position, to be reduced as one observation. The number of the observations may be increased if desirable, although it is good practice to limit the number of sightings to not over six in any one series. Any of them may be reduced separately if desired to check against an error in the reading of the angles. As each sighting is "centered" on the star, the differences in the *rate of travel* in time, horizontal angle, and vertical angle, will be uniform.

It is emphasized that none of the reduced altitude observations for azimuth, in terms of the indicated bearing of the reference mark, standing alone as one observation, can be regarded as within the attainable limit of accuracy of the one-minute transit until duly verified by a completely independent method, such as the Polaris observation to check the altitude observation, or the altitude observation southeasterly balanced with one southwesterly.

2-57. An altitude observation of the sun for azimuth consists in the simultaneous determination of the true vertical and horizontal angles to the sun's center, the horizontal angle being referred to a fixed point. With the true vertical angle to the sun's center, the declination of the sun, and the latitude of the station all known, one of the following equations is entered and a calculation made of the azimuth of the sun's center at the epoch of observation, as referred to the true meridian; the relation between the sun's calculated azimuth and the recorded angle to the sun's center gives the bearing of the reference point.

Altitude observation of the sun for azimuth, *first formula*—Reverse the signs of "δ" for south declinations:

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

The spherical angles “ $\zeta$ ”, “ $\phi$ ”, and “ $\delta$ ” appear in this equation combined as in one formula for the reduction of an altitude observation of the sun for apparent time.

2-58. Altitude observation of the sun for azimuth, *second formula*—For south declinations the function “ $\sin \delta$ ” becomes negative by virtue of the sine of a negative angle being treated as negative in analytical reductions: If the algebraic sign of the result is positive the azimuth “ $A$ ” is referred to the north point, but if negative, the azimuth “ $A$ ” is referred to the south point:

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

2-59. Altitude observation of the sun for azimuth, *third formula*—The following equation is expressed directly in terms of the spherical triangle “pole-zenith-sun.” Reverse the sign of “ $\delta$ ” for south declinations:

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

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

#### OBSERVING PROGRAM, MORNING

2-60. Thoroughly level the transit.

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

Reverse the transit.

Observe and record the horizontal angle from the fixed reference point to the sun’s left limb, and the vertical angle to the sun’s lower limb; these observations must be simultaneous; the sun will appear as indicated; note the watch at the moment of the observation:  $\ominus$

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

#### OBSERVING PROGRAM, AFTERNOON

2-61. In the afternoon the program is modified only as to the order in which the sun’s limbs are observed, which is as follows:

First observation, telescope direct, observe the sun’s right and lower limbs:  $\oplus$

Second observation, telescope reversed, observe the sun’s left and upper limbs:  $\ominus$

2-62. By the above observing programs the horizontal and vertical angles in the direct positions of the telescope will be found of about the same numerical values as in the reversed position of the telescope, by reason of the sun passing in a direction that will carry it across the field of the telescope during the time taken in the reversal and second setting. Differential refraction is therefore eliminated; it is desirable that the corresponding angles in the direct and reversed positions of the telescope be about the same rather than as far apart as would result in any other observing plan.

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

The data for each altitude observation, resolved to the sun’s center, are obtained with minimum involvement through the steps that have been outlined in the observing plan described above. This is recommended until skill in the technique of the observing has been acquired. After that has been accomplished, the period that is required for the observing may be shortened by arranging the recording on the plan show below, the six sightings to be reduced as one observation. The check against chance error in the readings is secured through comparing the means A-B-C that are indicated, which should be about the same numerically

	Tel.	This order, A. M. ↗	This order, P. M. ↘	Watch time	Hor. Ang.	Vert. Ang.
1	Dir.	Upper-right .....	Lower-right .....			
6	Rev.	Lower-left .....	Upper-left .....			
			Mean .....	A	A	A
2	Dir.	Upper-right .....	Lower-right .....			
5	Rev.	Lower-left .....	Upper-left .....			
			Mean .....	B	B	B
3	Dir.	Upper-right .....	Lower-right .....			
4	Rev.	Lower-left .....	Upper-left .....			
			Mean .....	C	C	C
			Mean of all .....	A-B-C	A-B-C	A-B-C

provided the time spacing is nearly uniform from 1 to 2, 2 to 3, 4 to 5, and 5 to 6. Any large discrepancy in the means will indicate a misreading at some point. If the means are slightly irregular, the *differences* from 1 to 2, 2 to 3, 4 to 5, and 5 to 6, which should be proportional, may be checked by slide rule method.

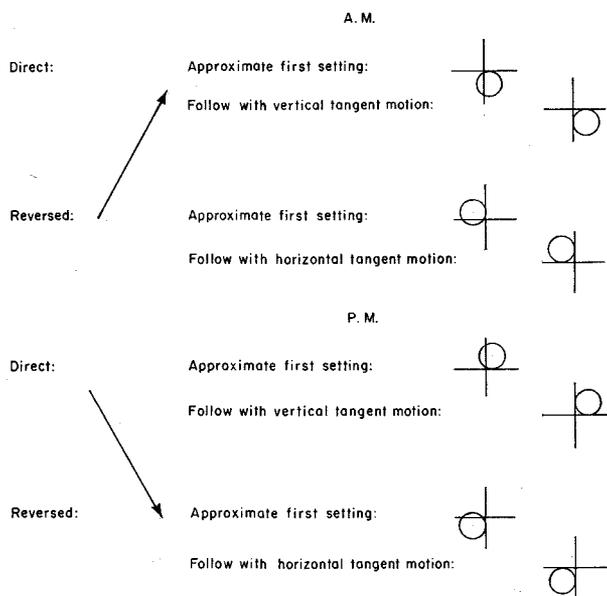
An equivalent observing plan, thought by many surveyors to be a simpler tangent-motion manipulation, may be substituted if desired, as follows:

2-63. Example of direct altitude observation of the sun for azimuth and time, sun north declination:

The altitude observations are made of the sun, each with the telescope in direct and reversed positions, observing opposite limbs of the sun. The horizontal angle is read from a flag on line to the east, southward to the sun. The known position of the instrument station is in latitude  $41^{\circ}22'40''$  N., and longitude  $111^{\circ}46'40''$  W. Observation is begun at 9:15 a.m., l. m. t., with watch set to approximate local mean time.

The declination of the sun for the mean period of the three observations is  $17^{\circ}09'30''$  N.

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



Observation	Telescope	Sun	Watch time	Vertical angle	Horizontal angle, flag to sun
1st set	Direct	d	9 <sup>h</sup> 15 <sup>m</sup> 05 <sup>s</sup>	46° 34' 00"	21° 00' 00"
	Reversed	p	9 15 59	46 10 00	20 29 00
	Mean		9 <sup>h</sup> 15 <sup>m</sup> 32 <sup>s</sup>	46° 22' 00"	20° 44' 30"
2d set	Direct	d	9 <sup>h</sup> 17 <sup>m</sup> 02 <sup>s</sup>	46° 54' 00"	21° 28' 00"
	Reversed	p	9 17 36	46 26 00	20 49 00
	Mean		9 <sup>h</sup> 17 <sup>m</sup> 19 <sup>s</sup>	46° 40' 00"	21° 08' 30"
3d set	Direct	d	9 <sup>h</sup> 18 <sup>m</sup> 41 <sup>s</sup>	47° 12' 00"	21° 52' 00"
	Reversed	p	9 19 20	46 45 00	21 16 00
	Mean		9 <sup>h</sup> 19 <sup>m</sup> 00 <sup>s</sup>	46° 58' 30"	21° 34' 00"

By 1st obsn. flag bears ..... N. 89°59'10" E.  
 By 2nd obsn. flag bears ..... N. 89 59 23 E.  
 By 3rd obsn. flag bears ..... N. 89 59 08 E.  
 Mean true bearing of flag ..... N. 89°59'14" E.  
 Watch slow of l. m. t., 1st obsn. .... = 25"  
 " " " " 2nd " ..... = 20  
 " " " " 3rd " ..... = 25  
 Mean watch time slow of l. m. t. .... = 23"

	1st obsn.	2nd obsn.	3rd obsn.
<i>v</i> .....	46°22'00"	46°40'00"	46°58'30"
Refraction .....	-55"	-55"	-54"
Parallax .....	+06"	+06"	+06"
<i>h</i> .....	46°21'11"	46°39'11"	46°57'42"

The reductions by formula for azimuth and time are usually made by use of natural functions and calculators. Logarithms have been em-

ployed here as a sometimes useful substitute method.

The following examples of reduction are all by the equation:

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

1st set:

log cos $\phi$	9.875274	log sin $\delta$	9.469842	log tan $\phi$	9.944941
log cos $h$	9.838983			log tan $h$	0.020520
log	9.714257	log	9.714257	log	9.965461
		log	9.755585	nat-	.92355
		nat+	.56962	nat+	.56962

Cos *A* - .35393  
 True bearing of sun S.69°16'20" E.  
 Angle, flag to sun +20°44'30"  
 S.90°00'50" E.  
 True bearing of flag N.89°59'10" E.

2d set:

log cos $\phi$	9.875274	log sin $\delta$	9.469842	log tan $\phi$	9.944941
log cos $h$	9.836586			log tan $h$	0.025074
log	9.711860	log	9.711860	log	9.970015
		log	9.757982	nat-	.93328
		nat+	.57277	nat+	.57277

Cos A .36051  
 True bearing of sun S.68°52'07" E.  
 Angle, flag to sun +21°08'30"  
 S.90°00'37" E.  
 True bearing of flag N.89°59'23" E.

3d set:

log cos $\phi$	9.875274	log sin $\delta$	9.469842	log tan $\phi$	9.944941
log cos $h$	9.834095			log tan $h$	0.029762
log	9.709369	log	9.709369	log	9.974703
		log	9.760473	nat-	.94342
		nat+	.57607	nat+	.57607

Cos A - .36735  
 True bearing of sun S.68°26'52" E.  
 Angle, flag to sun +21°34'00"  
 S.90°00'52" E.  
 True bearing of flag N.89°59'08" E.

The above observations are reduced for time by the equation:

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

1st obsn.:

log cos $\phi$	= 9.875274	log sin $h$	= 9.859503	log tan $\phi$	= 9.944941
log cos $\delta$	= 9.980228			log tan $\delta$	= 9.489614
	9.855502		9.855502	log	= 9.434455
		log	= 0.004001	nat(-)	= .27199
		nat (+)	= 1.00925		
			.27199		

cos  $t$  = .73726  
 $t = 42^\circ 30' 05'' = 2^h 50^m 00^s$  ..... =  $9^h 10^m 00^s$  a. m.  
 Equation of time ..... = +5 57  
 L.m.t. of observation ..... =  $9^h 15^m 57^s$  a. m.  
 Watch time of observation ..... = 9 15 32 a. m.  
 Watch slow of l.m.t. .... = 25<sup>s</sup>

2d obsn:

log sin $h$	= 9.861660
log cos $\phi$ cos $\delta$	= 9.855502
log	= 0.006158
nat (+)	= 1.01428
nat tan $\phi$ tan $\delta$ (-)	= .27199

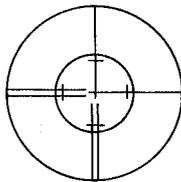
cos  $t$  = .74229  
 $t = 42^\circ 04' 23'' = 2^h 48^m 18^s$  ..... =  $9^h 11^m 42^s$  a. m.  
 Equation of time ..... = +5 57  
 L.m.t. of observation ..... =  $9^h 17^m 39^s$  a. m.  
 Watch time of observation ..... = 9 17 19 a. m.  
 Watch slow of l.m.t. .... = 20<sup>s</sup>

3d obsn:

log sin $h$	=	9.863856
log cos $\phi$ cos $\delta$	=	9.855502
log	=	0.008354
nat (+)	=	1.01942
nat tan $\phi$ tan $\delta$ (-)	=	.27199
cos $t$	=	.74743
$t = 41^{\circ}37'54'' = 2^{\text{h}}46^{\text{m}}32^{\text{s}}$	=	$9^{\text{h}}13^{\text{m}}28^{\text{s}}$ a. m.
Equation of time	=	+5 57
L.m.t. of observation	=	$9^{\text{h}}19^{\text{m}}25^{\text{s}}$ a. m.
Watch time of observation	=	9 19 00 a. m.
Watch slow of local mean time	=	25

### The Solar Circle

2-64. The design of the reticle of the transit telescope to include a circle that is equal to the image of the sun's diameter adds a desirable improvement to the technique of the altitude observation for azimuth. There are two advantages, first, all sightings for vertical angle and horizontal angle read to the sun's center; second, the manipulation of the vertical and horizontal tangent-motions to the position of concentric fitting of the circle to the sun's image may be accomplished with utmost certainty that the values for the vertical and horizontal angles are exactly simultaneous. Any single sighting may be reduced separately, if desired; or, in the event of a suspected misreading of an angle, the *differences* between the several sightings, in travel time, vertical angle, and horizontal angle, which should be proportional, may be quickly checked to make certain which reading, if any, shows a discrepancy in excess of what should be expected in good observing.



The solar circle has a radius of  $15'45''$ ; this is spaced for the sun's semidiameter on July 1, which is the approximate minimum for the year. The design of the reticle provides for stadia

observations by using both the vertical and horizontal rod, on the ratio of 1:132.

The double cross wires in the left and in the lower halves (direct position of the telescope) are spaced at  $40''$ ; this is to improve the daylight stellar observation. The double lines avoid the covering of the star by the cross wire (which may easily obscure the star). The centering and the manipulation of the tangent motions is indicated in the following diagrams:

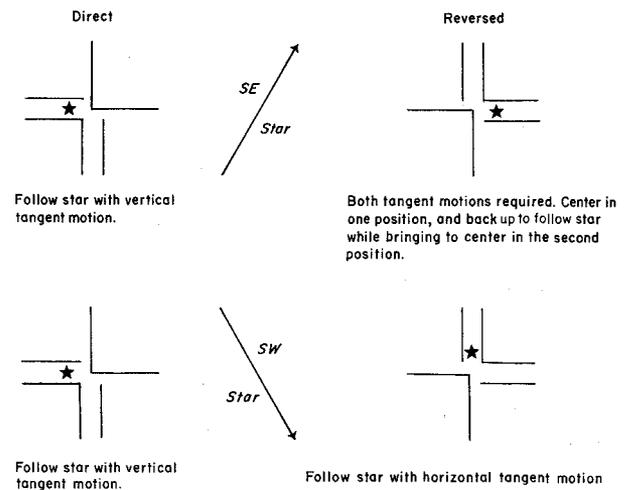


FIGURE 9.—Tangent motion in daylight stellar observation.

Example of notation in direct altitude observation of the sun for azimuth, using a transit equipped with the solar circle:

Observation	Telescope	Apparent time	Vertical angle	Horizontal angle from reference to sun
1.....	Direct	8 <sup>h</sup> 13 <sup>m</sup> 25 <sup>s</sup>	39°57'00"	34°38'00"
2.....	Direct		40°02'00"	34°33'00"
3.....	Direct		40°07'00"	34°29'00"
4.....	Reversed		40°20'30"	34°18'00"
5.....	Reversed		40°25'30"	34°14'00"
6.....	Reversed	8 16 25	40°32'00"	34°09'00"
Mean		8 <sup>h</sup> 14 <sup>m</sup> 55 <sup>s</sup>		

### *Equal Altitude Observations of the Sun for Meridian*

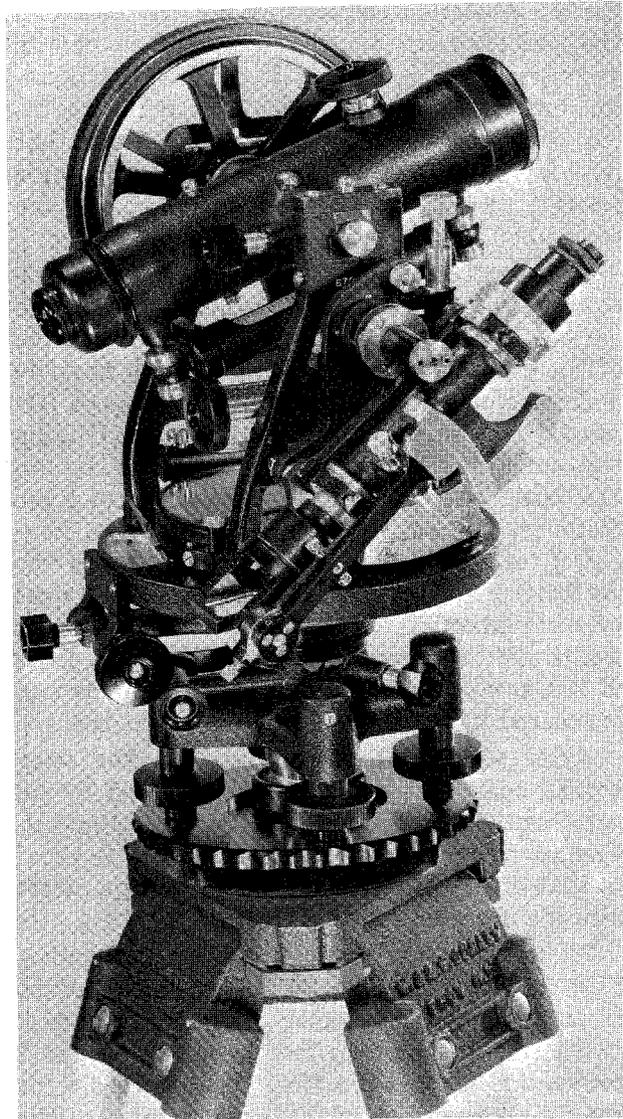
2-65. The true meridian may be established by the method of equal altitude observations of the sun. The observation is not well adapted to line work, but it possesses a certain usefulness in camp, in that the surveyor may thus determine the true meridian by the sun with mere approximations as to time and latitude.

The fixation of the true meridian by this method depends upon the theory that the sun's center at equal altitudes occupies symmetrical positions in azimuth east and west of the meridian in the morning and in the afternoon except for the correction necessary to be applied due to the change in the sun's declination in the interval between the a.m. and p.m. observations. The formula for this correction appears in the Standard Field Tables.

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

### **The Solar Transit**

2-66. Beginning with the Burt solar compass in 1836, a number of instruments have been designed to solve mechanically the polezenith-sun celestial triangle by means of an attached solar unit. Because such instruments can be oriented rapidly without reference to a backsight or a new direct observation, they are suited to surveying through timber, dense undergrowth, and mountainous terrain. The modern solar transit is fully equipped for making the necessary stellar and solar observations by direct means as well. A standard model of the solar transit is shown in Plate No. 1.



Standard model of the solar transit.

The solar unit is in fact a second instrument, operating in its own right independently. Latitude and declination arcs remain clamped and set to their proper values. The polar axis conforms with the line of collimation of the solar telescope. The mounting is designed to bring the vertical plane of the polar axis into parallel with the vertical plane of the transit.

When oriented, the vertical plane of the polar axis is in the plane of the great circle of the meridian. When turned in hour angle at the moment of an observation, the plane normal to the axis of the reflector is in the plane of the

great circle that passes through the pole and the sun. The sun's hour angle at that moment is the angle measured along the plane of the Equator, intercepted between the plane of the meridian and the plane of the great circle that passes through the pole and the sun. This angle reads "apparent time" on the hour circle of the solar unit.

The vertical angle inclination of the polar axis equals the latitude of the station; this angle is set on the latitude arc. The angle on the plane of the great circle that passes through the pole and the sun, counting between them equals  $90^\circ$  minus the sun's north declination, or  $90^\circ$  plus the sun's south declination, corrected by an increment equivalent to the refraction in polar distance. The settings for this angle are computed for each day in advance; it is set on the declination arc to agree with the apparent time of observation. The correct position of the sun's zenith distance measured on the vertical plane of the great circle that passes through the sun is secured by the careful leveling of the transit.

After setup and careful leveling, the solar transit may be instrumentally oriented by an experienced surveyor in less than two minutes. The accuracy or acceptable "tolerance" is equal to that of any single, unverified, average direct altitude observation on the sun.

In line running, through timber and undergrowth, there may be 20, 30, or more setups to the mile, each by solar orientation without cutting or opening the line to secure an exact backsight. In this practice, the net result for the mile is the mean of the whole number of the observations, in which many of the smaller differences are compensated, and in which the azimuth of the line between the monuments should normally be brought well inside of the tolerance of  $1' 30''$ .

What is more, each azimuth determination gives the angular value referred to the true north at that station. This of course is the only method by which a true parallel of latitude can be run by instrumental orientation. The determinations of the true parallel by the "tangent" or "secant" method require the careful running of a "back-and-foresight" line with measured offsets.

Use of the solar unit avoids the cumulative error normally encountered in long "back-and-foresight" lines and in traverse lines where there are many turns. A traverse line may be run by occupying each alternate station, cutting in half the time required for the instrumental work. Heavy winds or insecure ground, wind-falls, timber, undergrowth, and obstructions that require offset are not in themselves any preventative to rapid and accurate solar orientation.

2-67. The instrumental orientation of the solar unit is made possible through five elements in the construction, as follows:

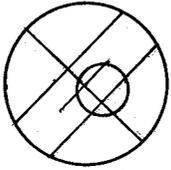
(1) A telescope whose line of collimation is the polar axis; the polar axis corresponds to an element of the more elaborate observatory "equatorial instrument mounting," which is designed for the telescope to follow a star's travel in diurnal circle. The solar telescope is mounted in collar bearings whose bases are attached to a vertical limb; the telescope may be revolved or turned 12 hours in hour angle.

(2) The vertical limb is an arc that is graduated to read in latitude; a vernier mounted on the base frame gives the reading in latitude; the center of the limb is called the latitude axis, and is horizontal.

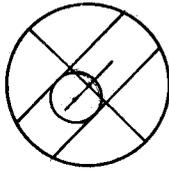
(3) A reflector at the objective end of the telescope picks up the light rays of the sun; its axis is normal to the line of collimation. An arm controls the angle of the reflector in the plane of the great circle that passes through the pole and the sun; a vernier on the arm gives the reading on a graduated declination arc.

(4) A small graduated circle on the telescope, normal to the line of collimation, reads in hour angle from 6 a.m., 7, 8, up to 12, and 1, 2, 3, up to 6 p.m.; this reads directly in *apparent time*.

(5) The plan of the reticle includes three "equatorial wires" that are set parallel to the axis of the reflector. One is in the line of collimation, the others parallel, spaced at  $15' 45''$  to conform with the sun's July 1 diameter (the smallest for the year). A fourth cross wire, normal to the others, passes through the line of collimation, indicating the center of the field in *time*.

*Not oriented*

When turning the transit in horizontal angle, the image of the sun cuts across the equatorial wires.

*Oriented*

The travel of the sun's image is along the path of the equatorial wires.

#### *Orientation of Sun's Image on Reticle*

The frame of the solar unit is attached to one standard of the transit, controlled in position by three foot posts. This is the standard on the east when the transit is oriented in the meridian. The vertical plane of the polar axis may be adjusted to true parallel with the vertical plane of the transit telescope. By first setting the plate reading at zero, when preparing to orient, all horizontal angles will count from the meridian.

When oriented, and turned in hour angle to agree with the apparent time, the image of the sun will travel across the field of the solar telescope along the path of the equatorial wires. If the transit is turned away from the meridian to the right or to the left, the sun's image will cut across the equatorial wires. Thus to bring the solar unit into proper orientation, all that is needed is to see that the image of the sun is centered anywhere along the length of the equatorial wires. This centering is done with the lower tangent motion, the plates clamped at zero.

On the declination arc, an actual arc or segment of  $5^\circ$  is graduated for reading  $10^\circ$ ; this is because a movement of  $5^\circ$  in the reflector position makes an angle of  $10^\circ$  between the light rays of incidence and those reflected. At zero declination the plane of the reflector is at  $45^\circ$  to the line of collimation. The declination arc is graduated north and south from zero for the range of the sun's position during the year.

One important element of the mounting is that the three points of control at the foot posts are placed to form a right-angle, one side of which is vertical, the other horizontal. In adjustment, the foot post at the  $90^\circ$  angle remains fixed. One of the foot posts controls the position of the latitude axis in horizontal. One foot

post controls the direction of pointing of the line of collimation when in horizontal sighting, to bring that into parallel with the vertical plane of the transit. The foot-post controls are secured with capstan or hexagon nuts.

At one end of the frame that supports the collar bearings, there is a mechanism (corresponding to that of a telescope level) for adjusting the polar axis so that it is normal to the latitude axis. This is needed when the solar telescope is changed in latitude setting.

2-68. With the transit and solar unit in satisfactory adjustment, the simple steps in solar orientation at any setup are these: carefully level, with the solar unit on the west; reverse the instrument and correct *half* of any discrepancy in the centering of the plate bubbles; set the plates at zero; set the latitude and declination, or check the previous setting; turn the solar telescope to the reading in approximate apparent time; move the whole instrument in horizontal angle for position near the meridian, at this time bringing the sun's image into the field of the solar telescope, then tighten the lower clamp; use the lower tangent motion for final orientation, in which step the sun's image should be centered on the equatorial wires.

The solar transit is equipped for making any type of stellar or solar observation that may be employed profitably in land surveying practice as adapted to the one-minute transit. This calls for accuracy to a tolerance of  $\pm 15''$  in the direction of lines, where that may be required. This accuracy is greater than that called for by the precision of distance measurement unless the character of the survey is such as to justify the greatly increased cost of exactness in measurement.

The use of the solar unit may be almost continuous as when running the line through timber or tall undergrowth, or it may be more or less incidental as when running in an open country. It is important, too, in the open country, and on almost any type of survey, to have the use of the solar unit in making the start in the line running or observing. Even on the work that requires the greatest refinement in the important lines, there are many off-line stations to be occupied for collateral data, mapping, or tra-

versing, where the direction from true north should be employed.

For these reasons, the preparation of each day's work requires that the data shall be at hand, in the field tablet, for the sun's declination for the day, reading for value in the apparent time of the local meridian, and to which has been applied the correct refractions in polar distance for that position of the sun and that latitude. Additionally, the true latitude and the *instrumental latitude* should be known.

Proper accuracy in solar orientation becomes attainable as soon as the sun is high enough to reduce the refraction correction to not over 4' or 5', and continuing until 10:30 a.m. or a little later with care and suitable checks; a corresponding period applies in the afternoon. Thus from 10:30 a.m. to 1:30 p.m., or for about that period, the line running should be by back-and-foresight. If the sun becomes obscured, the usual transit methods are employed. In stopping for the day, an azimuth mark should be set for use the next morning.

**2-69. Computing Hourly Declinations of the Sun.**

For use with the solar unit, hourly declinations of the sun for each date may be prepared in tabular or graphic form, the graphic form being most advantageous.

Example of a table of hourly declinations of the sun, combined with refraction in polar distance, for March 14, 1972, at station in latitude 33°10' N., longitude 116°45' W. (7<sup>h</sup>-47<sup>m</sup>):

Declination of the sun at Greenwich apparent noon, March 14, 1972.....	2°22'30.8" S.
Difference in time from Greenwich apparent noon to 7 a.m., app. time, longitude 116°45' W. For longitude ..... = 7 <sup>h</sup> 47 <sup>m</sup> For time, a.m., 12 <sup>h</sup> - 7 <sup>h</sup> 00 <sup>m</sup> ..... = -5 00 2.78 <sup>h</sup> = 2 <sup>h</sup> 47 <sup>m</sup>	
Hourly difference in declination ..... = 59.21"	
Difference in declination from Green- wich apparent noon to 7 a.m., app. time, longitude 116°45' W., 2.78 × 59.21 = 164.6" ..... = 2'44.6" N.	
Declination of the sun, 7 a.m., app. time =	<u>2°19'46.2" S.</u>

Apparent time	True declination	Refraction	Declination setting
7 a.m. ....	2°19'46" S.	2'39" N.	2°17'07" S.
7½ .....	2 19 17	1 47	2 17 30
8 .....	2 18 47	1 21	2 17 26
9 .....	2 17 48	0 57	2 16 51
10 .....	2 16 49	0 47	2 16 02
11 a.m. ....	2 15 49	0 44	2 15 05
Noon .....	2 14 50	0 41	2 14 09
1 p.m. ....	2 13 51	0 44	2 13 07
2 .....	2 12 52	0 47	2 12 05
3 .....	2 11 53	0 57	2 10 56
4 .....	2 10 53	1 21	2 09 32
4½ .....	2 10 24	1 47	2 08 37
5 p.m. ....	2 09 54	2 39	2 07 15

Example of a table of hourly declinations of the sun, combined with refraction in polar distance, for August 11, 1972, at a station in latitude 47°10' N., longitude 111°00' W. (7<sup>h</sup>-24<sup>m</sup>).

Declination of the sun at Greenwich apparent noon, August 11, 1972 .....	15°09'38.1" N.
Difference in time from Greenwich apparent noon to 6 a.m., app. time, longitude 111°00' W. For longitude ..... = 7 <sup>h</sup> 24 <sup>m</sup> For time, a.m., 12 <sup>h</sup> - 6 <sup>h</sup> 00 <sup>m</sup> ..... = -6 00 1.40 <sup>h</sup> = 1 <sup>h</sup> 24 <sup>m</sup>	
Hourly difference in declination ..... = -44.73"	
Difference in declination from Green- wich apparent noon to 6 a.m., app. time, longitude 111°00' W., 1.40 × 44.73 = 62.6" ..... = 1'02.6" S.	
Declination of the sun, 6 a.m., apparent time .....	<u>15°08'35.5" N.</u>

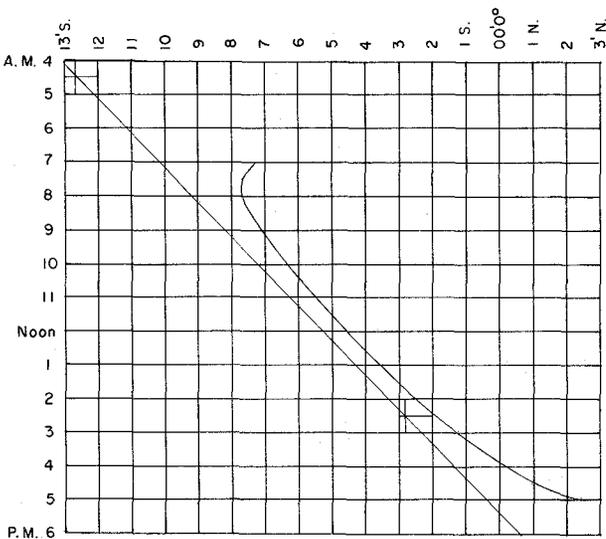
Apparent time	True declination	Refraction	Declination setting
6 a.m. ....	15°08'35" N.	3'28"	15°12'03" N.
6½ .....	15 08 13	2 21	15 10 34
7 .....	15 07 51	1 45	15 09 36
8 .....	15 07 06	1 08	15 08 14
9 .....	15 06 21	0 51	15 07 12
10 .....	15 05 37	0 41	15 06 18
11 a.m. ....	15 04 52	0 38	15 05 30
Noon .....	15 04 07	0 36	15 04 43
1 p.m. ....	15 03 22	0 38	15 04 00
2 .....	15 02 38	0 41	15 03 19
3 .....	15 01 53	0 51	15 02 44
4 .....	15 01 08	1 08	15 02 16
5 .....	15 00 23	1 45	15 02 08
5½ .....	15 00 01	2 21	15 02 22
6 p.m. ....	14 59 39	3 28	15 03 07

Examples of diagrams showing declinations of the sun for given dates, combined with refractions in polar distance, are given in figures 10 and 11. The horizontal lines represent each hour of the day; the vertical lines represent intervals of one minute in declination. It is convenient to use the right-hand side of the sheet to represent north, the left-hand side to represent south. North declinations increase numerically to the right-hand side of the sheet, south declinations to the left-hand side. The vertical lines are numbered to suit the range of declination for the date.

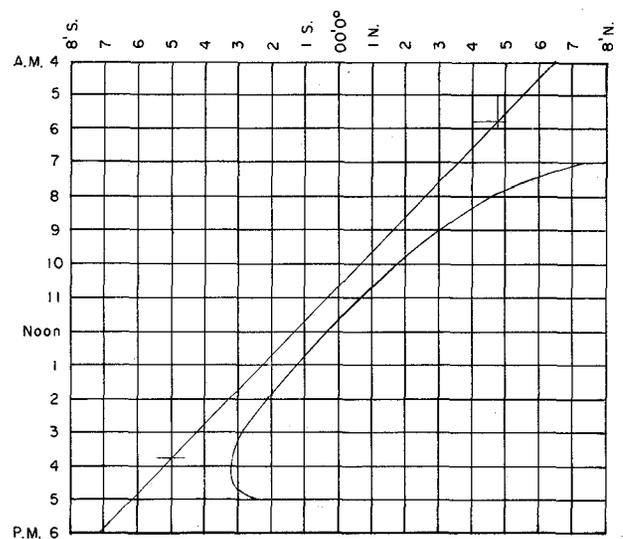
The advantage of the diagram method is found in the avoidance of errors of computation and the ease with which it is checked, together with the fact that in the use of the diagram actual values are obtained at any time instead of by a linear interpretation.

Two points are marked on the diagram to agree with the true declination of the sun; the first point is marked with the argument of declination agreeing with the declination of the sun taken from the Ephemeris for Greenwich apparent noon, with the argument of time agreeing with the apparent time at the longi-

tude of the station, corresponding to Greenwich noon; the second point is marked agreeing with the proper declination and time 10 hours later. The straight line determined by the two points agrees with the sun's true declination for the apparent time at the longitude of the station. The proper refractions in polar distance are then scaled from the straight line to the N. for each tabulated refraction, a. m. and p. m., taken from table 23, Standard Field Tables, appropriate to the latitude of the station, and declination of the sun. The latter points are then connected to form a smooth curve representing the declinations of the sun, corrected for refraction in polar distance, for use with the solar unit. The scale of the refractions must equal the scale of the intervals of 1' in declination; the refractions are laid off along or parallel to the horizontal lines, and *not* normal to the line of true declination. At any time throughout the day the proper declination for use with the solar unit is obtained by reference to the curve at the point corresponding to the time of observation. To obtain any true value of the sun's declination for use in the reduction of *altitude observations* reference may be made to the



**FIGURE 10.—Diagram of sun's declinations.**  
 Date, March 20, 1970.  
 Station: Latitude 37°30' N. Longitude 112°30' W. (7<sup>h</sup>30<sup>m</sup>)  
 Declination at Greenwich app. noon  
 (4<sup>h</sup>30<sup>m</sup> a.m., app. time) = 0°12'39.3" S.  
 Difference in declination for 10<sup>h</sup> = 592.5" = 9'52.5" N.  
 Declination at 2<sup>h</sup>30<sup>m</sup> p.m., app. time = 0°02'46.8" S.



**FIGURE 11.—Diagram of sun's declinations.**  
 Date, September 23, 1971.  
 Station: Latitude 47°30' N. Longitude 94°30' W. (6<sup>h</sup>18<sup>m</sup>)  
 Declination at Greenwich app. noon  
 (5<sup>h</sup>42<sup>m</sup> a.m., app. time) = 0°04'44.0" N.  
 Difference in declination for 10<sup>h</sup> = 584.1" = 9'44.1" S.  
 Declination at 3<sup>h</sup>42<sup>m</sup> p.m., app. time = 0°05'00.1" S.

straight line of true declination at the point corresponding to the time of observation.

### *Apparent Time from the Solar Unit*

2-70. The solar unit of the solar transit has a graduated hour circle mounted normal to the polar axis. The readings are indicated at intervals of 10 minutes from 6 a.m. to 6 p.m., apparent time; the readings may be estimated to about  $\pm 1$  or 2 minutes. This accuracy is sufficient for taking out the sun's declinations, which are calculated in terms of apparent time. It can be an approximate check upon the altitude and meridian observations on the sun for apparent time.

By applying the equation of time to the reading of the hour circle, the watch may be set to approximate local mean time, with the tolerance indicated above. This will be accurate enough for the finding positions for the stellar observations. It is also sufficiently accurate for the observations on Polaris for azimuth at elongation or latitude at culmination.

An exact method for time determination should be followed for the watch correction in local mean time necessary for hour angle observations on Polaris.

### *Checks of the Solar Unit*

2-71. The following checks of the solar unit are all that are ordinarily required at the beginning of a survey:

(1) The reading of the latitudinal vernier with the solar telescope in true horizontal position.

(2) The reading of the latitude arc at noon with the solar telescope oriented on the meridian and the correct declination setting. This is the "instrumental latitude."

(3) The reading of the declination vernier when set in true zero declination,  $15^\circ$  north declination, and  $15^\circ$  south declination.

(4) The check for parallelism when the solar telescope is set and clamped in the latitude of the station.

(5) The checks for orientation when compared with a true meridian.

The solar unit should be checked on a true

meridian at least weekly in normal use and whenever it has been subject to unusually hard bumps or jars.

2-72. Reference should be made to the maker's bulletin or a surveying textbook for care and adjustment of the transit. The adjustments of the solar unit are described in appendix I.

### *Errors in Azimuth, Due to Small Errors in Declination or Latitude*

2-73. It may frequently happen with a solar transit, especially at the beginning of a survey or with an instrument insufficiently tested, that the first meridional trials are made with slight errors in the settings of the latitude and declination arcs, resulting in small errors in azimuth. This may be particularly true prior to a determination of the instrumental latitude. The discrepancies in azimuth due to such errors have been tabulated in the Standard Field Tables, which may be applied to results of single observations with considerable certainty. The corrections are not applicable to a series of observations as in ordinary line work owing to the changing values (for hours from noon) of the correction coefficients. The explanation with the table gives a key to the direction of the azimuth errors on account of small incorrect values in setting the latitude and declination arcs.

For example, at 9<sup>h</sup>40<sup>m</sup> a.m., app. t., at a station in latitude assumed to be  $46^\circ 20' N.$ , a test was made with a solar transit whereby the trial indication was found to be S.  $0^\circ 05' W.$ , or  $0^\circ 05'$  west of the true meridian. Subsequent determinations of the true latitude of the station and of the correctness of the vernier of the declination arc showed that the actual latitude of the station was  $46^\circ 21.5' N.$ , and that the vernier of the declination arc had an index error which gave readings  $0^\circ 00.5'$  S. of the calculated declination (i.e. reading  $15^\circ 19.5' N.$  for a calculated declination of  $15^\circ 20' N.$ ) Thus in the test the latitude arc was set  $1.5'$  S. of the correct latitude of the station, and the declination arc was actually set  $0.5'$  N. of the value that would have been set had the index error been known.

By reference to the Standard Field Tables:

Latitude	Hours from noon			
	2 <sup>h</sup> 0 <sup>m</sup>	2 <sup>h</sup> 20 <sup>m</sup>	3 <sup>h</sup> 0 <sup>m</sup>	
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 apparent errors of the solar transit, but are not intended for use in line work, and cannot be accepted in lieu of subsequent tests based on correct values.

## THE GEODESY OF LARGE-SCALE CADASTRAL SURVEYS

### Transfer of Azimuth, Station Error, and Curvature

2-74. When carrying forward the direction of lines through intermediate transit stations by the method of fore-and-back sights and deflection angles, two corrections become important where the purpose is to maintain accuracy. First, each station setup involves uncertainty in the maintenance of the direction of a line, or in the value of the angle that may be turned, called "station error." Second, if the line is other than a meridian, its direction will have an increment of *curvature*; this is applied in order to convert from the forward azimuth to the back azimuth of that same line at the next station.

As solar transit orientation is designed to give the meridian at each station, thereby avoiding cumulative errors of conventional transit methods, the corrections for station error and curvature do not enter into the ordinary solar transit directions. However, for the purpose of a comparison of the solar transit direction of the chord of a long line, half the value of the

convergency of the meridians of the two end stations is applied.

For example, a parallel of latitude as run by solar transit methods is a true latitudinal curve, i. e.—a small circle of the earth, everywhere due east or west. The transit line or chord between any two distant points of the parallel is a great circle, whose mean azimuth, or bearing at midpoint, is due east and west. At one end of the chord the forward azimuth is always northeasterly (or northwesterly); at the opposite end, the back azimuth will be northwesterly (or northeasterly). At the end stations of the chord, the difference between the forward (or back) azimuth *and due east or west*, will be equal to half the value of the curvature counting from the two end stations. At the end stations of the chord, the difference between the forward azimuth and the back azimuth  $\pm 180^\circ$  will be the full value of the convergency of the meridians of the two end stations.

By basic law, and the Manual requirements, the directions of all lines are stated in terms of angular measure referred to the true north (or south) at the point of record. Therefore, after carrying a transit line forward a considerable distance through a number of intermediate stations, it is necessary to solve the problem of the change from the starting direction to that at the last station. The back azimuth at the last station  $\pm 180^\circ$  should equal the starting direction, plus or minus the algebraic sum of the deflection angles, plus or minus the value of the

convergency of the meridians from the two end stations. The discrepancy will be the accumulated error in the transit operations.

To determine this discrepancy, the first step is to make dependable azimuth observations at the two end stations; then compare the values, allowing for the convergency of the meridians of the end stations. The difference that remains is the *cumulative* error. The latter value, in terms of seconds, may be divided by the number of the intermediate stations; the quotient is the cumulative error per station, or just "station error." The latter should be distributed according to the number of the intermediate stations.

The total curvature, or correction for convergency is an element of the *departure* between the end stations, and of the mean latitude. It is tabulated in the Standard Field Tables, for the value in angular measure for a *departure of six miles*, or 480 chains, for each degree of latitude. It is often convenient to convert the curvature to a value for a departure of 100 chains, for proportional reduction to other distances. The whole convergency should be distributed in proportion to the *departure of each course*.

A transit line running easterly will curve to the right in bearing angle, thus increasing a northeasterly bearing, or decreasing a southeasterly bearing. A transit line running westerly will curve to the left in bearing angle, thus increasing a northwesterly bearing, or decreasing a southwesterly bearing.

When computing latitudes and departures, and transferring a geographic position by means of a long connecting line, the *mean azimuth* should be employed for the direction of the line, i.e.—the mean between the forward azimuth and the back azimuth  $\pm 180^\circ$ . That azimuth or bearing angle will be the direction of the chord of the great circle that passes through the ends of the connecting line.

Where the transfer of azimuth is by triangulation, a check is secured by the closure of each triangle, and the reductions of the lengths of the lines.

The angles employed for the calculations of the lengths of lines will be the differences in the directions between the two forward azimuths at each station.

The sum of the three angles should close to  $180^\circ$  within the allowable tolerance.

The *mean course* of any side (actually the mean bearing of the chord) will be the mean between the forward and the back azimuth  $\pm 180^\circ$  of that line.

The correction for curvature of the longest line in easting or westing in any triangle should equal the sum of the corrections for curvature of the other two sides.

As a check on the lengths of lines, the latitude of the longest line in any triangle should equal the sum of the latitudes of the other two sides.

The distances in departure must be reduced first to the mean position in latitude of each side.

A check is secured by reducing each departure to a common position in latitude. In this reduction, the amount to be added to or subtracted from each departure is equal to the amount of the distance along the meridian between the two latitudinal lines at the transfer, multiplied by the tangent of the angle of convergency.

After reducing to a common latitude, the departure of the longest line in easting or westing in any triangle should equal the sum of the departures of the other two.

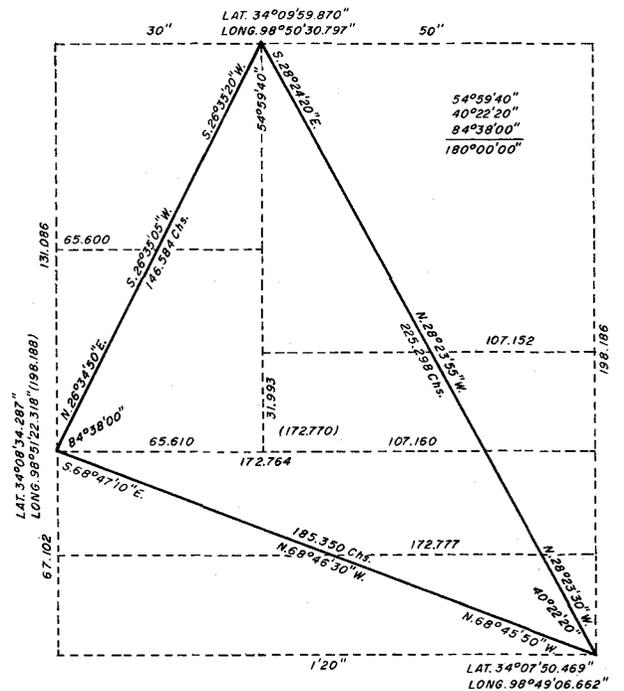


FIGURE 12.—Curvature of lines of a large triangle.

The one-minute transit, carefully handled, is capable of holding the station error to under 10' per station, or even to about half that amount if the nature of the survey requires a very high degree of accuracy, and there is justification for the consequent needed increase in care.

Where the survey is made with the one-minute transit, it is inappropriate to represent the computed result of an observation closer than 30'', 15'', or 10'', according to the strength of the observation.

A tolerance of 10' in the direction of a line calls for a measurement that is good to within 1:20,000; 15'', to within 1:13,333; 30'', to within 1:6,667; 1' 00'', to within 1:3,333; 1' 30'' (the Manual tolerance for solar transit orientation) to within 1:2,300. This comparison will emphasize the point that in land-surveying practice, and particularly in the subdivision of large areas as in the rectangular survey of the public lands, more stress should be placed on accuracy of distance measurement if those values are to be as good as the values required in the direction of lines.

### The True Parallel of Latitude

2-75. The base lines and standard parallels of the rectangular system are established on the true parallel of latitude; the random latitudinal township boundary lines are also projected on the same curve; this curve is defined by a plane at right angles to the earth's polar axis cutting the earth's surface on a small circle. At every point on the true parallel the curve bears due east and west, the direction of the line being at right angles to the meridian at every point along the line. Two points at a distance of 20 chains apart on the same parallel of latitude may be said to define the direction of the curve at either point, without appreciable error, but the projection of a line so defined in either direction, easterly or westerly, would describe a great circle of the earth gradually departing southerly from the true parallel. The great circle tangent to the parallel at any origin or reference point along the parallel is known as the "tangent to the parallel," and it is coincident with the true latitude curve only at the point of origin. The rate of

the change of the azimuth of the tangent is a function of the latitude on the earth's surface. The azimuth of the tangent varies directly as the distance from the origin, and the offset distance from the tangent to the parallel varies as the square of the distance from the point of tangency. A great circle connecting two distant points on the same latitude curve has the same angle with the meridian at both points and the azimuth of such a line at the two points of intersection is a function of one-half the distance between the points.

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

### Solar Method

2-76. The solar instruments are capable of following the true parallel of latitude without substantial offsets. If such an instrument, in good adjustment, is employed, the true meridian may be determined by observation with the solar unit at each transit point. A turn of 90° in either direction then defines the true parallel, and if sights are taken not longer than 20 to 40 chains distant, the line so established does not appreciably differ from the theoretical parallel of latitude. The locus of the resulting line is a succession of points each one at right angles to the true meridian at the previous station. There are periods each day, however, when solar observations are not practicable or the sun may be obscured. Moreover, the instrument available might not have a solar attachment or one in proper adjustment. In these circumstances reference must be made to a transit line from which to establish the true latitude curve by one of the alternative methods given below.

### Tangent Method

2-77. The tangent method for determination of the true latitude curve consists in establishing the true meridian at the point of beginning, from which a horizontal deflection angle of 90° is turned to the east or west, as may be required; the projection of the line thus deter-

mined is called the tangent. The tangent is projected six miles in a straight line, and as the measurements are completed for each corner point, proper offsets are measured north from the tangent to the parallel, upon which line the corners are established.

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

The Standard Field Tables show the various offsets from the tangent north to the parallel, tabulated for any degree of latitude from 25° to 70° N., for each half mile from 1/2 to 6 miles.

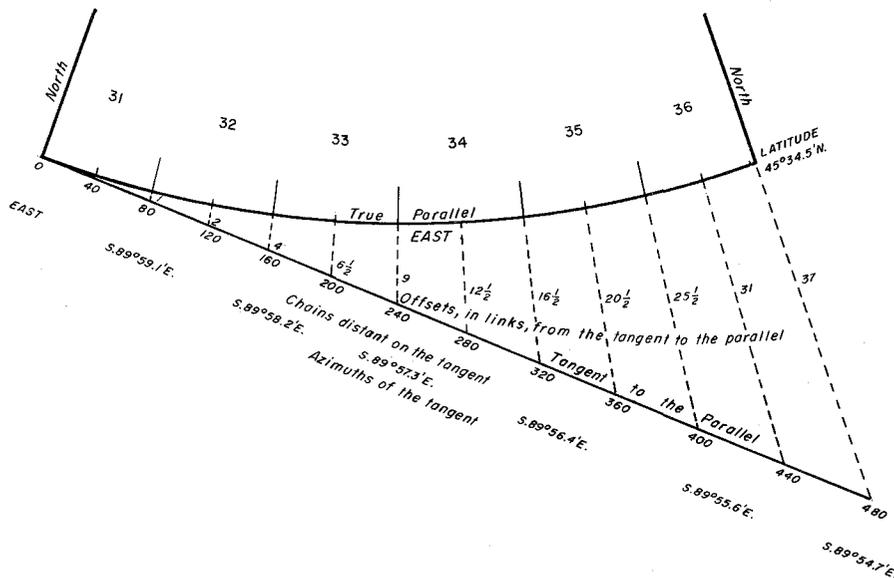
Figure 13 illustrates the establishment of a standard parallel in latitude 45°34.5' N., by the tangent method.

Objection to the use of the tangent method

in a timbered country is found owing to the requirement that all blazing is to be made on the true surveyed lines. Also, all measurements to items of topography entered in the field notes are to be referred to the true established lines. These objections to the tangent method, on account of the increasing distance from the tangent to the parallel, are largely removed in the secant method.

**Secant Method**

2-78. The designated secant is a great circle which cuts any true parallel of latitude at the first and fifth mile corners, and is tangent to an imaginary latitude curve at the third mile point. From the point of beginning to the third mile corner the secant has a northeasterly or northwesterly bearing; at the third mile corner the secant bears east or west; and from the third to the sixth mile corners the secant has a southeasterly or southwesterly bearing, respectively, depending upon the direction of pro-



$$\text{Offset (in chains)} = \frac{1}{R_p} \cdot \frac{(m\phi)^2}{2} \cdot \sin b, \text{ where}$$

$\frac{1}{R_p}$  is taken from the table in section 2-79 for the latitude of the beginning point

$m\phi$  = distance from the beginning point in chains

$b$  = forward bearing at the beginning point

FIGURE 13.—A tangent to the parallel.

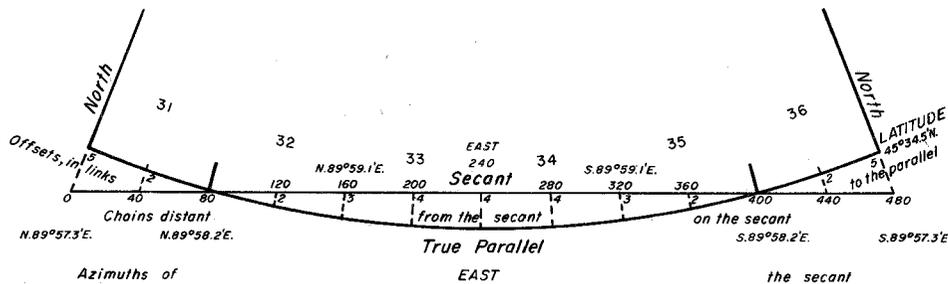


FIGURE 14.—A secant of the parallel.

jection, east or west. From the point of beginning to the first mile corner and from the fifth to the sixth mile corners the secant lies south of the true parallel, and from the first to the fifth mile corners the secant lies north of the true parallel. It will thus be seen that the secant method is a mere modification of the tangent method, so arranged that the minimum offsets can be made from the projected transit line to the established true parallel of latitude.

The secant method of determination of the true latitude curve consists in establishing the true meridian at a point south of the beginning corner a measured distance taken from the table, from which meridian the proper horizontal deflection angle, as taken from the table, is turned to the northeast or northwest to define the secant. The secant is projected 6 miles in a straight line, and as the measurements are completed for each corner point, proper offsets are measured, north or south, from the secant to the parallel, upon which parallel the corners are established.

The Standard Field Tables give the bearing angles or azimuths of the secant, referred to the true N. point for the first 3 miles, and the same symmetrical bearing angles or azimuths referred to the true S. point for the last 3 miles, tabulated for any degree of latitude from 25° to 70° N., for the end of each mile from 0 to 6 miles.

The Standard Field Tables show the various offsets from the secant to the parallel, tabulated for any degree of latitude from 25° to 70° N., for each half mile from 0 to 6 miles.

Figure 14 illustrates the establishment of a standard parallel in latitude 45°34.5' N. by the secant method.

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

### Convergency of Meridians

2-79. The linear amount of the convergency of two meridians is a function of their distance apart, of the length of the meridian between two reference parallels, of the latitude, and of the spheroidal form of the earth's surface.

The following equation is convenient for the analytical computation of the linear amount of the convergency on the parallel, of two meridians any distance apart, and any length. The correction for convergency in any closed figure is proportional to the area, and may be computed from an equivalent rectangular area:

- " $m_\lambda$ ": Measurement along the parallel.
- " $m_\phi$ ": Measurement along the meridian.
- " $a$ ": Equatorial radius of the earth=3963.3 miles.
- " $e$ ": Factor of eccentricity,  $\log e=8.9152515$ .
- " $dm_\lambda$ ": Linear amount of the convergency on the parallel, of two meridians distance apart " $m_\lambda$ " and length " $m_\phi$ " along the meridian: " $dm_\lambda$ " " $m_\lambda$ " " $m_\phi$ " 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 <sup>2</sup> sin <sup>2</sup> φ	=	7.503 457	
nat " " "	=		0.0031875
" (1 - e <sup>2</sup> sin <sup>2</sup> φ)	=		0.9968125
log " " "	=	9.998 614	
" √1 - e <sup>2</sup> sin <sup>2</sup> φ	=	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 <sub>λ</sub>	=	1.039 482	
nat " "	=	10.9517	chs.

The above equation may be written  $dm_{\lambda} = \frac{1}{R_p} m_{\lambda} m_{\phi}$ , where  $R_p = \frac{a \cot \phi}{\sqrt{1 - e^2 \sin^2 \phi}}$ . The computed linear convergence will be in the same unit as  $m_{\lambda}$  and  $m_{\phi}$ . Values of  $\frac{1}{R_p}$  for latitudes 25° to 75° are listed in the table below.

Lat.	1/R <sub>p</sub>	Lat.	1/R <sub>p</sub>	Lat.	1/R <sub>p</sub>
25°	.000001470	42°	.000002836	59°	.000005236
26	.000001537	43	.000002937	60	.000005449
27	.000001606	44	.000003041	61	.000005675
28	.000001676	45	.000003149	62	.000005916
29	.000001747	46	.000003260	63	.000006173
30	.000001819	47	.000003376	64	.000006449
31	.000001893	48	.000003496	65	.000006745
32	.000001969	49	.000003621	66	.000007064
33	.000002046	50	.000003751	67	.000007409
34	.000002125	51	.000003887	68	.000007784
35	.000002206	52	.000004028	69	.000008192
36	.000002289	53	.000004176	70	.000008640
37	.000002374	54	.000004331	71	.000009132
38	.000002461	55	.000004494	72	.000009677
39	.000002551	56	.000004665	73	.000010284
40	.000002643	57	.000004845	74	.000010965
41	.000002738	58	.000005035	75	.000011734

Using the same values as in the previous example:

$$dm = .000002971 \times 1920 \times 1920 = 10.952 \text{ chains.}$$

The convergence, 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 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 the Standard Field Tables.

2-80. The Standard Field Tables list the linear amounts of the convergency of meridians, six miles long and six miles apart, for each degree of latitude from 25° to 70° N., together with the angle of convergency of the same meridians. These amounts of linear convergency are at once the proper corrections to apply to the north boundary of a regular township in the computation of the closing error around a township, or other computation by which a theoretical length of a north or south boundary of a township is compared with the length of the opposite boundary; the tabulated linear amounts of convergency are equal to double the amounts of the offsets from a tangent to the parallel at six miles for the same latitudes. Simple interpolation may be made for any intermediate latitude, and the amount of the convergency for a fractional township or other figure may be taken in proportion to the tabulated convergency as the fractional area is to 36 square miles.

The tabulated angle of convergency represents at once the deviation in azimuth of the tangent from the parallel at six miles; and 1/6, 1/3, 1/2, 2/3, and 5/6 of the tabulated angles of convergency represent at once the amounts of the correction in the bearing of meridional section lines to compensate for convergency within a township.

In the same table are given the differences of longitude for six miles in both angular and time measure, also the differences of latitude for one or six miles, in angular measure, in the various tabulated latitudes.

In the plan of subdivision of townships the meridional section lines are established parallel to the east boundary or other governing line. This necessitates a slight correction on account of the angular convergency of meridians. Meridional section lines west of the governing line are deflected to the left of the bearing of the governing line the amount shown in

<sup>2</sup>This factor is introduced here for the purpose of conversion from the unit expressed in miles to the unit expressed in chains.

the Standard Field Tables, which is entered under two arguments: (1) latitude, and (2) distance from the governing line. Meridional section lines east of a governing boundary are given the same amount of correction for bearing but the deflection is made to the right.

### Lengths of Arcs of the Earth's Surface

2-81. All computations involving a difference of latitude for a given measurement along a meridian or the converse calculation, or other computations involving a difference of longitude for a given measurement along a parallel or a similar converse calculation, are readily accomplished by use of the values given in the Standard Field Tables. The table gives the lengths in miles and decimal part of a mile of one degree of longitude measured on the parallel, and the lengths in miles of one degree of latitude measured on the meridian, for any latitude from  $25^{\circ}$  to  $70^{\circ}$  N.

The tabulated values may be reduced to miles and chains, or to chains or feet, as convenient. In taking out lengths of degrees of longitude measured on the parallel the value should be taken out for the mean position in latitude of that portion of the meridian whose length is to be computed.

### Geographic Positions

2-82. The term "geographic position" is used interchangeably with "geodetic position," and refers to a position on the spheroid representing the earth. The spheroid in general use in North America is Clarke's Spheroid of 1866. It is defined by the dimension of its equatorial axis and the ratio to this length of the amount it exceeds the polar axis. The spheroid closely approximates the shape the earth would have if the ocean surface were continuous. Any position is defined by its latitude and longitude measured from the intersection of a meridian through Greenwich and the equator. It will be seen that linear measurements made between geodetic positions must be reduced to sea level to check the theoretical distance. In the ordinary cadastral survey this refinement will generally not be necessary.

In the township plats of the rectangular system it is the practice to give the geographic position of the southeast corner as determined from the best available source. The surveyor should tie his work to horizontal control stations of the National Geodetic Survey and the United States Geological Survey whenever practicable.

Geodetic control has assumed increased importance to the cadastral surveyor with the use of protractors to define parcels of unsurveyed land.

Connections from land lines to geodetic control may be made by intersection from transit stations while the survey is in progress or by a transit traverse to the control station.

The Standard Field Tables include a tabulation of "M and P factors" for use in converting distances in chains to differences in latitude and longitude. "M" refers to distances along the meridian and "P" along the parallel. Distances in chains multiplied by the M or P factor for the appropriate latitude give the differences in latitude or longitude in seconds.

Differences in latitude are computed first. If the distance is large, the latitude of the unknown position is estimated, and the M factor is taken from the table for the mean latitude. In using the P factor, an interpolation to seconds of latitude is made for each segment of the line, as this factor changes rapidly.

### Plane Coordinates

2-83. The local surveyor is often concerned with feet, rather than chains. Townsite surveys, highway surveys, and surveys for other engineering projects are made in feet. It is convenient for purposes of a permanent record of positions on such work, and as a check on the closures obtained, to make use of the State coordinate systems.

The State coordinate systems are rectangular grids designed to fit the curved shape of the earth to a plane surface with as little distortion as possible. By choosing a limited area and a conformal projection, this is accomplished. The State systems are based on either the Transverse Mercator or the Lambert projection. Use of such a system depends on the availability of a sufficient number of geodetic control monu-

ments to permit the determination of the grid position of points in the survey by plane surveying.

The scale error varies from zero up to about one part in 10,000. The grid azimuth is a true azimuth only along the central meridian of the

zone. Any point can be reestablished once its coordinates have been determined.

The State coordinate systems are used in the definition of some mineral leasing blocks on the outer continental shelf. Other applications are in photogrammetric and electronic surveys.

## The System of Rectangular Surveys

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3-1. The extension of the rectangular system of public land surveys over the public domain in the United States has been in progress since 1785. Although few of the original surveys now being made cover extensive areas, all facets of the rectangular system occasionally come into use. For this reason, and to make clear the procedures which have been followed in surveying public lands, a complete discussion of the system is included in this manual. It will be seen that the underlying principle is to provide a simple and certain form of land identification and legal description of the public lands.

### GENERAL SCHEME

3-2. The law provides that (1) the public lands of the United States shall be divided by lines intersecting true north and south lines at right angles so as to form townships six miles square; (2) the townships shall be marked with progressive numbers from the beginning; (3) the townships shall be subdivided into 36 sections, each one mile square and containing 640 acres as nearly as may be; and (4) the sections shall be numbered, respectively, beginning with the number 1 in the northeast section, and proceeding west and east alternately through the township with progressive numbers to and including 36 (R.S. 2395; 43 U.S.C. 751).

3-3. In accordance with the foregoing legal requirements, the public lands are surveyed under the method called the system of rectangular surveys, which embraces the following procedure:

(1) The establishment of independent initial points, each to serve as an origin for surveys to be extended in separated localities.

(2) The survey of principal meridians and base lines, originating at the initial points.

(3) The establishment of guide meridians initiated at base lines, and of standard parallels initiated at principal meridians, at intervals short enough to maintain a workable adherence to the legal definition of the primary unit, the township six miles square.

(4) The survey of township exteriors within the framework so established. Townships are numbered to the north or south commencing with number 1 at the base line, and with range numbers to the east or west beginning with number 1 at the principal meridian.

(5) The subdivision of the townships into 36 sections by running parallel lines through the township from south to north and from east to west at distances of one mile. The sections are numbered commencing with number 1 in the northeast section of the township, proceeding thence west to section 6, thence south to section 7, thence east to section 12, and so on, alternately, to number 36 in the southeast section.

3-4. By law, (1) the corners marked in public land surveys shall be established as the proper corners of sections, or of the subdivisions of the sections, which they were intended to designate, and (2) the boundary lines actually run and marked shall be and remain the proper boundary lines of the sections or subdivisions for which they were intended, and the lengths of these lines as returned shall be held as the true length thereof (R.S. 2396; 43 U.S.C. 752). The original corners must stand as the true corners they were intended to represent, even though not exactly where professional care might have placed them in the first instance. Missing corners must be reestablished in the

identical positions they originally occupied. When the positions cannot be determined by existing monuments or other verifying evidence, resort must be had to the field notes of the original survey. The law provides that the lengths of the lines, as returned in the field notes, shall be held as the true lengths, and the distances between identified corner positions given in the field notes constitute proper data from which to determine the position of a lost corner; hence the rule that lost corners are restored at distances proportionate to the original measurements between identified positions. (chapter V, Restoration of Lost Corners.)

3-5. In the sections that follow, the first explanations are with respect to ideal procedure in the rectangular plan. The plan must be modified in various ways in order to begin new work where the initial and closing lines already established by prior survey do not qualify under the current specifications for rectangularity and

closure but cannot now be changed because of the passing of titles based on them. The purpose is to avoid the incorporation of the discrepancies of the older lines in the running of new original surveys.

### INITIAL POINTS

3-6. During the period since the organization of the system of rectangular surveys, numbered and locally named principal meridians and base lines have been established as listed in the accompanying table. These bases and meridians are shown on the large wall map of the United States published by the Bureau of Land Management, on a special map entitled "Principal Meridians and Base Lines Governing the United States Public Land Surveys" published by the Bureau, and on the various State maps and topographic maps published by the United States Geological Survey.

#### *Meridians and Base Lines of the United States Rectangular Surveys*

Meridian	Adopted	Governing surveys (wholly or in part) in States of	Initial Points					
			Latitude			Longitude		
			°	'	"	°	'	"
Black Hills .....	1878	South Dakota .....	43	59	44	104	03	16
Boise .....	1867	Idaho .....	43	22	21	116	23	35
Chickasaw .....	1833	Mississippi .....	35	01	58	89	14	47
Choctaw .....	1821	do .....	31	52	32	90	14	41
Cimarron .....	1881	Oklahoma .....	36	30	05	103	00	07
Copper River .....	1905	Alaska .....	61	49	04	145	18	37
Fairbanks <sup>1</sup> .....	1910	do .....	64	51	50.048	147	38	25.949
Fifth Principal .....	1815	Arkansas, Iowa, Minnesota, Missouri, North Dakota, and South Dakota .....	34	38	45	91	03	07
First Principal .....	1819	Ohio and Indiana .....	40	59	22	84	48	11
Fourth Principal .....	1815	Illinois .....	40	00	50	90	27	11
do .....	1831	Minnesota and Wisconsin .....	42	30	27	90	25	37
Gila and Salt River .....	1865	Arizona .....	33	22	38	112	18	19
Humboldt .....	1853	California .....	40	25	02	124	07	10
Huntsville .....	1807	Alabama and Mississippi .....	34	59	27	86	34	16
Indian .....	1870	Oklahoma .....	34	29	32	97	14	49
Kateel River <sup>2</sup> .....	1956	Alaska .....	65	26	16.374	158	45	31.014
Louisiana .....	1807	Louisiana .....	31	00	31	92	24	55
Michigan .....	1815	Michigan and Ohio .....	42	25	28	84	21	53
Mount Diablo .....	1851	California and Nevada .....	37	52	54	121	54	47
Navajo .....	1869	Arizona .....	35	44	56	108	31	59
New Mexico Principal .....	1855	Colorado and New Mexico .....	34	15	35	106	53	12
Principal .....	1867	Montana .....	45	47	13	111	39	33
Salt Lake .....	1855	Utah .....	40	46	11	111	53	27
San Bernardino .....	1852	California .....	34	07	13	116	55	48
Second Principal .....	1805	Illinois and Indiana .....	38	28	14	86	27	21
Seward .....	1911	Alaska .....	60	07	37	149	21	26
Sixth Principal .....	1855	Colorado, Kansas, Nebraska, South Dakota, and Wyoming .....	40	00	07	97	22	08

*Meridians and Base Lines of the United States Rectangular Surveys—Continued*

Meridian	Adopted	Governing Surveys (wholly or in part) in States of	Initial Points		
			Latitude	Longitude	
St. Helena	1819	Louisiana	30 59 56	91 09	36
St. Stephens	1805	Alabama and Mississippi	30 59 51.463	88 01	21.076
Tallahassee	1824	Florida and Alabama	30 26 03	84 16	38
Third Principal	1805	Illinois	38 28 27	89 08	54
Uintah	1875	Utah	40 25 59	109 56	06
Umiat <sup>3</sup>	1956	Alaska	69 23 29.654	152 00	04.551
Ute	1880	Colorado	39 06 23	108 31	59
Washington	1803	Mississippi	30 59 56	91 09	36
Willamette	1851	Oregon and Washington	45 31 11	122 44	34
Wind River	1875	Wyoming	43 00 41	108 48	49

<sup>1</sup> U.S.C. & G.S. station "Initial, 1941" is located S. 66° 44' E., 2.85 feet distant from the initial point of the Fairbanks Meridian. The geodetic station (latitude 64° 51' 50.037" N., longitude 147° 38' 25.883" W.) was inadvertently used as the origin from which to compute positions on the Fairbanks Meridian protraction diagrams.

<sup>2</sup> The Kateel River initial point is identical with U.S.C. & G.S. station "Jay, 1953";

<sup>3</sup> The Umiat initial point is identical with U.S.C. & G.S. station "Umiat, 1953", positions are as published by the United States Coast and Geodetic Survey.

3-7. The rectangular system was initiated in the State of Ohio in 1785 from a point on the west boundary of Pennsylvania, on the north shore of the Ohio River, in longitude 80° 32' 20". The State boundary served as the first reference meridian. A number of other reference meridians and bases were employed in Ohio to govern particular areas for purposes of

disposal. In its early stages the system was somewhat experimental, and Ohio may well be referred to as the proving ground for the present rectangular system of surveys. The rectangular surveys that have no initial point as an origin of township identification are listed in the following table.

*Public Land Surveys Having No Initial Point as an Origin for Both Township and Range Numbers*

Survey (and year commenced)	Townships numbered	Ranges numbered
Ohio River Survey ..... 1785 (Ohio)	North from Ohio River	West from west boundary of Pennsylvania
U.S. Military Survey ..... 1797 (Ohio)	North from south boundary of military grant.	West from west boundary of the Seven Ranges
West of the Great Miami (Ohio) ..... 1798	North from Great Miami River	East from Ohio-Indiana boundary
Ohio River Base ..... 1799 (Indiana)	North from Ohio River	From Ohio-Indiana boundary and its projection south
Scioto River Base ..... 1799 (Ohio)	North from Scioto River	West from west boundary of Pennsylvania
Muskingum River Survey (Ohio) ..... 1800	1 and 2	10
Between the Miamis, north of Symmes Purchase (Ohio) ..... 1802	East from Great Miami River	North from Ohio River (continuing numbers from Symmes Purchase)
Twelve-Mile-Square Reserve (Ohio) ..... 1805	1, 2, 3, and 4	None

**PRINCIPAL MERIDIAN**

3-8. A principal meridian is intended to conform to the true meridian, extending north or south, or in both directions, from the initial point as conditions require. Regular quarter-

section and section corners are established alternately at intervals of 40 chains, and regular township corners at intervals of 480 chains. Corners designated as meander corners are established at the intersection of the line with meanderable bodies of water.

3-9. In the survey of the principal meridian and other standard lines (base lines, standard parallels, and guide meridians), two independent sets of measurements are made, but only the mean of the two measurements is shown in the final field notes. Double measurement may be omitted if subdivisational closings are provided in the same assignment with the standard line, in which case the closings furnish a verification of the length.

Should the difference between the two sets of measurements of a standard line exceed 7 links per 80 chains, the line is remeasured to reduce the difference. Should independent tests of the alinement of a standard line indicate that the line has deflected more than 3 minutes from the true cardinal course, the line must be rerun. These are the maximum discrepancies allowable in new surveys.

**BASE LINE**

3-10. The base line is extended east and west from the initial point on a true parallel of latitude. Standard quarter-section and section corners are established alternately at intervals of 40 chains and standard township corners at intervals of 480 chains. Meander corners are established where the line intersects meanderable bodies of water.

3-11. The manner of making the measurement of the base line and the accuracy of alinement and measurement are the same as required in the survey of the principal meridian. The determination of the alinement of the true latitude curve may be made by the solar method, the tangent method, or the secant method as conditions require. The detailed process is described in the field notes.

**STANDARD PARALLELS**

3-12. Standard parallels, which are also called correction lines, are extended east and west from the principal meridian, at intervals of 24 miles north and south of the base line, in the manner prescribed for the survey of the base line.

3-13. Where standard parallels previously have been placed at intervals of 30 or 36 miles, and present conditions require additional standard lines, an intermediate correction line is established to which a local name may be given, such as "Fifth Auxiliary Standard Parallel North," or "Cedar Creek Correction Line," run, in all respects, like a regular standard parallel.

**GUIDE MERIDIANS**

3-14. Guide meridians are extended north from the base line, or standard parallels, at intervals of 24 miles east and west from the principal meridian, in the manner prescribed for running the principal meridian. The guide meridians are terminated at the points of their intersections with the standard parallels. The guide meridian is projected on the true meridian, and the fractional measurement is placed in the last half mile. At the true point of intersection of the guide meridian with the standard parallel a closing township corner is established. The parallel is retraced between the first standard corners east and west of the point for the closing corner, in order to determine the

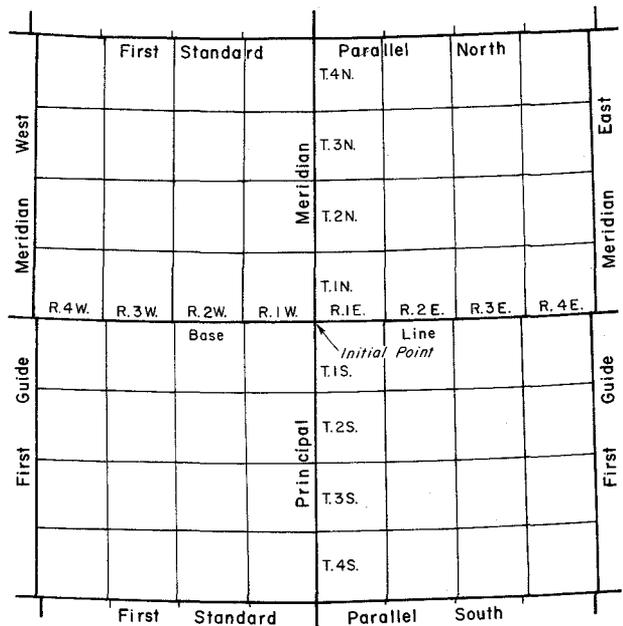


FIGURE 15.—Survey of quadrangles, each embracing 16 townships bounded by standard lines, showing the coordinate system of numbering townships.

exact alinement of the line closed upon. The distance is measured and recorded to the nearest corner on the standard parallel.

3-15. When existing conditions require that guide meridians be run south from the base or correction lines, they are initiated at the theoretical point for the closing corner of the guide meridian, calculated on the basis of the survey of the line from south to north initiated at the proper standard township corner. At the theoretical point of intersection a closing township corner is established.

3-16. Where guide meridians have been placed at intervals exceeding the distance of 24 miles, and new governing lines are required, a new guide meridian is established, and a local name is assigned, such as "Twelfth Auxiliary Guide Meridian West," or "Grass Valley Guide Meridian." Auxiliary guide meridians are surveyed in all respects like regular guide meridians.

### TOWNSHIP EXTERIORS

#### Regular Order

3-17. The south and east boundaries of a township are normally the governing lines of the subdivisional surveys. Defective conditions in previously established exteriors cannot be eliminated where subdivisional lines have been initiated from or closed upon an old boundary, but the errors of former surveys are not incorporated into the new. Where the previously established south and east boundaries cannot on that account be used to govern the subdivision of the adjoining township, other controlling lines known as the sectional correction line and the sectional guide meridian are employed as expedient.

#### Meridional Boundaries

3-18. Whenever practicable the township exteriors are surveyed successively through a quadrangle in ranges of townships, beginning with the townships on the south. The meridional township boundaries have precedence in the order of survey and are run from south to north on true meridians. Quarter-section and section corners are established alternately at

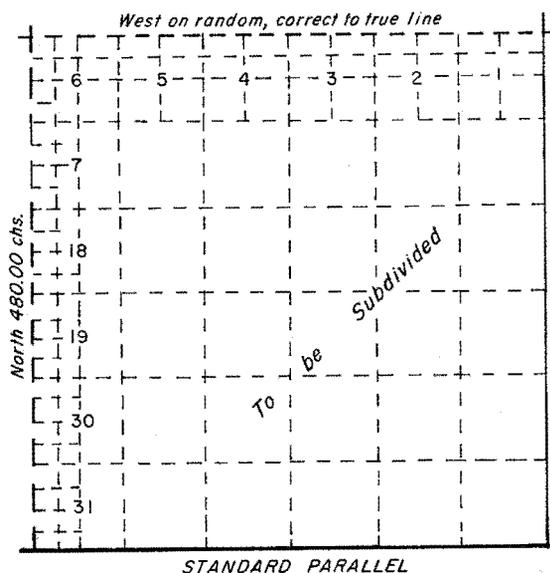


FIGURE 16.—Regular order of completing exteriors where south boundary (standard parallel) and east boundary previously surveyed.

intervals of 40 chains, and meander corners are established at intersections of the line with meanderable bodies of water. A temporary township corner is set at a distance of 480 chains, pending determination of its final position. The temporary point is then replaced by

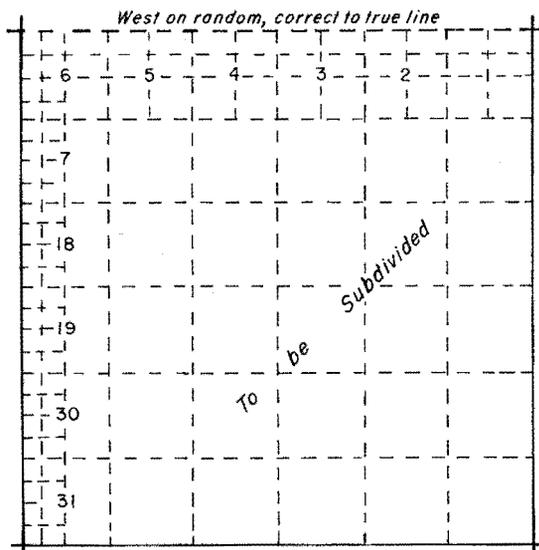


FIGURE 17.—Regular order of completing exteriors where south, east, and west boundaries previously surveyed.

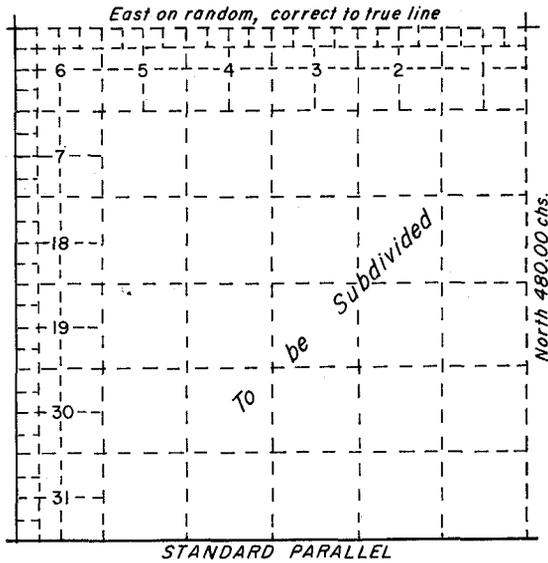


FIGURE 18.—Regular order of completing exteriors where south boundary (standard parallel) and west boundary previously surveyed.

a permanent corner in proper latitudinal position.

3-19. A meridional exterior is terminated at the point of intersection with a standard parallel. The excess or deficiency in measurement is placed in the north half mile. A closing corner is established at the point of intersection. The

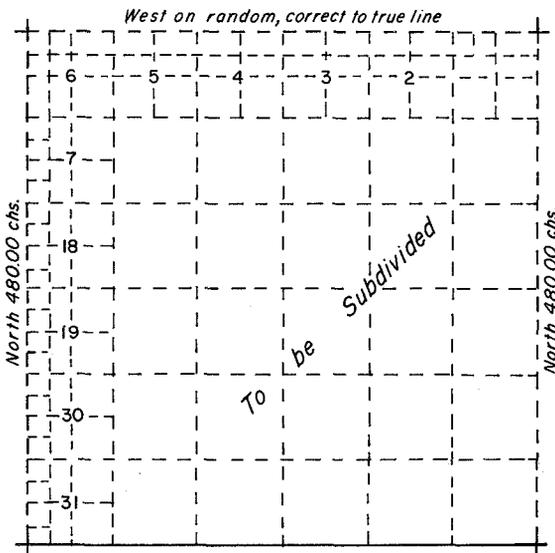


FIGURE 19.—Regular order of completing exteriors where south boundary previously surveyed.

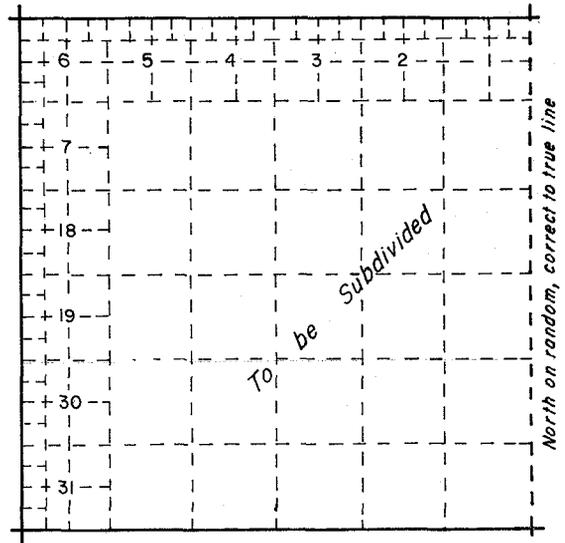


FIGURE 20.—Regular order of completing exteriors where north, south, and west boundaries previously surveyed.

parallel is retraced between the nearest standard corners to east and west to find the exact alinement, and the distance to the nearest corner is measured and recorded.

3-20. In order to complete the exteriors of a township it often remains to establish a meridional boundary between previously established

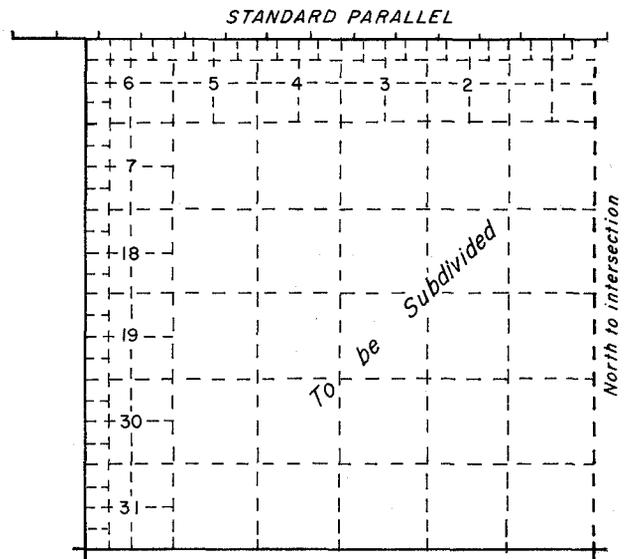


FIGURE 21.—Regular order of completing exteriors where north boundary (standard parallel), south boundary, and west boundary previously surveyed.

township corners. Such boundaries are run from south to north on random lines, with temporary corners set at intervals of 40 chains. If defective conditions are not met with, the random is corrected to a true line. By this procedure, the excess or deficiency of measurement is placed in the north half mile, and double sets of corners are avoided where unnecessary.

**Latitudinal Boundaries**

3-21. The latitudinal township boundary is run first as a random line, setting temporary corners, on a cardinal course from the old toward the new meridional boundary, and is corrected back on a true line if conditions are ideal. Where both meridional boundaries are new lines or where both have been established previously, the random latitudinal boundary is run from east to west. In either case, if defective conditions are not met with, the random is corrected back on a true line. Regular quarter-section corners and section corners are established at intervals of 40 chains, alternately, counting from the east, and meander corners are set where the true line intersects meanderable bodies of water. The fractional measurement is placed in the last half mile.

3-22. The bearing of the true line is calculated from the falling of the random. The falling is the distance, on the normal, by which a line falls to the right or left of an objective corner. The temporary points on any random line are replaced by permanent corners on the true line. The true line is blazed through timber, and distances to important items of topography are adjusted to correct true line measurement.

**Field Notes of Township Exteriors**

3-23. The field notes contain a complete record of the manner in which township exteriors have been run and established. The direction of the projection of the random latitudinal curve, the amount of falling, and the calculated return course or true line are recorded in the field tablets but not in the final notes. The final field notes will contain a prefacing statement that random lines are omitted. The details of

offsets, triangulations, and observations may be shown where a special purpose is served.

**Irregular Order and Partial Surveys**

3-24. It is often necessary to depart from the ideal procedure. The possible combinations are too numerous to state in detail, but where an irregular order appears necessary, the departure from the ideal order is specifically outlined in the special instructions. The departure is always based on the principle of accomplishing the same relation of one township boundary to another as would result from regular establishment under ideal conditions. Some examples are illustrated in figures 22 through 27.

3-25. Where it is impracticable to establish the boundaries in full, it may be necessary to run section lines as offsets to township exteriors. Such lines are run either on cardinal courses or parallel to the governing township boundaries, and even may be established when subdividing, as existing conditions require.

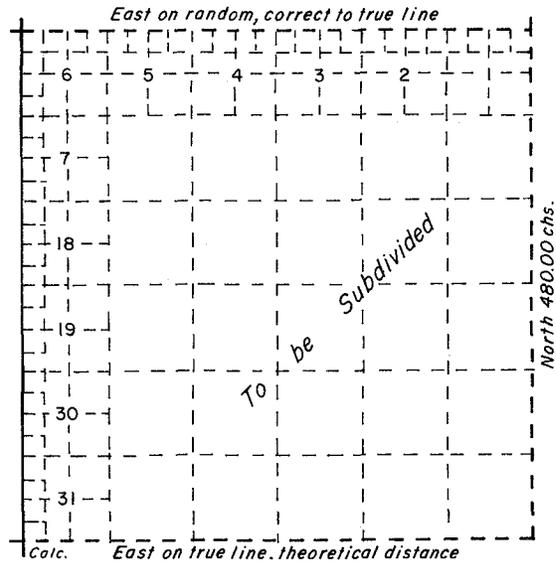


FIGURE 22.—Exception to regular order of completing exteriors; only west boundary previously surveyed.

**Allowable Deviation in Bearing**

3-26. It is 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

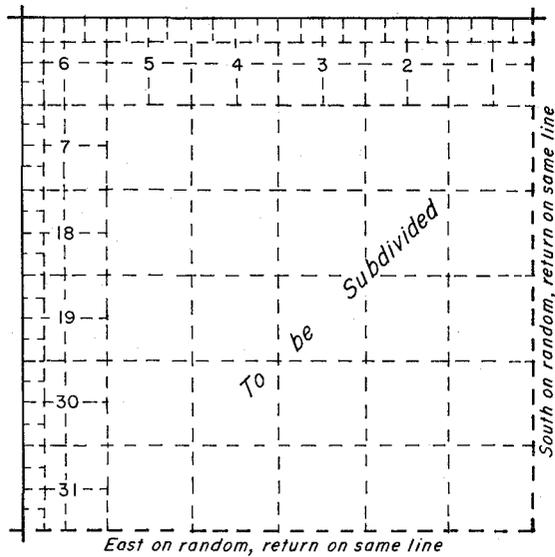


FIGURE 23.—Exception to regular order of completing exteriors; only north and west boundaries previously surveyed.

the true cardinal course. Therefore, the random line, run upon the cardinal course, is made the true line where the falling would otherwise require a correction exceeding 14' of arc. Where the random latitudinal boundary closes on a

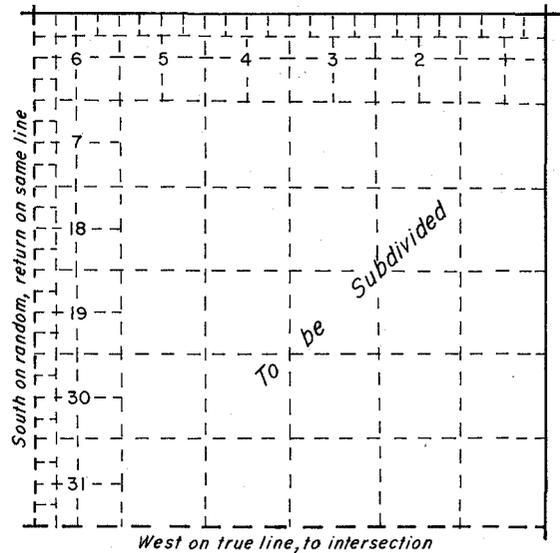


FIGURE 25.—Exception to regular order of completing exteriors; only north and east boundaries previously surveyed.

new meridional exterior, the temporary township corner is adjusted to the latitude of the opposite township corner. But where both meridional boundaries have been previously surveyed, a closing township corner is established

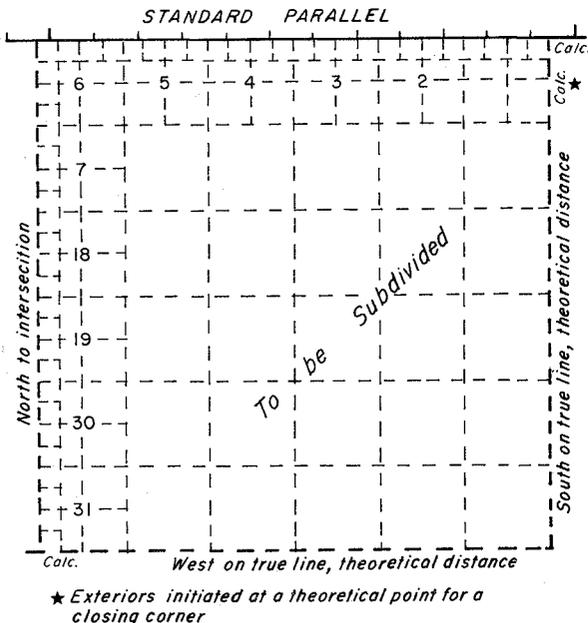


FIGURE 24.—Exception to regular order of completing exteriors; only north boundary (standard parallel) previously surveyed.

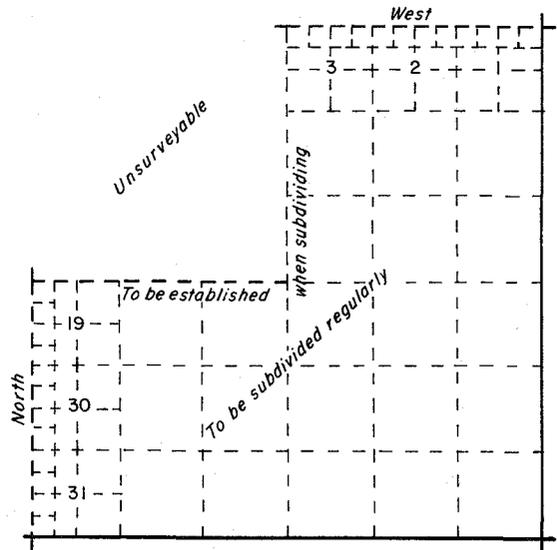


FIGURE 26.—Exception to regular order of completing exteriors; south and east boundaries previously surveyed, but part of township unsurveyable.

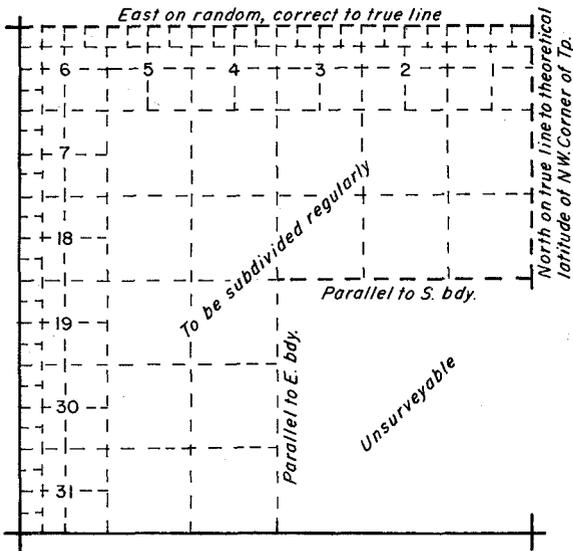


FIGURE 27.—Exception to regular order of completing exteriors; south and west boundaries previously established, but part of township unsurveyable.

at the point of intersection of the random latitudinal line with the meridional boundary, or its projection to the north or south as the case may be.

3-27. A random meridional boundary is made the true line if the falling plus the correction for parallelism of the meridional subdivisional lines would result in calculated bearings (in the northernmost miles of the latter lines) in excess of 14' from cardinal. The bearing of a governing east boundary must therefore fall within certain extremes suited to the latitude of the township.

Applying corrections for convergency within a township, taken from table 2, Standard Field Tables:

*Latitude 25° N.*

1st Mi. Mer. Subdv. ....	N. 0°14' E.	5th Mi. Mer. Subdv. ....	N. 0°14' W.
Corr. for Conv. ....	+00	Corr. for Conv. ....	-02
E. bdy. may be .....	<u>N. 0°14' E.</u>	E. bdy. may be .....	<u>N. 0°12' W.</u>

*Latitude 70° N.*

1st Mi. Mer. Subdv. ....	N. 0°14' E.	5th Mi. Mer. Subdv. ....	N. 0°14' W.
Corr. for Conv. ....	+02	Corr. for Conv. ....	-10
E. bdy. may be .....	<u>N. 0°16' E.</u>	E. bdy. may be .....	<u>N. 0°04' W.</u>

3-28. The 14' limit for exteriors applies only to the establishment of new boundaries. A previously established boundary, every part of which is within 21' of cardinal, is not considered defective in alinement. Even in the case of new exteriors, where the surveyor who establishes the line also subdivides the township of which it is the governing boundary, the margin of 14' may be exceeded to a limited extent if the existing conditions favor keeping within the 21' limit in the subdivisional survey. The purpose of the 14' limit is merely to facilitate the establishment of all subdivisional lines within the prescribed definite limit of 21' from cardinal.

**Completion of Partially Surveyed Exteriors**

3-29. Where the end portions of a township exterior have been previously surveyed and fixed in position by use, the fractional unsurveyed middle part is completed by random and true line without offset regardless of the deviation from cardinal direction. The fractional measurements are placed as a general rule in the north or west half miles, as the case may be, thereby permitting the subdivisional lines to be extended as usual from south to north or from east to west.

3-30. Where a fractional part of an exterior remains unsurveyed at either end of the line, a trial random line is projected in a cardinal direction from the previously established terminal corner toward the objective township corner. The random is corrected to a true line where the calculated bearing of any subdivisional line governed by the exterior comes within 14' from cardinal direction. If this condition cannot be met, or if no objective township

6	R.B.T.	5	R.B.T.	4	R.B.T.	3	R.B.T.	2	R.B.T.	1
7										12
18										13
19										24
30	N.0°12'E.	N.0°12'E.	N.0°12'E.	N.0°13'E.	N.0°14'E.					25
31	N.0°12'E.	N.0°12'E.	N.0°12'E.	N.0°13'E.	N.0°14'E.					25
31	N.0°12'E.	N.0°12'E.	N.0°12'E.	N.0°13'E.	N.0°14'E.					25
32	N.0°12'E.	N.0°12'E.	N.0°12'E.	N.0°13'E.	N.0°14'E.					25
33	N.0°12'E.	N.0°12'E.	N.0°12'E.	N.0°13'E.	N.0°14'E.					25
34	N.0°12'E.	N.0°12'E.	N.0°12'E.	N.0°13'E.	N.0°14'E.					25
35	N.0°12'E.	N.0°12'E.	N.0°12'E.	N.0°13'E.	N.0°14'E.					25
36	N.0°12'E.	N.0°12'E.	N.0°12'E.	N.0°13'E.	N.0°14'E.					25

6	R.B.T.	5	R.B.T.	4	R.B.T.	3	R.B.T.	2	R.B.T.	1
7										12
18										13
19										24
30	N.0°14'W.	N.0°14'W.	N.0°13'W.	N.0°13'W.	N.0°12'W.					25
31	N.0°14'W.	N.0°14'W.	N.0°13'W.	N.0°13'W.	N.0°12'W.					25
32	N.0°14'W.	N.0°14'W.	N.0°13'W.	N.0°13'W.	N.0°12'W.					25
33	N.0°14'W.	N.0°14'W.	N.0°13'W.	N.0°13'W.	N.0°12'W.					25
34	N.0°14'W.	N.0°14'W.	N.0°13'W.	N.0°13'W.	N.0°12'W.					25
35	N.0°14'W.	N.0°14'W.	N.0°13'W.	N.0°13'W.	N.0°12'W.					25
36	N.0°14'W.	N.0°14'W.	N.0°13'W.	N.0°13'W.	N.0°12'W.					25

Latitude 25°N.

6	R.B.T.	5	R.B.T.	4	R.B.T.	3	R.B.T.	2	R.B.T.	1
7										12
18										13
19										24
30	N.0°06'E.	N.0°08'E.	N.0°10'E.	N.0°12'E.	N.0°14'E.					25
31	N.0°06'E.	N.0°08'E.	N.0°10'E.	N.0°12'E.	N.0°14'E.					25
32	N.0°06'E.	N.0°08'E.	N.0°10'E.	N.0°12'E.	N.0°14'E.					25
33	N.0°06'E.	N.0°08'E.	N.0°10'E.	N.0°12'E.	N.0°14'E.					25
34	N.0°06'E.	N.0°08'E.	N.0°10'E.	N.0°12'E.	N.0°14'E.					25
35	N.0°06'E.	N.0°08'E.	N.0°10'E.	N.0°12'E.	N.0°14'E.					25
36	N.0°06'E.	N.0°08'E.	N.0°10'E.	N.0°12'E.	N.0°14'E.					25

6	R.B.T.	5	R.B.T.	4	R.B.T.	3	R.B.T.	2	R.B.T.	1
7										12
18										13
19										24
30	N.0°14'W.	N.0°12'W.	N.0°10'W.	N.0°08'W.	N.0°06'W.					25
31	N.0°14'W.	N.0°12'W.	N.0°10'W.	N.0°08'W.	N.0°06'W.					25
32	N.0°14'W.	N.0°12'W.	N.0°10'W.	N.0°08'W.	N.0°06'W.					25
33	N.0°14'W.	N.0°12'W.	N.0°10'W.	N.0°08'W.	N.0°06'W.					25
34	N.0°14'W.	N.0°12'W.	N.0°10'W.	N.0°08'W.	N.0°06'W.					25
35	N.0°14'W.	N.0°12'W.	N.0°10'W.	N.0°08'W.	N.0°06'W.					25
36	N.0°14'W.	N.0°12'W.	N.0°10'W.	N.0°08'W.	N.0°06'W.					25

Latitude 70°N.

FIGURE 28.—Illustrating the adjustment in the direction of the meridional lines of a subdivisational survey on account of convergency of meridians, also the 14' limit of the rectangular "safety zone."

corner has been previously established, the partially surveyed exterior is completed on a cardinal course. In either case the fractional measurement is generally placed in the north or west half mile.

**Retracements and Resurveys Before Subdividing**

3-31. If there is reason to question the accuracy of previously surveyed township exteriors or the condition of the corner monuments,

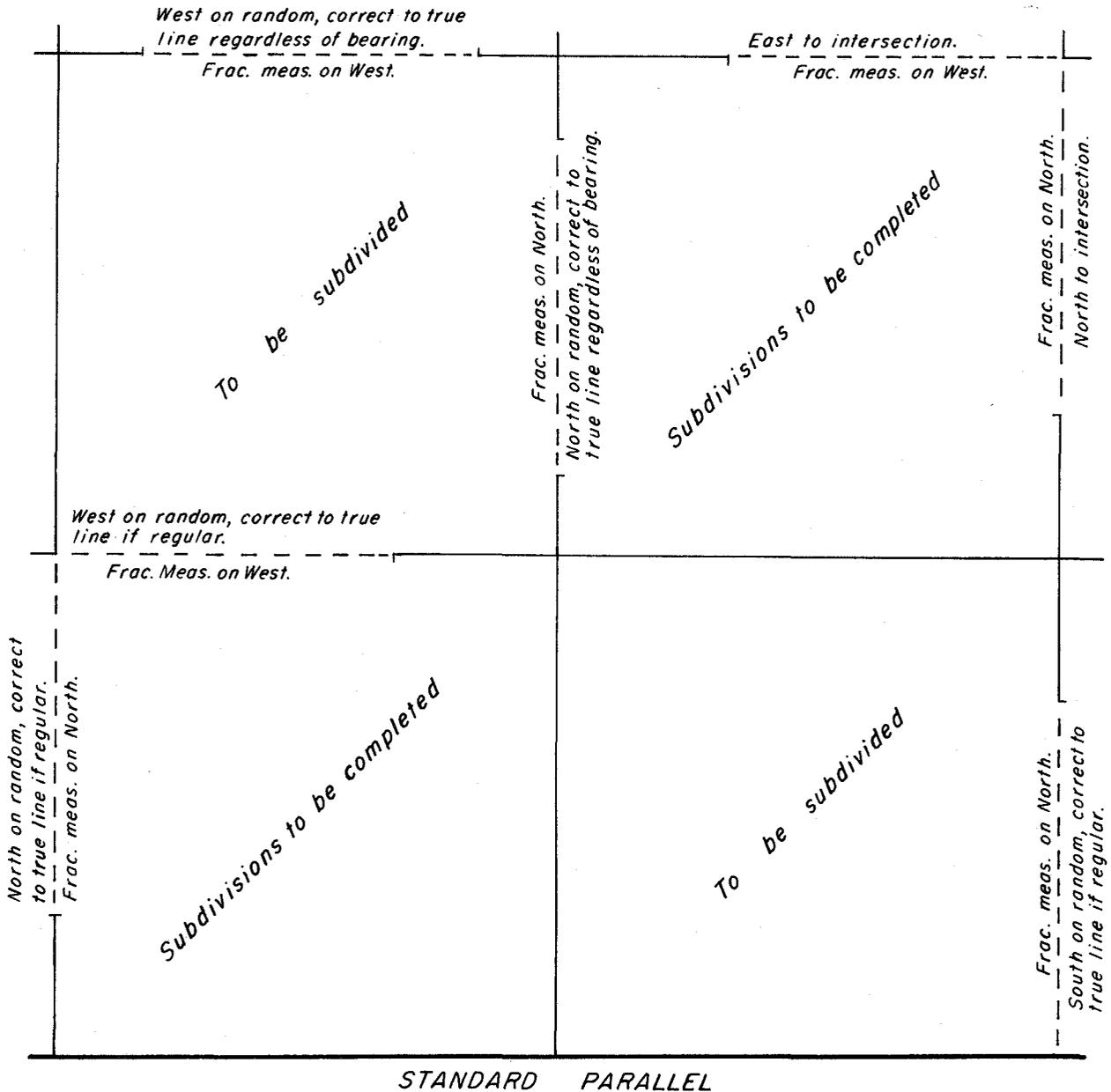


FIGURE 29.—Representative cases of incomplete township exteriors showing methods for completion.

the special instructions should call for the surveyor to reestablish missing corners, remonument dilapidated corner monuments, determine the direction and length of all lines, furnish data needed for the computation of areas of fractional lots, and recommend any improvements indicated for the plan of subdivision.

3-32. All resurvey data are embodied in the

field notes and shown upon the plat of the survey unless the retracement results are in substantial agreement with the record of the original surveys. In the latter case, a statement to the effect is made in the field notes, and the original record governs the data placed on the plat.

### Rectangular Limits

3-33. Before discussing the subdivision of townships it is necessary to consider the requirements of law relative to rectangular surveys, wherein the square mile, or section, is the unit of subdivision. The normal township includes 36 sections, only 25 of which are returned as containing 640 acres each. Sections against the north and west boundaries, except section 6, contain regular aliquot parts totaling 480 acres with four additional fractional lots in each section. Section 6 contains regular aliquot parts totaling 360 acres with seven additional fractional lots.

3-34. It has been necessary to establish a definite relationship between rectangularity as contemplated by law and the unit of subdivision resulting from a survey on the earth's surface. The ideal section is allowed to give way to one that is termed "regular." The amounts by which a section, or its aliquot parts, may vary from the ideal section and still be considered regular are referred to as the *rectangular limits*:

(1) For *alinement*, the section's boundaries must not exceed 21' from cardinal in any part, nor may the opposite (regular) boundaries of a section vary more than 21'.

(2) For *measurement*, the distance between regular corners is to be normal according to the plan of survey, with certain allowable adjustments not to exceed 25 links in 40 chains.

Township exteriors, or portions of exteriors, are considered defective when they do not qualify within the above limits. It is also necessary, in order to subdivide a township regularly, to set a third limit, as follows:

(3) For *position*, the corresponding section corners upon the opposite boundaries of the township are to be so located that they may be connected by true lines which will not deviate more than 21' from cardinal.

The rectangular limits should not be confused with the allowable error of closure discussed under sections 3-46 and 3-124.

3-35. A previously established exterior is not defective if the above limits are satisfied. If the rectangular limits have already been exceeded, or the danger point is likely to be reached at an early stage in the subdivisional

survey, the necessary corrective steps are taken before subdividing.

### Defective Exteriors

3-36. Township boundaries already established may be defective in alinement, measurement, or position. A defective boundary not previously closed upon and from which subdivisional lines have not been initiated is obliterated after being superseded by survey of a new boundary and connection of the old with the new monuments. If it is known that a mineral survey, homestead entry survey, small holding claim, right of way, reservoir, or other survey has been connected with a corner of an exterior subject to rectification, the fact is stated in the special instruction. In such a case the marks "A M" (signifying "amended monument") are added to the original corner monument, and the old corner is connected by course and distance to the new. A record of the connection is placed in the field notes together with a full description of the monument and its accessories. Where a special purpose is served, the position of the old monument is shown on the plat of the survey.

3-37. If a boundary is defective in measurement or position and is not subject to rectification, the location of the original corners cannot be changed, but the marks on the monuments and the marks upon (or position of) the accessories are appropriately altered to stand only for the sections of the previously established surveys. New corners to control the surveys of the adjoining township are established on the old line at regular distances of 40 and 80 chains. Where new corners are placed on an oblique exterior, whose bearing departs more than 1° from cardinal, they are so located for measurement that the *cardinal* equivalents are 40 and 80 chains.

3-38. Where subdivisional lines have been initiated from or closed upon one side of only a portion of a township boundary, the remaining portion may be superseded if it is found to be defective.

3-39. The position of the new exteriors, or of corners set on defective township boundaries in the new survey, must be established by an actual rerunning of the lines. Data acquired in

surveying subdivisional lines closing upon a defective exterior is not acceptable in lieu of re-tracement or resurvey.

3-40. The south boundary of a township is regularly the governing latitudinal boundary unless defective in alinement. If the boundary is defective in measurement, and not subject to rectification, the original corners are changed to refer only to the sections of the township to the south. New corners of two sections and quarter-section corners of sections of the township to the north are established at regular intervals of 40 chains, counting from the east, and the excess or deficiency in measurement is placed in the west half mile. If the south boundary is defective in alinement, a sectional correction line is required.

3-41. The east boundary of a township is regularly the governing meridional boundary unless defective in alinement. If the boundary is defective in measurement, and not subject to rectification, the original corners are changed to refer only to the sections of the township to the east. New corners of two sections and quarter-section corners of the sections of the township to the west are established at regular intervals of 40 chains, counting from the south. If the east boundary is defective in alinement, a sectional guide meridian is required.

3-42. New east and south boundaries of a township become the closing meridional and latitudinal boundaries of the townships to the east and south respectively. Where doubt exists as to how unsurveyed lines may close, the corners are established only for the sections of the townships of which the new lines are the governing boundaries. The corners of the sections upon the opposite side are established as closing corners at the time of subdivision of the adjoining townships if the original corners are found to be defective in position. If regular connections can be made at that time, the marks on the original monuments are altered to signify corners of maximum control.

3-43. Where the previously established north or west boundaries are defective in measurement or position and subdivisional surveys have been initiated from them, the original corners are changed to refer only to sections to the north or west, respectively. Closing section

corners are established when subdividing. New quarter-section corners are placed on the old line at the mean distances between closing section corners, or at 40 chains from one direction, depending upon the plan of subdivision of the section. Where the previously established north or west boundaries are defective in alinement, but not in measurement or position, no changes are required. The section lines of the township which is being subdivided are connected regularly to the the original corners. Fractional measurements are placed in the north and west half miles.

3-44. Figures 30 through 37 illustrate the guiding principles involved in establishing new governing boundaries where the previously surveyed exteriors are defective. Each diagram illustrates a simple condition affecting one boundary only, and the examples are taken only from the regular order of procedure. Figure 38 shows a series of conditions which might occur in the field. Combinations of defective conditions are best analyzed by breaking them down into the several simple defective conditions. The same holds true in the establishment of township exteriors under an irregular order of procedure. Where extraordinary conditions are encountered which cannot be solved in this manner, the surveyor should report the facts to the proper administrative office, which will issue appropriate instructions.

3-45. The rules for completion and rectification of township exteriors are intended to secure the most direct return to normal procedure. The preliminary retracements and resurveys may show that some modification will obtain better results. Approval of the modified plan should be obtained from the proper administrative office. Each case should be treated on its own merits.

#### **Tables of Latitude and Departure and Closing Errors**

3-46. Upon the completion of the survey of one or more township exteriors closing the figure of either a full or fractional township, a table of latitudes and departures will be prepared with allowance for convergency of meridians. The maximum tolerable error of closure is  $1/1280$  of the perimeter in either latitude or

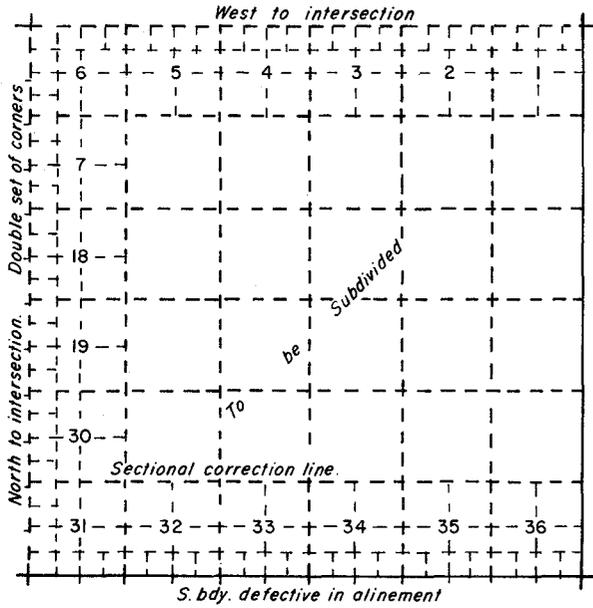


FIGURE 30.—Rectification of fixed south boundary defective in alinement.

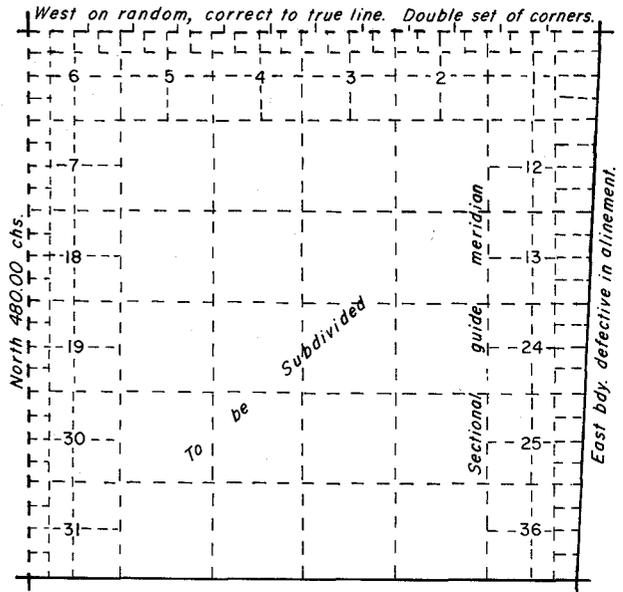


FIGURE 32.—Rectification of fixed east boundary defective in alinement.

departure. If the limit is exceeded, additional retracements or other corrective steps may be necessary to perfect the survey. The table of latitudes and departures and closing errors, including every part of any closed figure embrac-

ing township exteriors, should be returned with the field tablets and computation sheets.

### SUBDIVISION OF TOWNSHIPS

#### Regular Boundaries

3-47. The boundaries of a township are within satisfactory governing limits for control of the subdivisional survey when the lines may be theoretically projected from the boundaries without closely approaching the rectangular limits. The danger zone has already been placed at theoretical bearings exceeding 14' from cardinal, and the corresponding zone in respect to lengths of lines may be placed at theoretical adjustments exceeding 33 links per mile.

#### Meridional Section Lines

3-48. These lines have precedence in the order of survey. They are initiated at the section corners on the south boundary of the township and are run north parallel to the governing east boundary. Meridional lines are numbered counting from the east and are surveyed successively in the same order. If the east boundary is within limits, but has been found by

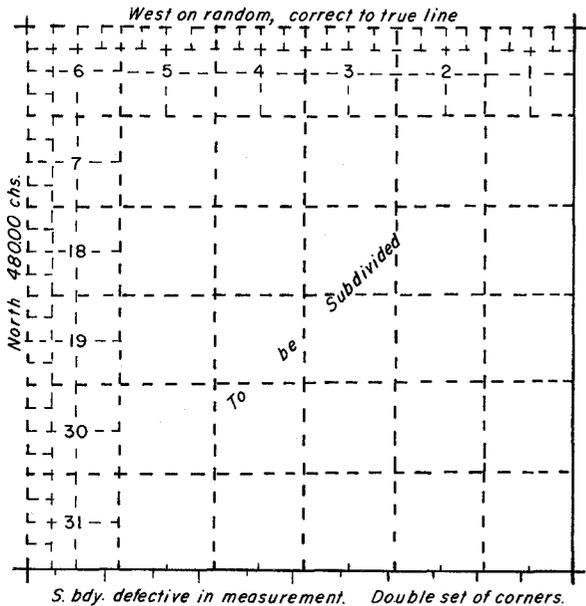


FIGURE 31.—Rectification of fixed south boundary defective in measurement.

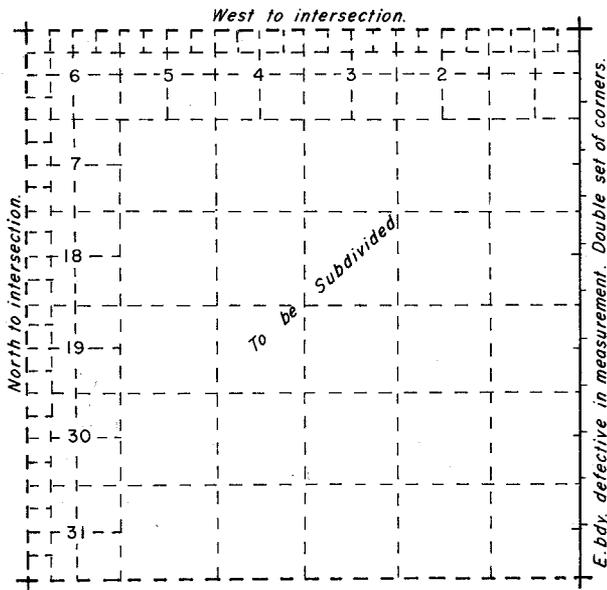


FIGURE 33.—Rectification of fixed east boundary defective in measurement.

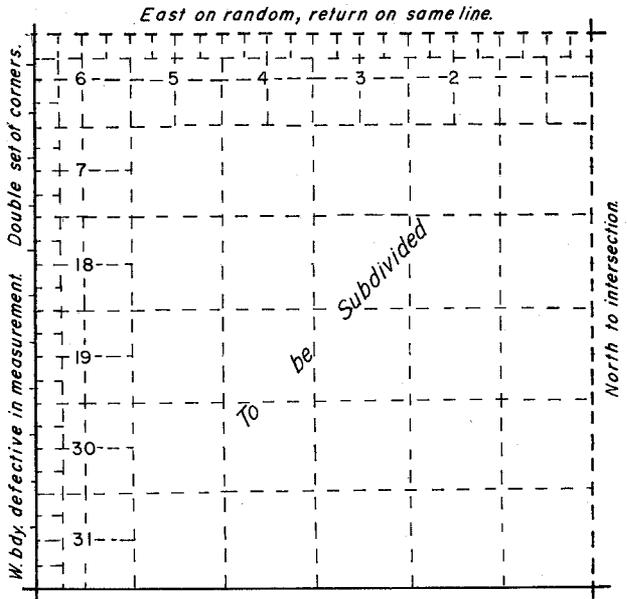


FIGURE 35.—Rectification of west boundary defective in measurement where both south and west boundaries fixed in position.

retracement to be imperfect in alinement, the meridional section lines are run parallel to the mean course. Regular quarter-section and section corners are established alternately at inter-

vals of 40 and 80 chains as far as the northernmost interior section corner.

3-49. A meridional section line is not continued north beyond a section corner until after

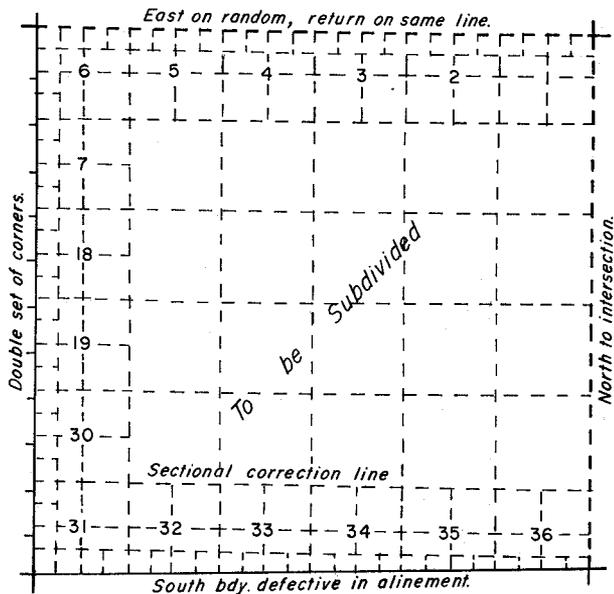


FIGURE 34.—Rectification of south boundary defective in alinement where both south and west boundaries fixed in position.

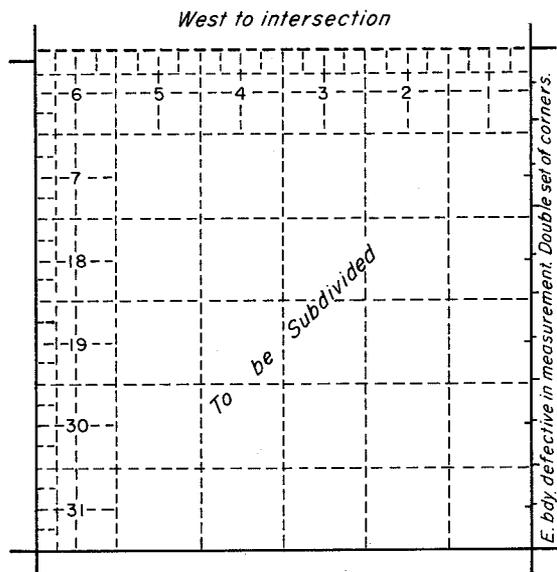


FIGURE 36.—Rectification of east boundary defective in measurement where east and south boundaries fixed in position.

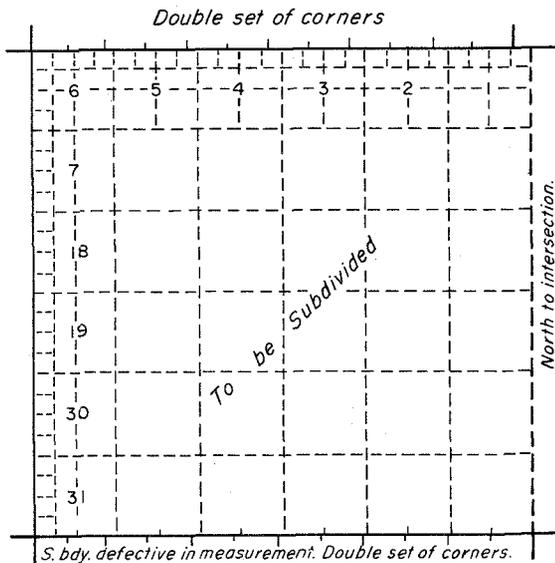


FIGURE 37.—Rectification of south boundary defective in measurement where south, north, and west boundaries fixed in position.

the connecting latitudinal sectional line has been surveyed. In the case of the fifth meridional section line, both latitudinal section lines connecting east and west are surveyed before continuing with the meridional line beyond a section corner. The successive meridional lines are surveyed as convenient, but none should be carried beyond uncompleted sections to the east.

3-50. The last mile of a meridional line is continued as a random line, without blazing through timber, each successive random line being parallel to the true east boundary of the section to which it belongs. A temporary quarter-section corner is set at 40 chains, the distance is measured to the point of intersection of the random line with the north boundary of the township, and the falling of the random line east or west of the objective section corner is noted. The random is then corrected to a true line by blazing through timber and permanently establishing the quarter-section corner on the true line at a distance 40 chains from the south, placing the fractional measurement in the north half mile.

3-51. Where the north boundary of the township is a base line or standard parallel, the last miles of the meridional section lines are

continued as true lines parallel to the east boundary of the township. Permanent quarter-section corners are established at 40 chains from the south, and closing corners are established at the points of intersection with the north boundary. The distance is measured to the nearest standard corner in each case. New quarter-section corners for the sections of the township being subdivided are established at mean distances between closing corners, or at 40 chains from one direction, depending on the plan of the subdivision of the section.

### Latitudinal Section Lines

3-52. The latitudinal section lines, except in the west range of sections, are normally run on random lines from west to east, parallel to the south boundaries of the respective sections. Temporary quarter-section corners are set at 40 chains. The distances are measured to the points of intersection of the random lines with the north and south lines passing through the objective section corners; bearings of true lines are calculated on the basis of the fallings. Each random line is corrected to a true line by blazing and marking between the section corners, including the permanent establishment of quarter-section corners at the midpoints on the true lines.

In the west range of sections the random latitudinal section lines are run from east to west, parallel to the south boundaries of the respective sections. On the true lines the permanent quarter-section corners are established at 40 chains from the east, placing the fractional measurements in the west half miles.

### Survey Record

3-53. The field notes describing the survey of subdivisional lines are compiled in ranges of sections beginning with the easternmost, and the west two ranges are compiled by alternating with the adjoining east and west sections (figure 39). The field notes contain a complete record of the manner in which the subdivisional lines are run and established. The direction of projection of random lines, the amount of the falling left or right of the objective corner, and the calculated return course or true line are recorded in the field tablets but not in the final

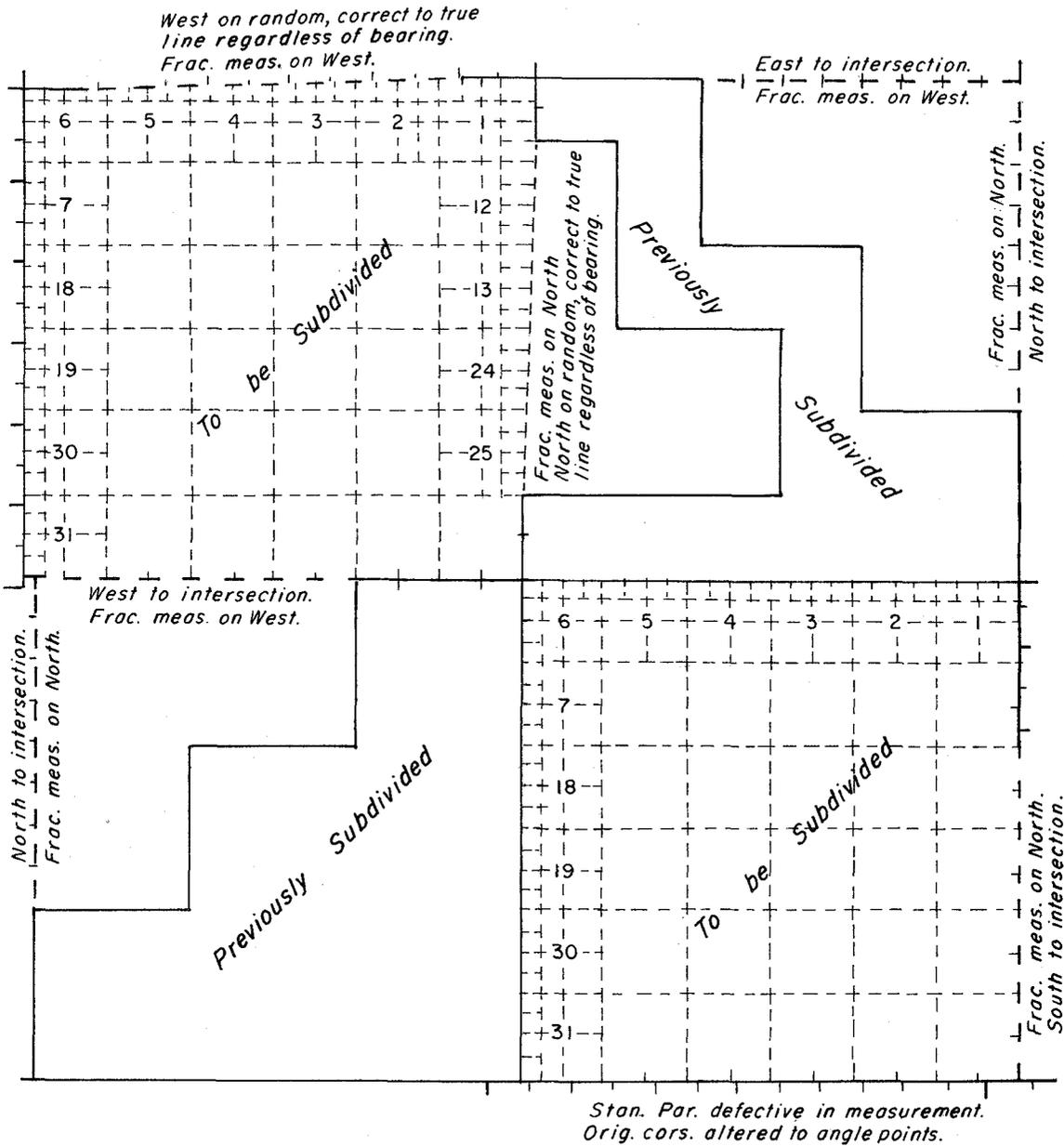


FIGURE 38.—Various defective boundaries, showing methods for completing exteriors.

notes. A prefacing statement in the final field notes will explain that random line field notes are omitted. The details of offsets, triangulations, and observations may be shown where a special purpose is served.

**Accumulated Error**

3-54. Error in the alinement of the meridional section lines is taken up in part in the

measurement of the latitudinal lines, which must be within 50 links of 80 chains in length, except in the west range of sections where the convergency of the meridional lines is provided for. The accumulated error in alinement for the five miles of true meridional line is taken up in the sixth mile, which is run random and true. Here the true line must be within 21' of cardinal. The slight, ordinary errors in the measure-

6	60	5	44	4	33	3	22	2	11	1
59		58		43		32		21		10
7	57	8	42	9	31	10	20	11	9	12
56		55		41		30		19		8
18	54	17	40	16	29	15	18	14	7	13
53		52		39		28		17		6
19	51	20	38	21	27	22	16	23	5	24
50		49		37		26		15		4
30	48	29	36	28	25	27	14	26	3	25
47		46		35		24		13		2
31	45	32	34	33	23	34	12	35	1	36

FIGURE 39.—Sequence of numbers on section lines shows normal order of subdivision.

ment of the meridional lines are taken up by the adjustment of the bearings of the latitudinal section lines, which must be within 21' of cardinal. The accumulated error in measurement in running north is placed in the last fractional half mile. Here the meridional distance is checked by a calculated closing around the last section, and the latitudinal error must not exceed 25 links in order to come within the limits of closure. The limit of rectangularity will be exceeded if the accumulated error is greater than  $3\frac{1}{2}'$  in alinement or  $8\frac{1}{3}$  links per mile in measurement. Cumulative error must be guarded against and avoided, and the prescribed order of survey furnishes continuous checks upon the accuracy of all lines.

### Modifications

3-55. Where the objective section corner is in sight, a random subdivisional line may be run for distance only and the bearing recorded, but the usual rules for running random lines and true lines are observed in every other respect. The random latitudinal section lines, except in the west range of sections, are normally run from west to east, thus always closing upon a previously established section cor-

ner. Under the exigencies of field work, in order to economize the time of his party, the surveyor may project the random from east to west to a temporary section corner set at 80 chains, but the true point for the section corner is determined as usual at the 80-chain point on the meridional section line. The connection of the random latitudinal line and the permanent marking of the true line are completed as regularly provided.

### Irregular Boundaries

3-56. Where either of the governing boundaries of a township is disqualified as a controlling line upon which to initiate a subdivisional survey, the necessary retracements and resurveys or alterations are made before subdividing as previously explained under the subject of township exteriors. Every possible provision for a correct subdivisional survey is thereby assured except as either the south or the east boundary is defective in alinement and not subject to rectification.

3-57. The specific plan described below may be modified where conditions justify a change. The basic requirements are (1) adherence to the normal rectangular plan where practicable, (2) a normal location and an area of 640 acres each for granted lands that are identified by the survey (the school sections), (3) the maximum number of regular sections of 640 acres each, or aliquot parts of sections, (4) avoidance of two sets of corners when one set is ample for subdivisional requirements, and (5) simplicity of survey, most readily understood by the public.

### Sectional Guide Meridian

3-58. If the east boundary of the township is defective in alinement, and cannot be rectified, the corners on the north boundary will not be properly related to those on the south boundary, even though the measurement of the north boundary is not defective. The north boundary is then said to be defective in position (figure 40). The first meridional line is projected as a sectional guide meridian due north to an intersection with the north boundary, where a closing section corner is established and the

distance measured to the nearest regular corner. The intermediate quarter-section and section corners are established alternately at regular intervals of 40 chains, counting from the south unless the south boundary of the township is itself defective in alinement.

3-59. Where, as shown in figure 41, the north boundary is not defective in position (nor within the danger zone) with reference to the corners on the south boundary (errors in the alinement of the east boundary being compensable), the first meridional section line is projected 5 miles as a true line on a bearing calculated to intersect the objective section corner on the north boundary. The last mile is run as a random line on the same course, and corrected to a true line after the falling has been measured. The remaining meridional section lines are run parallel to the one first established, in the usual manner, to closing section corners on the last mile or random and true as the case may be.

3-60. The fractional measurements of the latitudinal section lines in the first range of sections are placed in the east half mile. Elsewhere, unless the south boundary is defective in alinement, the latitudinal section lines are run in the usual manner.

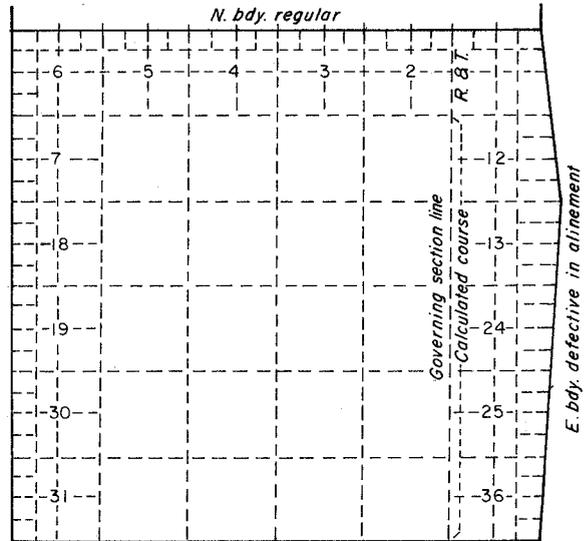


FIGURE 41.—Projection of first meridional section line as governing section line where defective east boundary does not leave north boundary defective in position.

**Sectional Correction Line**

3-61. If the south boundary of the township is defective in alinement, and cannot be rectified, so that the west boundary is defective in position, a sectional correction line is established (figure 42). This line is surveyed on a true latitudinal curve initiated at the first regular section corner on the east boundary and projected to an intersection with the west boundary of the township, where a closing corner is established and the distance measured to the nearest regular corner. The intermediate quarter-section and section corners are marked as temporary points at regular intervals of 40 chains, alternately, counting from the east.

3-62. Where, as shown in figure 43, the west boundary is not defective in position (nor within the danger zone) with reference to the section corners on the east boundary (errors in alinement of the south boundary being compensable), the first latitudinal section line is projected 5 miles on a bearing calculated to intersect the objective section corner on the west boundary. Temporary quarter-section corners and section corners are marked at regular intervals of 40 chains alternately, counting from the east.

3-63. The section corners on the sectional

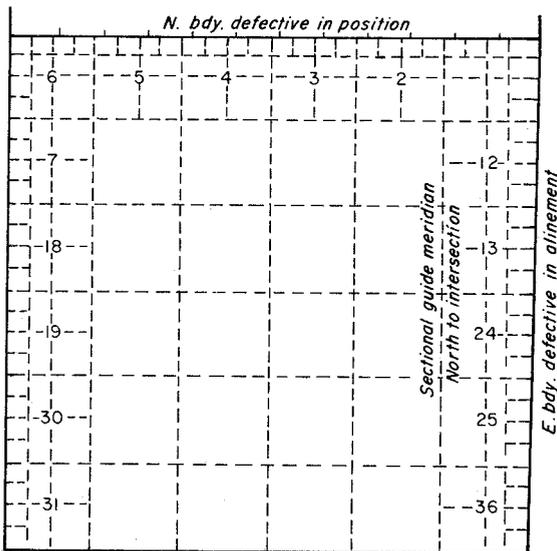


FIGURE 40.—Projection of first meridional section line as guide meridian where defective alinement of east boundary leaves north boundary defective in position.

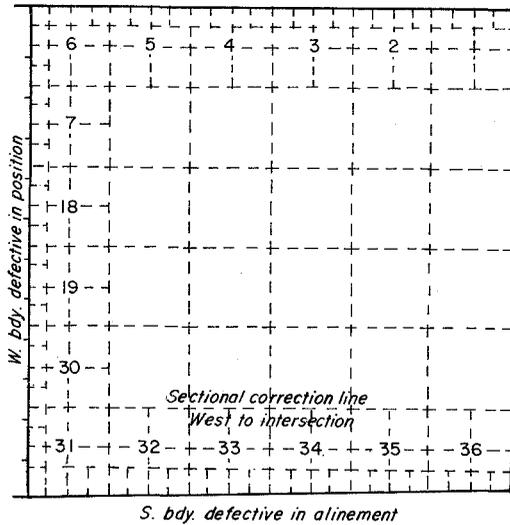


FIGURE 42.—Projection of first latitudinal section line as sectional correction line where defective alinement of south boundary leaves west boundary defective in position.

correction line are established at the points of intersection of the meridional section lines alined in the normal manner. Thereafter, the quarter-section corners on the sectional correction lines are established at the usual midpoints except in the east and west ranges of sections. The quarter-section corner between

sections 25 and 36 is established at 40 chains from the west if the east boundary is defective in alinement. Otherwise it is fixed at the usual midpoint position. The quarter-section corner between sections 30 and 31 is placed at 40 chains from the east. If the sectional correction line has not been terminated at a closing section corner on the west boundary, the line between sections 30 and 31 is run random and true in the normal manner. The quarter-section corners on the meridional section lines in the south tier of sections are established at 40 chains south from the corners on the sectional correction line. The remaining subdivisional lines are continued from the sectional correction line in the usual manner.

**Partial Irregularity**

3-64. Where the south part of the east boundary, or the east part of the south boundary, is regular, and the balance is defective in alinement and not subject to rectification, the subdivisional survey is made regular as far as possible. The initial point for the sectional guide meridian, or for the sectional correction line, is determined by existing conditions. The first meridional section line is continued as a sectional guide meridian if the north part of the east boundary is defective in alinement and the

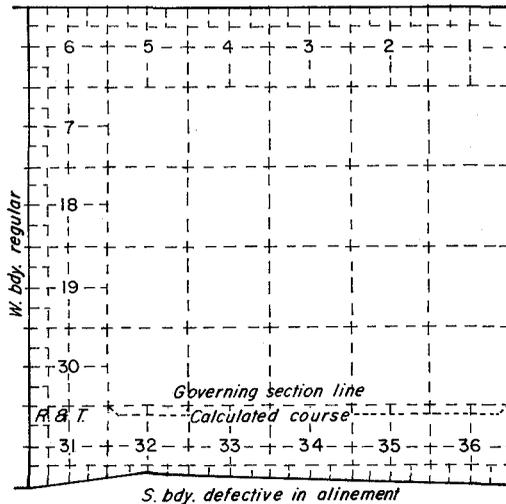


FIGURE 43.—Projection of first latitudinal section line as governing section line where defective south boundary does not leave west boundary defective in position.

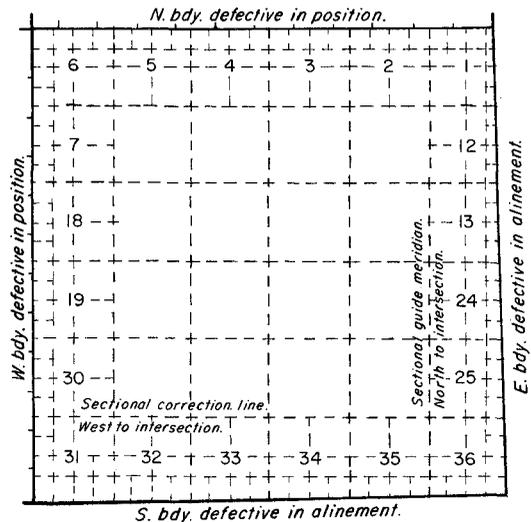


FIGURE 44.—Projection of both sectional guide meridian and sectional correction line where combination of defective conditions exists.

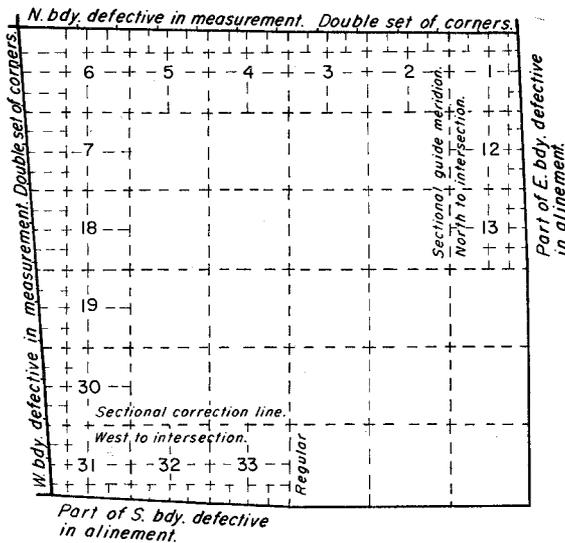


FIGURE 45.—Projection of both sectional guide meridian and sectional correction line in case of partial irregularity.

north boundary is therefore defective in position.

3-65. If the north boundary is not defective in position (nor within the danger zone), the first meridional section line is continued on a course calculated to intersect the objective section corner on the north boundary of the township. The same principle is observed if the west part of the south boundary is defective in alignment, and the west boundary is not defective in position (nor within the danger zone). If the west boundary is defective in position, the sectional correction line is established on the true latitudinal curve.

### Summary

3-66. The object of the plan is to secure the maximum number of normal sections. The sections adjoining the east boundary are regular if they conform with the usual rectangular limits. Where that is the case, the quarter-section corners on the latitudinal section lines are placed at the normal midpoint position. The sections adjoining the south boundary of the township are not regular unless the meridional lines are established at 80 chains in length, and the sections are otherwise in conformity with the usual rectangular limits. Exceptions will

be noted under the subject of "fractional subdivision".

### Survey Record

3-67. The field notes of subdivisational surveys including a sectional guide meridian, a sectional correction line, or other governing section line, are compiled in the same regular order previously described, but appropriate explanatory remarks are added to show the method and order of procedure.

### Closing Section Lines

3-68. Several types of closing lines have been discussed earlier. Guide meridians are closed against standard parallels as a device to avoid the extreme effect of convergency on the breadth of sections (section 3-14). Township and section lines are closed on standard parallels as a part of the same plan (sections 3-19 and 3-51). Both township and section lines may be made closing lines to maintain rectangularity (sections 3-26 and 3-34). A different type of closing line occurs where the lines of the rectangular system of survey cross or close on the boundaries of reservations or grants, State boundaries, or the lines of various kinds of claims.

3-69. Closing corners are normally established at intersections with a surveyed reservation, grant, or State boundary. The bearing and the distance to the nearest corner or angle point of the irregular boundary should always be noted. It is usually necessary to retrace the boundary to the nearest corner in each direction to insure placement of the closing corner at the exact intersection.

3-70. Quarter-section corners are established between closing corners for sections closing on a reservation or grant boundary. Since the Bureau of Land Management has no general authority to survey or resurvey State boundaries, quarter-section corners should not be established between closing corners on State boundaries. Although the closing corners themselves are established, State names should not be marked on the monuments (sections 4-25 and 5-19).

**3-71.** A closing corner monument is not set at intersection with the line of a surveyed mineral claim, forest homestead claim, small holding claim, or the like, unless required to provide an interval of monumentation of one-half mile or less. In some instances, crossing closing corners may be needed for operational or litigation purposes, in which event they should be provided for in the special instructions.

Where a line of the rectangular survey crosses a surveyed claim, the bearing of the intersected claim line and the distance to the nearest corner are determined and noted. In the case of a claim located entirely within a section, a connection is made from a corner of the claim to a regular corner of the section. If the connection is made by traverse, it is reduced to the equivalent direct course and distance for inclusion in the field notes and plat.

Since the accuracy of lotting in the section depends on a correct location of the claim, it may be desirable to retrace one or all of the claim lines. If a multiplicity of claims exists, their treatment should be covered in the special instructions.

**3-72.** If a survey is concluded upon an irregular boundary at variance with the lines of legal subdivision, or if the survey is continued on a blank line to acquire a definite location upon the opposite irregular boundary, but without monumenting the rectangular survey between the irregular boundaries, a closing corner is always required at the point of intersection of the regular with the irregular line. On the other hand, if the survey is continued across the reservation or grant for the purpose of establishing a full complement of corners for the control of the subdivision of a section so invaded, a closing corner may not be required.

**3-73.** Closing corners are intended to be established where a closing line intersects a boundary already fixed in position. While the closing corner thereafter controls the direction of the closing line, a failure to place it at the true point of intersection does not alter the position of the line closed upon but may cause interested parties to rely on the faulty position. The line closed upon should always be

retraced between the first corners to the right and left. Determination of the point of intersection by calculation is not permissible.

## SUBDIVISION OF SECTIONS

**3-74.** Revised Statutes, secs. 2396, 2397 (43 U.S.C. 752 and 753), contain the fundamental provisions for the subdivision of sections into quarter sections and quarter-quarter sections. The sections are not subdivided in the field by Bureau of Land Management cadastral surveyors unless provision is made in the special instructions, but certain subdivision-of-section lines are always protracted upon the official plat.

**3-75.** Under the rectangular system the unit of survey is the township of 36 sections. The unit of subdivision is the section of 640 acres. Under the general land laws, broadly, the unit of administration is the quarter-quarter section of 40 acres. The function of the cadastral surveyor of the Bureau of Land Management has been fulfilled when he has executed and monumented his survey properly and returned an official record in the form of detailed field notes and a plat. The plats are constructed in harmony with the field notes returned by the surveyor. The lands are identified on the ground by fixed monuments established in the survey. A United States patent conveys the title to an area defined by those fixed monuments and related by description and outline to the official plat.

**3-76.** The local surveyor is employed as an expert to identify lands which have passed into private ownership. This may be a simple or a most complex problem, depending largely upon the condition of the original monuments as affected principally by the lapse of time since the execution of the original survey. The work usually includes the subdivision of the section into the fractional parts shown upon the approved plat. In this capacity the local surveyor is performing a function contemplated by law. He cannot properly serve his client or the public unless he is familiar with the legal requirements concerning the subdivision of sections. In the event that the original monuments have become lost, the surveyor needs to be familiar with the scheme of the original survey, the

record of the particular survey involved, and the principles upon which the courts have based rulings with regard to corner restorations.

The Bureau of Land Management assumes no control or direction over the acts of local and county surveyors in the matters of subdivision of sections and reestablishment of lost corners of original surveys where the lands have passed into private ownership, nor will it issue instructions in such cases. It follows the general rule that disputes arising from uncertain or erroneous location of corners originally established by the United States are to be settled by the proper local authorities or by amicable adjustment. The Bureau desires that the rules controlling the acts of its own cadastral surveying service be considered by all other surveyors as merely advisory and explanatory of the principles which should prevail in performing such duties.

### Subdivision by Protraction

3-77. Upon the plat of all regular sections the boundaries of the quarter sections are shown by broken straight lines connecting the opposite quarter-section corners. The sections bordering the north or west boundary of a normal township, excepting section 6, are further subdivided by protraction into parts containing two regular half-quarter sections and four lots. Section 6 has lots protracted against both the north and west boundaries, and so contains two regular half-quarter sections, one quarter-quarter section, and seven lots. The position of the protracted lines and the regular order of lot numbering are shown in figure 46. The lots are numbered in a regular series progressively from east to west or from north to south in each section. The lots in section 6 are numbered commencing with No. 1 in the northeast, thence progressively to No. 4 in the northwest, and south to No. 7 in the southwest fractional quarter-quarter section.

3-78. The regular quarter-quarter sections are aliquot parts of quarter sections based upon midpoint protraction. These lines are not indicated upon the official plat.

3-79. Sections which are invaded by meanderable bodies of water, or by approved claims at variance with the regular legal subdivisions,

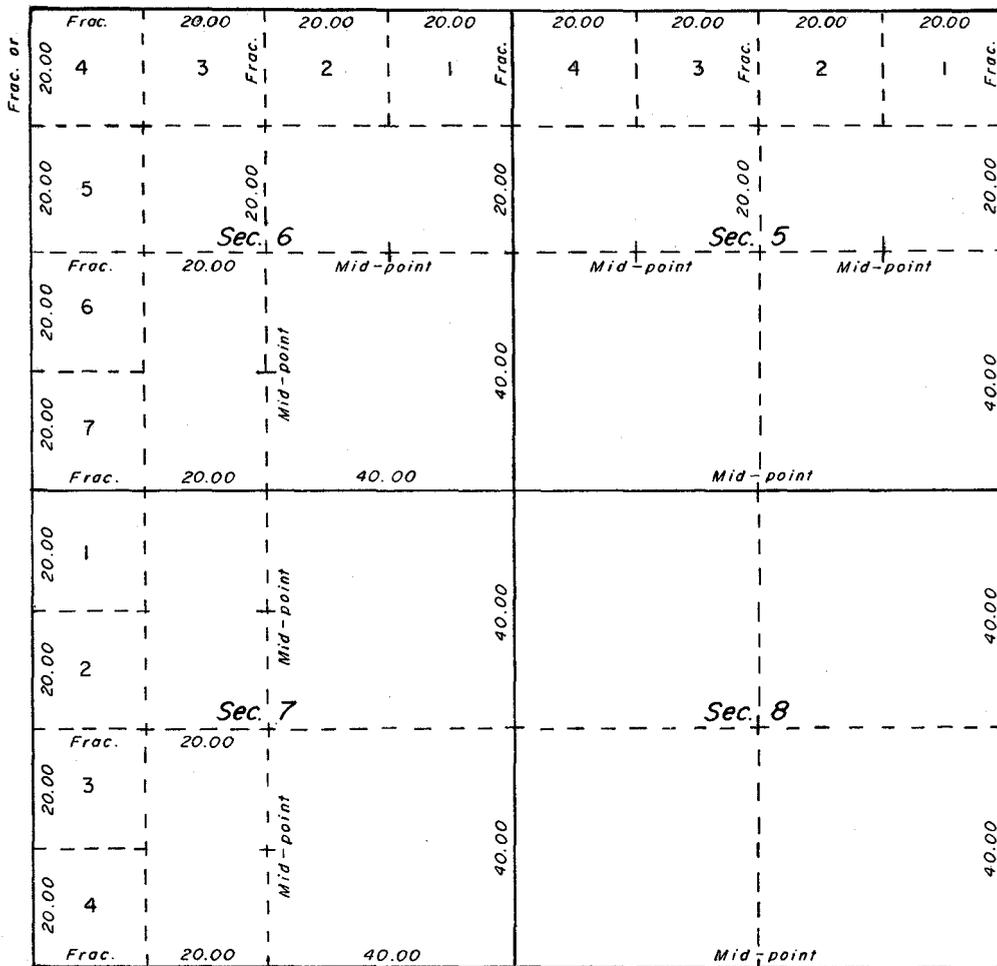
are subdivided by protraction into regular and fractional parts as may be necessary to form a suitable basis for the administration of the public lands remaining undisposed of, and to describe the latter separately from the segregated areas.

3-80. The meander line of a body of water and the boundary lines of private claims are platted in accordance with the lines run or connections made in the field. The sections invaded are subdivided as nearly as possible in conformity with the uniform plan. The subdivision-of-section lines are terminated at the meander line or claim boundary, but the position of the subdivision-of-section lines is controlled precisely as though the section had been completed regularly. In the case of a section whose boundary lines are in part within the limits of a meanderable body of water, or within the boundaries of a private claim, the fractional section lines are completed in theory, and the protracted position of the subdivision-of-section lines is controlled by the theoretical points so determined.

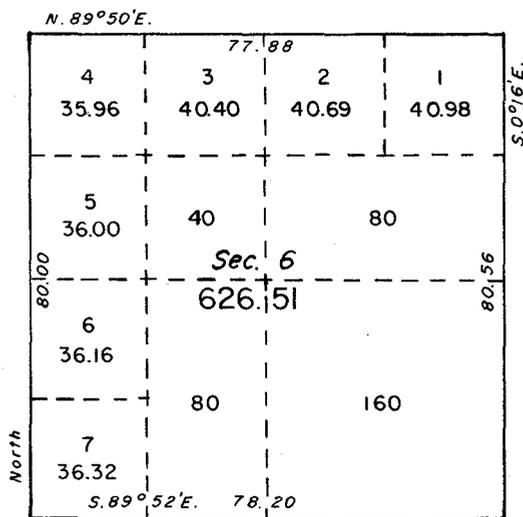
3-81. Fractional sections are subdivided so as to contain as many aliquot parts as possible, but a departure from this practice is made where it would result in poorly shaped fractional lots. In the case of fractional lots along the north and west boundaries of a township, and in other similar cases where a lot has a full normal width of 20 chains in one direction, it is generally advisable to avoid areas of less than 10 or more than 50 acres. In the instance of fractional lines along a meander line or other irregular broken boundary, where the width of the lot in both directions may be considerably less than 20 chains, resulting in tracts of more compact form, it is generally better to avoid an area of less than five or more than 45 acres. Extreme lengths or narrow widths should be avoided. The longer direction should extend back from a meander line or claim boundary rather than along it. It is inconsistent that a fractional lot lie partly in two sections, and it is generally better, when consistent with other rules, to avoid fractional lots extending from one into another fractional quarter section.

3-82. To visualize a uniform system for numbering lots of fractional sections, imagine

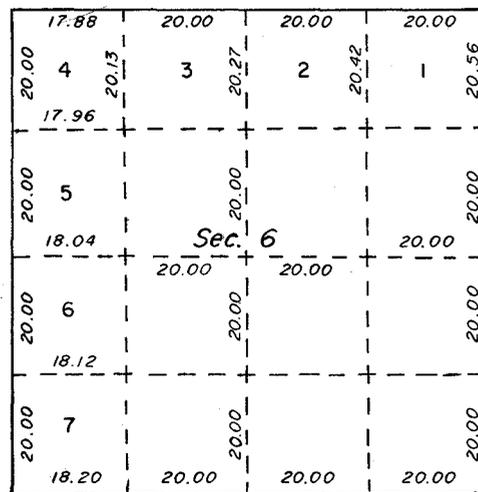
MANUAL OF SURVEYING INSTRUCTIONS



Showing normal subdivision of sections.

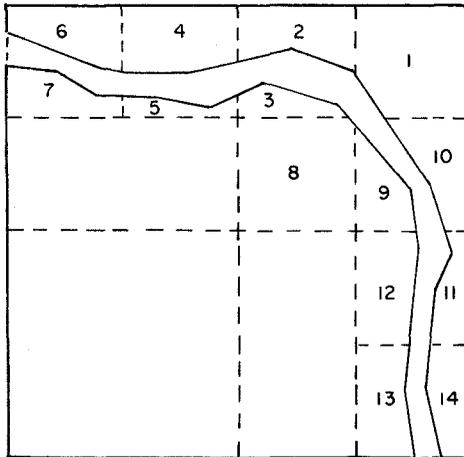


Showing areas.

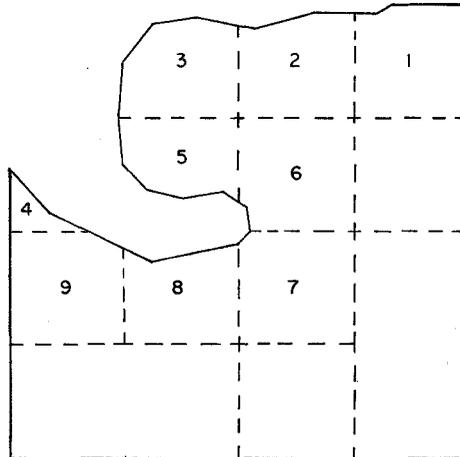


Showing calculated distances.

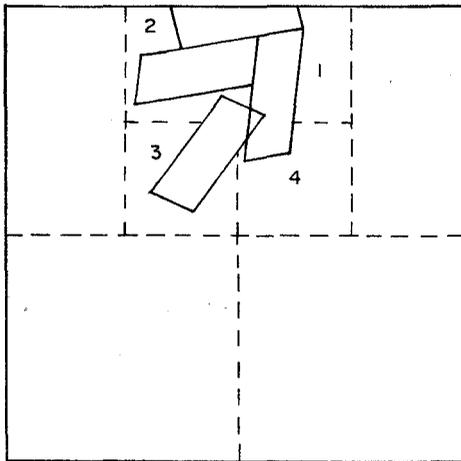
FIGURE 46.—Examples of subdivision by protraction.



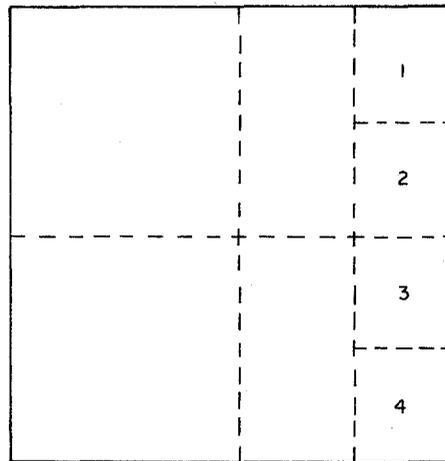
Meanderable River.



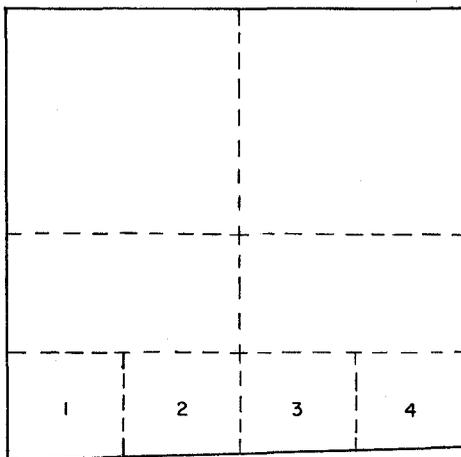
Meanderable Lake.



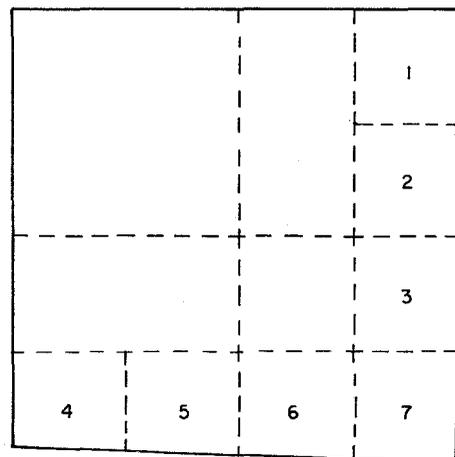
Mineral Claims.



E. bdy. defective in alinement.



S. bdy. defective in alinement.



E. & S. bdrs. defective in alinement.

FIGURE 47.—Examples of subdivision of fractional sections.

the section divided by parallel latitudinal lines into tiers, numbered from north to south. Then, beginning with the eastern lot of the north tier, call it No. 1, and continue the numbering west through the tier, then east in the second, west in the third, east in the fourth tier, until all fractional lots have been numbered. These directions are maintained even though some of the tiers contain no fractional lots. A lot extending north and south through two, or part of two tiers, is numbered in the tier containing its greater area. This method of numbering applies to any part of a section. A section that has been partly surveyed at different times should have no duplication of lot numbers.

3-83. When the length or width of a township exceeds 480 chains to such an extent as to require two or more tiers of lots adjoining the north or west boundary, the usual past practice has been to lot all of the area beyond the regular legal subdivisions as shown in figure 48(a) and 49(a). Henceforth, in order to avoid possible confusion of descriptions, the lotting should be extended throughout the fractional half of the section as shown in figures 48(b) and 49(b). This will also apply to the platting of resurveyed sections insofar as public land is involved. In modern practice, sections in excess of 120 chains are avoided by the creation of half-township or half-range numbers. This cannot be done where the elongated sections are situated in the interior of a township as the result of partially completed but grossly irregular former subdivisions. Lotting will then be extended as necessary.

3-84. If it has been necessary to establish a sectional guide meridian or a sectional correction line, fractional lots may result along the east or south boundary of the township. The sections bordering the defective boundaries are subdivided on the same plan as sections bordering the north and west boundaries of a normal township.

**Subdivision by Survey**

3-85. The rules for subdivision of sections by survey are based on the laws governing the survey of the public lands. Some cases arise, however, which are not covered by these rules and require the advice of the Bureau of Land

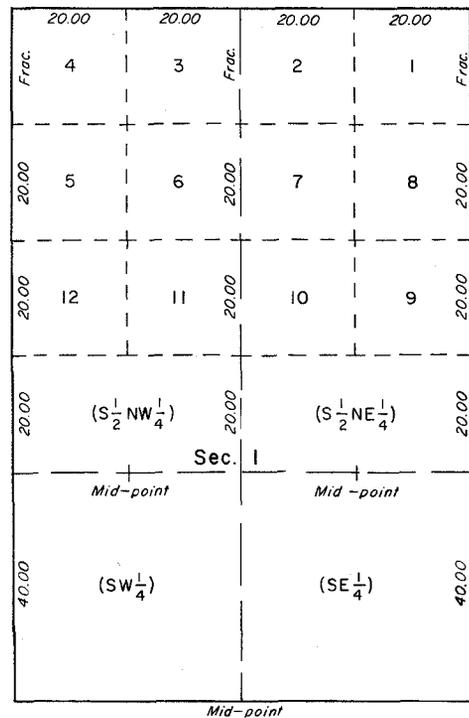


FIGURE 48(a).—Elongated section—subdivision by protraction.

Management. The letter of inquiry should contain a description of the particular tract or corner, with reference to township, range, and section of the public surveys, together with a diagram showing conditions found.

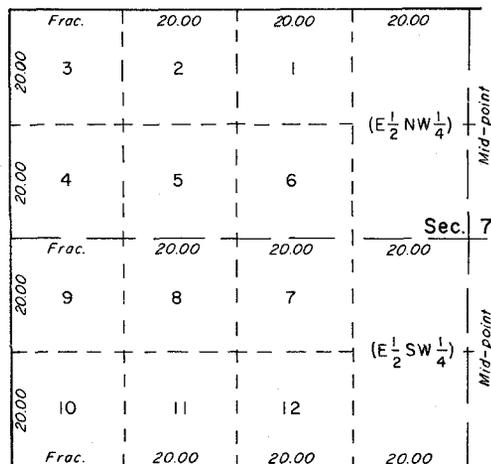


FIGURE 49(a).—Elongated section—subdivision by protraction.



tion lines shall be ascertained by running from the established corners north, south, east, or west, as the case may be, to the water course, reservation line, or other boundary of such fractional section, as represented upon the official plat.

In this the law presumes that the section lines are due north and south, or east and west lines, but usually this is not the case. Hence, in order to carry out the spirit of the law, it will be necessary in running the center lines through fractional sections to adopt mean courses where the section lines are not on due cardinal, or to run parallel to the east, south, west, or north boundary of the section, as conditions may require, where there is no opposite section line.

### *Subdivision of Quarter Sections*

3-89. Preliminary to the subdivision of quarter sections, the quarter-quarter- or sixteenth-section corners will be established at points midway between the section and quarter-section corners, and between the quarter-section corners and the center of the section, except on the last half mile of the lines closing on township boundaries, where they should be placed at 20 chains, proportionate measurement, counting from the regular quarter-section corner.

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

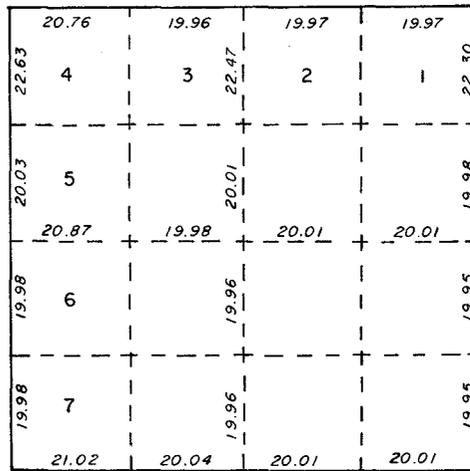
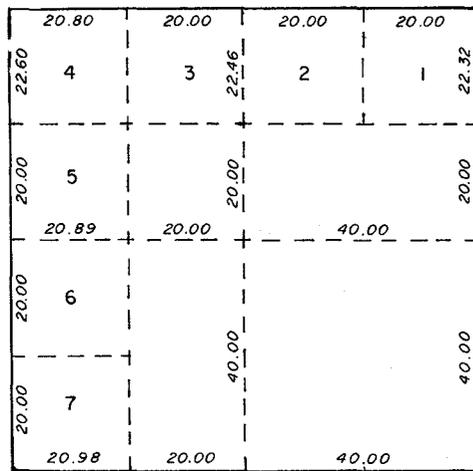
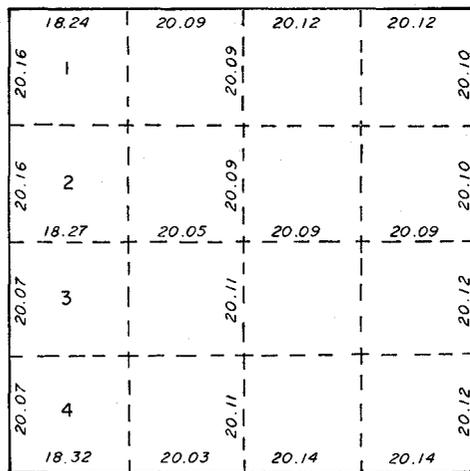
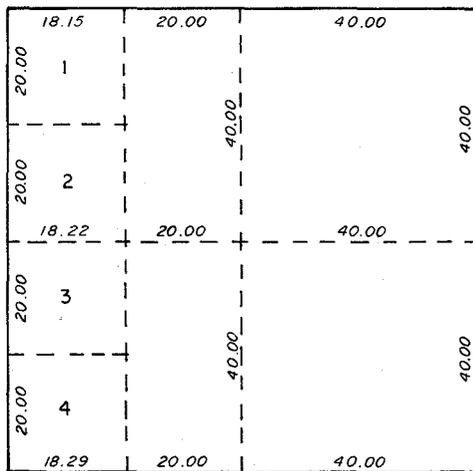
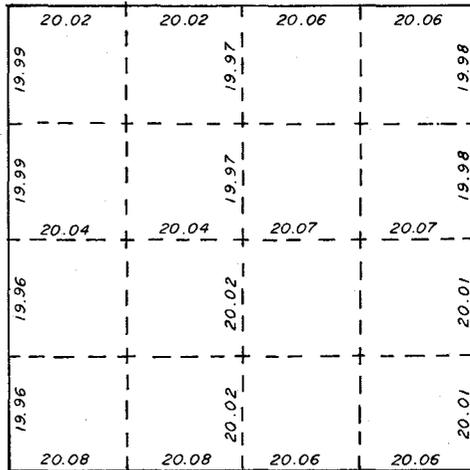
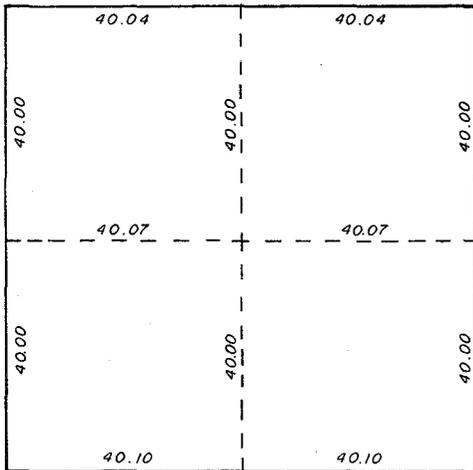
### *Subdivision of Fractional Quarter Sections*

3-90. The subdivisional lines of fractional quarter sections will be run from properly established quarter-quarter- or sixteenth-section corners, with courses governed by the conditions represented upon the official plat, to the lake, water-course, reservation, or other irregular boundary which renders such sections fractional.

3-91. Reasonable discrepancies between former and new measurements may generally be expected when retracing the section boundaries. The shortage or surplus is distributed by proportion in establishing a sixteenth-section corner. For example: The length of the line from the quarter-section corner on the west boundary of section 2 to the north line of the township, by the official survey was reported as 43.40 chains, and by the county surveyor's measurement was found to be 42.90 chains. The distance which the sixteenth-section corner should be located north of the quarter-section corner would be determined by proportion as follows: As 43.40 chains, the official measurement of the whole distance, is to 42.90 chains, the county surveyor's measurement of the same distance, so is 20 chains, original measurement, to 19.77 chains by the county surveyor's measurement. By proportionate measurement in this case the sixteenth-section corner should be set at 19.77 chains north of the quarter-section corner, instead of 20 chains north of said corner, as represented on the official plat. In this manner the discrepancies between original and new measurements are equitably distributed.

### *Summary*

3-92. By way of recapitulation it is emphasized that when entrymen have acquired title to certain legal subdivisions they have become the owners of the identical ground area represented by the same subdivisions upon the official plat. It is a matter of expert or technical procedure to mark out the legal subdivisions called for in a patent, and entrymen are advised that a competent surveyor should be employed. The surveyor must identify the section boundaries and locate the legal center of the section in order to determine the boundaries of a quarter section. Then, if the boundaries of quarter-quarter sections, or fractional lots, are to be determined on the ground, the boundaries of the quarter section must be measured, and the sixteenth-section corners fixed in accordance with the proportional distances represented upon the approved plat. Finally, the legal center of the quarter section may be duly located. Thus will be produced in



Official measurements.

Remeasurements.

FIGURE 50.—Examples of subdivision by survey showing relation of official measurements and calculated distances to remeasurements, and indicating proportional distribution of differences.

the field the figure represented upon the plat, every part of the former in true proportion to the latter, where the elements of absolute distance and area have given way to corresponding proportional units as defined by fixed monuments established in the original survey.

**SURVEY OF PARTS OF SECTIONS**

**3-93.** In rare cases portions of the section boundaries are impassable or so insecure that acceptable monumentation is impracticable, and yet a need exists for survey of the accessible area. Since rules covering every set of conditions cannot be given, the methods ordinarily are carried in the special instructions. Figures 51 and 52 show rectangular boundaries of parts of regular sections. A random subdivision-of-section line is run closing the area to be surveyed, each course parallel to the governing boundary, with lengths in multiples of 20 chains. The closing error is then distributed as provided in section 5-43 and monuments established. Figures 53 and 54 show rectangular boundaries of parts of closing sections. Fractional lottings are indicated. In figure 53 the whole closing error in latitude is placed as normally in the north tier of lots. In figure 54 the whole closing error in departure is placed as normally in the west range of lots. In all cases the interior sixteenth-section corners and

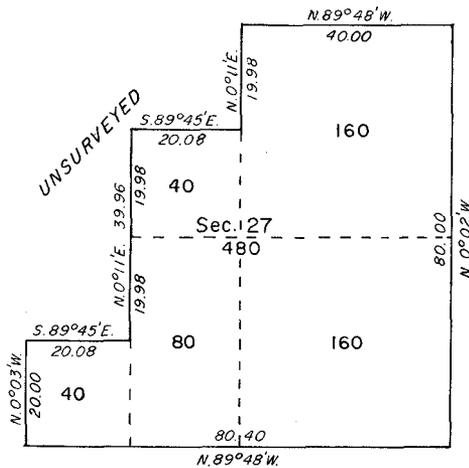


FIGURE 51.—Rectangular boundaries of parts of a regular section.

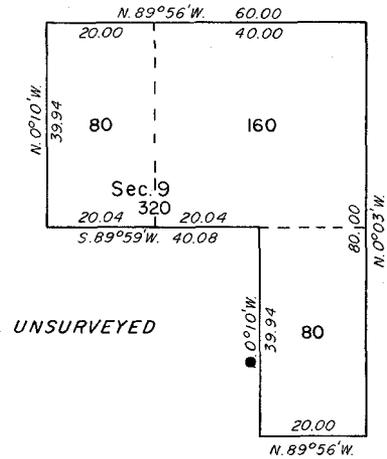


FIGURE 52.—Rectangular boundaries of parts of a regular section.

the center quarter-section corner are monumented at turning points of the lines actually run.

**3-94.** The field notes show only the true line courses and distances, the usual topography, the description of monuments, and a description of the difficulties which warranted an elimination of parts of the section or sections.

**3-95.** To subdivide a partly surveyed section, the remaining subdivision-of-section lines within the surveyed area would be determined by running straight lines between the nearest established control for the sectional center lines.

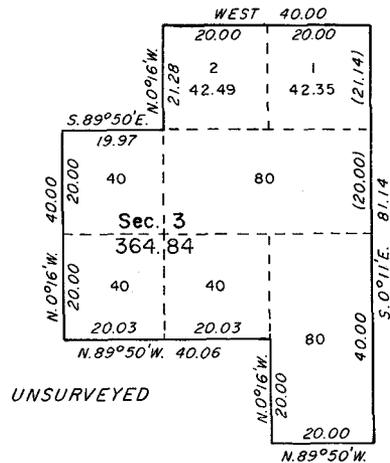


FIGURE 53.—Rectangular boundaries of parts of a section adjoining the north boundary.

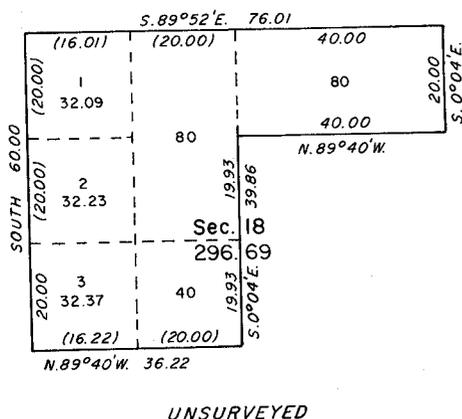


FIGURE 54.—Rectangular boundaries of parts of a section adjoining the west boundary.

The position for the center quarter-section corner is at the intersection of the center lines, unless previously marked. The remaining interior sixteenth-section corners on the sectional center lines are at midpoints between the exterior quarter-section corners and the center quarter-section corner, except within the sections normally fractional. The center lines of the quarter sections would be completed on a similar plan. In all sections normally fractional the excess or deficiency would be placed in its normal position.

3-96. Although the running of traverse lines on the margin of impassable areas has been largely discontinued, such a survey is sometimes called for where rectangular boundaries cannot otherwise be completed within the section. The method should be authorized in the special instructions only when supported by ample justification. In such surveys the angle points of the traverse line are given serial numbers in each fractional section, and the points are monumented. The subdivision-of-section lines are protracted only, unless a definition upon the ground is justified.

### FRACTIONAL TOWNSHIPS

3-97. The regular procedures described for subdividing full townships cannot always be adopted. A township invaded by a large mean-

derable body of water, impassable objects, or a State, reservation, or grant boundary may lack a full linear south or east boundary. If it has been found advisable to run section lines as offsets to the township exteriors, the fractional section lines south and east of these controlling lines are projected opposite to the usual directions. The fractional measurements and the resulting fractional lots are placed against the irregular boundary. If only the north or west part of a fractional township is involved, no departure from the regular order of subdivision is necessary, since fractional measurements on the exterior and subdivisional lines, and the resulting fractional lots, will be placed to the north and west against the irregular boundary.

3-98. Where no part of the south boundary of a township can be regularly established, the subdivision may proceed from north to south and from east to west, throwing fractional measurements and areas against the west boundary and the meanderable stream or other boundary limiting the township on the south. If the east boundary is without regular section corners and the north boundary has been run eastwardly as a true line, with section corners at regular intervals of 80 chains, the subdivision of the township may be made from west to east. In that case the fractional measurements and areas are thrown against the irregular east boundary. On the other hand, if the north boundary of section 6 is fractional, a sectional guide meridian, initiated at the easternmost regular section corner on the north boundary, is projected to the south to take the place of a governing east boundary. The subdivisional survey is then projected from north to south and from east to west, with fractional measurements and resulting fractional lots on the east, south and west boundaries of the township. Figures 55 through 58 illustrate the principles which control the subdivision of partial townships.

3-99. In the case of fractional townships the sections bear the same numbers they would have had if the townships were complete. That is, the section numbers are those relating to the governing boundaries.

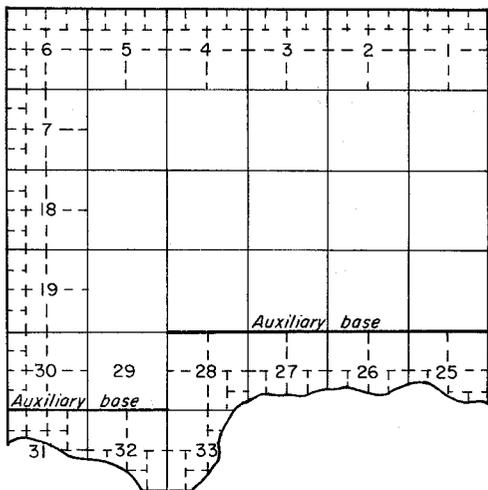


FIGURE 55(a).—Use of auxiliary base.

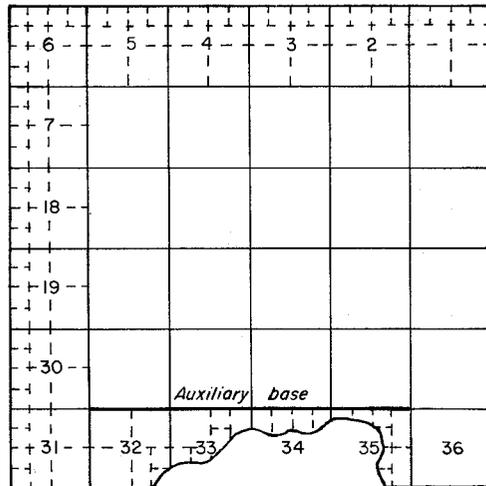


FIGURE 55(c).—Use of auxiliary base.

**EXTENSION AND COMPLETION SURVEYS**

3-100. Surveys coming before the Bureau of Land Management sometimes involve the continuation of the subdivisional survey of townships previously subdivided in part only. These surveys include the completion of partially surveyed sections or of sections containing outlying areas protracted as surveyed. If defective conditions are encountered in the previously established surveys, the problems concerning the procedure to be adopted multiply rapidly and require the greatest skill on the

part of the surveyor. In the construction of new township plats the former practice of platting outlying areas of sections protracted as surveyed has been abandoned as unsatisfactory and inconsistent with the surveying laws.

3-101. Most original surveys that are now to be extended were executed many years ago when the remaining areas were considered wastelands. Due to the ravages of time and the inferior monumentation of the early surveys, obliteration may be so far advanced that resurveys are needed to identify and remonument the limiting boundaries of the area to be surveyed. The surveyor often must retrace

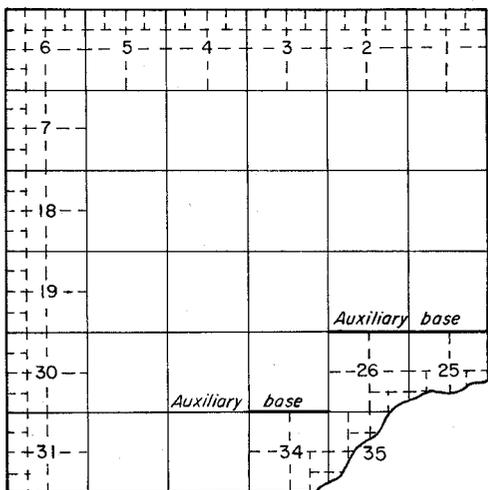


FIGURE 55(b).—Use of auxiliary base.

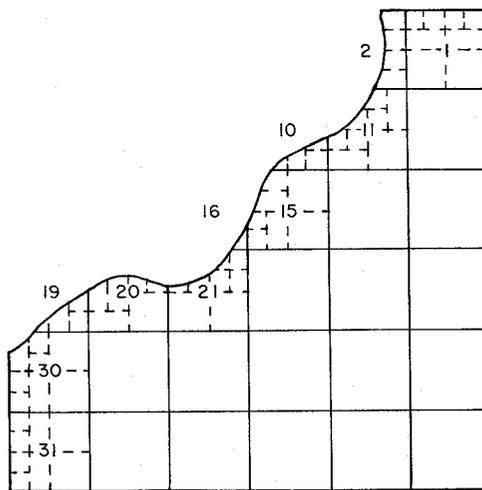


FIGURE 56.—Regular subdivision of fractional township.

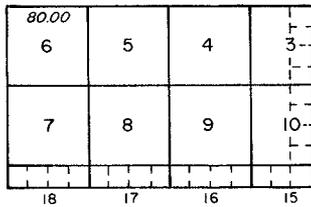


FIGURE 57.—Subdivision from north to south, and from west to east.

additional lines that are not the boundaries of sections containing the new areas to be surveyed. The theoretical position of a lost corner on such lines may be at variance with an unofficial corner established by local survey and recognized by the owners of the private lands affected. Controversy is avoided if reestablishments are confined to corners that control the position of the section boundaries or the subdivision-of-section lines of the public lands to be surveyed. Identified original corners adopted as control in reestablishing corners of the public land sections are rehabilitated but not remonumented in such cases. Corner restorations are made in accordance with the provisions of chapter V.

3-102. The field notes of necessary resurveys should include an explanation of their purpose and extent, including all needed historical references to the related prior surveys. The detail is written in the usual field note

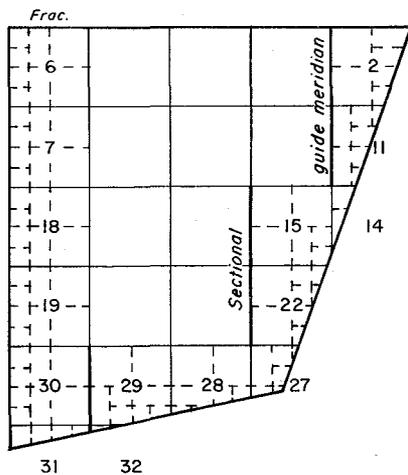


FIGURE 58.—Subdivision from north to south, and from east to west.

record form, following the introductory statement.

The plat, in addition to the usual data, may carry a marginal memorandum or diagram that clearly defines what lines of the prior survey have been retraced as a basis for extending the new lines. If no changes are made in the former lottings and areas in the resurveyed portions, it is stated that the lottings and area remain as shown on the plat or plats approved—(date or dates).

### Completion of Partially Surveyed Sections

3-103. In extending fragmentary surveys, first consideration is given to the completion of partially surveyed sections. If outlying portions of sections have been returned as surveyed on the previous plat, it is usually necessary to complete the survey of each section in such a way as to protect acquired rights. The procedure adopted must fix the remaining quarter-section corners in a position which will control the center lines as necessary to retain the form of the original areas within reasonable limits.

3-104. The new quarter-section corners are regarded as reasonably fixed when (1) the alinement does not exceed 21' from a cardinal course and (2) the measurement does not exceed 25 links from 40 chains, or in proportion when the opposite portion of the section boundary was returned as more or less than 40 chains. This concession as to limits is made in the interests of simplicity where the rectangularity of both old and new surveys can thus be maintained.

3-105. The position of the quarter-section corner on a new opposite boundary is controlled from only one direction if the old opposite distance was made to count from one direction only. If the old opposite distance was made to count from two directions, the position of the new quarter-section corner is controlled from the two directions. The lengths of the two portions of the new line are made proportional to the two parts of the old opposite boundary.

3-106. Given an original survey which is within rectangular limits, the survey of a fractional section is completed on the same plan begun in the original survey. When irregularity is developed, the simplest method of sur-

vey that will correct irregularities and provide an early resumption of regularity in the new subdivisional lines is adopted. The general rule is that each completed section will have four regular boundaries without offsets, with four governing section corners and four controlling quarter-section corners in such position as to maintain the integrity of the fractional areas shown upon the original plat.

3-107. Modification of the general rule is necessary where completing each of two sections in the above manner would cause an overlap or hiatus. In such a case each section is completed theoretically without regard to the other, and the position of each center line is fixed. The most reasonable position for a common boundary between the two sections is then determined, and the new quarter-section corners are established at points which maintain the center lines in their positions. If the theoretical position for each quarter-section corner falls within 25 links of a common point, with allowance for variance in length of the center line, one corner may be established which will secure maximum regularity in both sections.

3-108. The possible combinations of uncompleted sections are too numerous to discuss fully here. Directions will be given in the special instructions for the cases involved in an assignment, and the surveyor should seek advice from the proper administrative office when irregularities develop. A diagram showing the exact field conditions should always accompany his report.

3-109. A private survey made for the purpose of marking on the ground a theoretical line, platted but not run by the Government, where executed within allowable departure from cardinal course, and relied upon by owner under title passed by the United States in the placing of improvements upon the patented land, will not be disturbed, but it will be adopted by the Government as a boundary for closure of the survey of the adjoining public land. *Algoma Lumber Co. v. Kruger*, 50 L.D. 402 (1923).

3-110. The best test of the fitness of a proposed method for the completion of partially surveyed sections is to plat the subdivisional lines by protraction. Thereupon the regular rules for subdivision of sections should be ap-

pliable. The position of the new quarter-section corners, established to control the subdivision of the section in question, must be such as to permit the center lines to the opposite original quarter-section corners to be connected in harmony with conditions shown on the original plat, disregarding the effect upon the subdivision of the newly surveyed land. Likewise, the lines connecting the sixteenth-section corners on the opposite boundaries of a quarter section must conform to the conditions represented on the original plat. When the subdivision-of-section lines are platted, the section is satisfactory if the integrity of the original areas is in no way violated.

3-111. The following guidelines should be followed in platting:

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

(2) In the interest of regularity and simplicity of platting, the same meridional limit may be permitted as is ordinarily allowed in latitudinal section lines. A section may be considered regular if its boundaries do not depart more than 21' from a cardinal course in alignment and no more than 25 links from 40 chains in measurement between the section and quarter-section corners. Such regular sections may be subdivided into regular quarter sections and quarter-quarter sections as far as possible. A section having three regular boundary lines may be subdivided in accordance with the usual rules for subdividing sections along the north and west boundaries of a normal township. A section having two adjacent regular boundary lines may be subdivided by the same manner in which section 6 of a normal township is treated. All other sections should be treated as irregular, with subdivision-of-section lines protracted to mid-points on the boundaries of the quarter sections, except as a calculated proportional position for a sixteenth-section corner is made necessary by the showing of the original plat.

(3) All new fractional lots are numbered beginning with the next higher number in the

series shown on the previously approved plat, and proceeding in the usual order. The new series may begin with No. 1 if the fractional parts of the original area are not designated by lot number.

### Completion of Township Subdivision

3-112. Only after the partially surveyed sections have been completed should the surveyor proceed with the subdivision of the remaining portions of the township. If no irregularities are found in the previously established lines the new survey may proceed normally. If defective conditions are encountered, the irregularities are not extended into unsurveyed sections any farther than necessary to incorporate the resulting fractional measurements into suitable fractional lots adjoining the former surveys. Preference should be given to extending all surveys from south to north and from east to west. If a better control is available by reversing the procedure in one or both directions, resulting in a simpler survey by minimizing the number of extra corners as well as fractional lots, reversal of the procedure is warranted.

3-113. In the event that the previously surveyed subdivision lines are defective, the new section lines may serve the function of a sectional guide meridian or a sectional correction line as required. The corners from which the new surveys are initiated are established as corners of four sections, or of two sections as appropriate. Where new section lines cannot be connected regularly with the previously established section corners by random and true line not exceeding 21' from cardinal, a closing section corner is established at intersection with the line of the old survey. The fractional measurements of the closing section lines are placed adjacent to the old surveys. The original lines forming the boundary of the lands to be surveyed are retraced, as already provided and the marks upon the original corners are appropriately modified as necessary. New quarter-section corners marked to control the subdivision of the new sections are established on the original lines at midpoints between the closing section corners, or at 40 chains from one direc-

tion, according to the manner in which a new section is subdivided.

3-114. There are often two or more ways in which a fractional subdivision may be completed, but careful study of a sketch plat representing existing conditions will generally reveal the superiority of one method over another.

### MEANDERING

3-115. The traverse of the margin of a permanent natural body of water is termed a meander line. All navigable bodies of water and other important rivers and lakes are segregated from the public lands at mean high-water elevation. In original surveys, meander lines are run for the purpose of ascertaining the quantity of land remaining after segregation of the water area.

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

Low-water mark is the point to which a river or other body of water recedes, under ordinary conditions, at its lowest stage. High-water mark is the line which the water impresses on the soil by covering it for sufficient periods to deprive it of vegetation. The shore is the space between the margin of the water at its lowest stage and the banks at high-water mark. *Alabama v. Georgia*, 64 U. S. 505 (1859).

Numerous decisions in the United States Supreme Court assert the principle that meander lines are not boundaries defining the area of ownership of lands adjacent to the water. The general rule is that meander lines are run not as boundaries, but to define the sinuosities of the banks of the stream or other body of water, and as a means of ascertaining the quantity of land embraced in the survey; the stream, or other body of water, and not the meander line as actually run on the ground, is the bound-

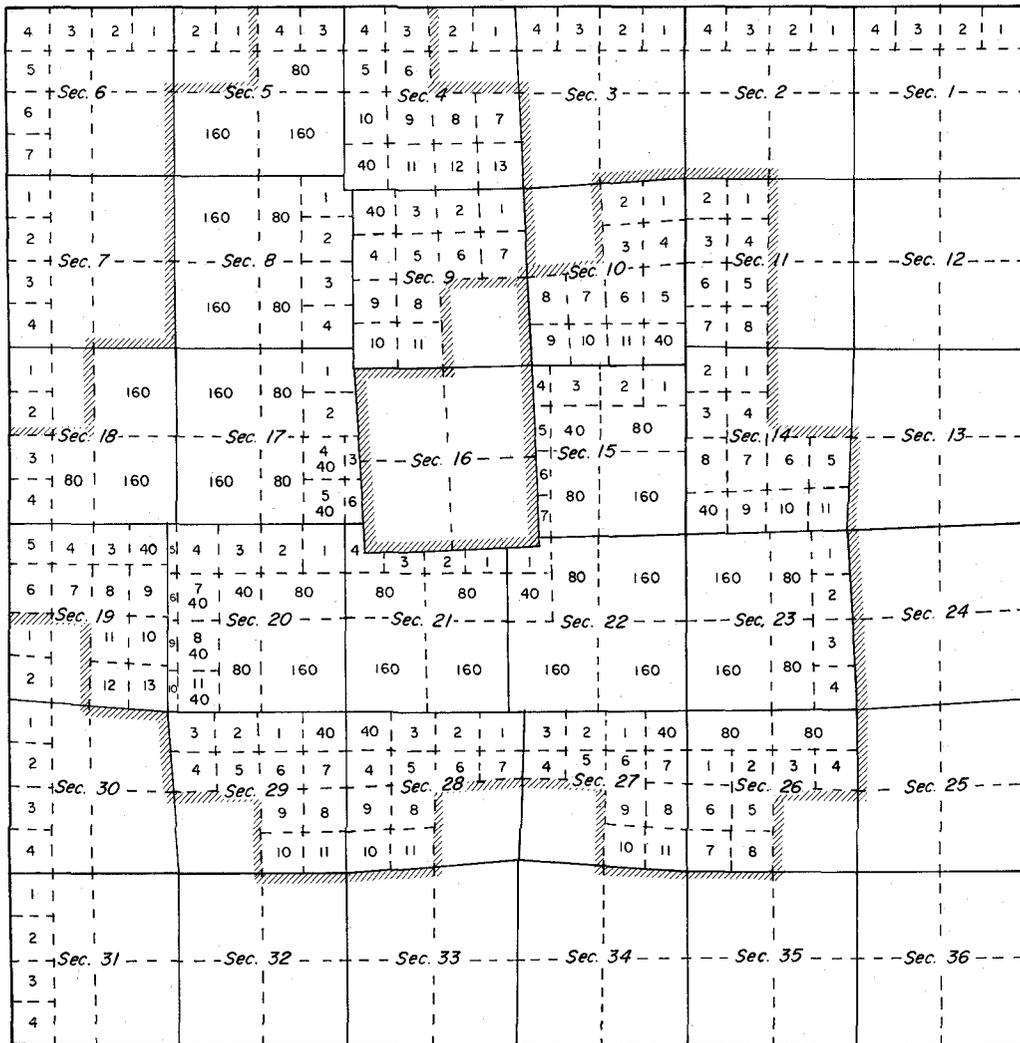


FIGURE 59.—Example showing completion of partially surveyed sections and completion of subdivisional lines of a township with necessary lottings.

ary. When by action of water the bed of the body of water changes, high-water mark changes, and the ownership of adjoining land progresses with it. *Lane v. United States*, 274 Fed. 290 (1921).

Meander lines will not be established at the segregation line between upland and swamp or overflowed land, but at the ordinary high-water mark of the actual margin of the river or lake on which such swamp or overflowed lands border.

3-116. Practically all inland bodies of water pass through an annual cycle of changes, be-

tween the extremes of which will be found mean high water. In regions of broken topography, especially where bodies of water are bounded by sharply sloping lands, the horizontal distance between the margins of the various water elevations is comparatively slight, and the surveyor does not experience much difficulty in determining the horizontal position of mean high-water level with approximate accuracy. Where the meanderable bodies of water are bordered by relatively flat lands, the horizontal distance between the successive levels is relatively great. The most reliable indication of

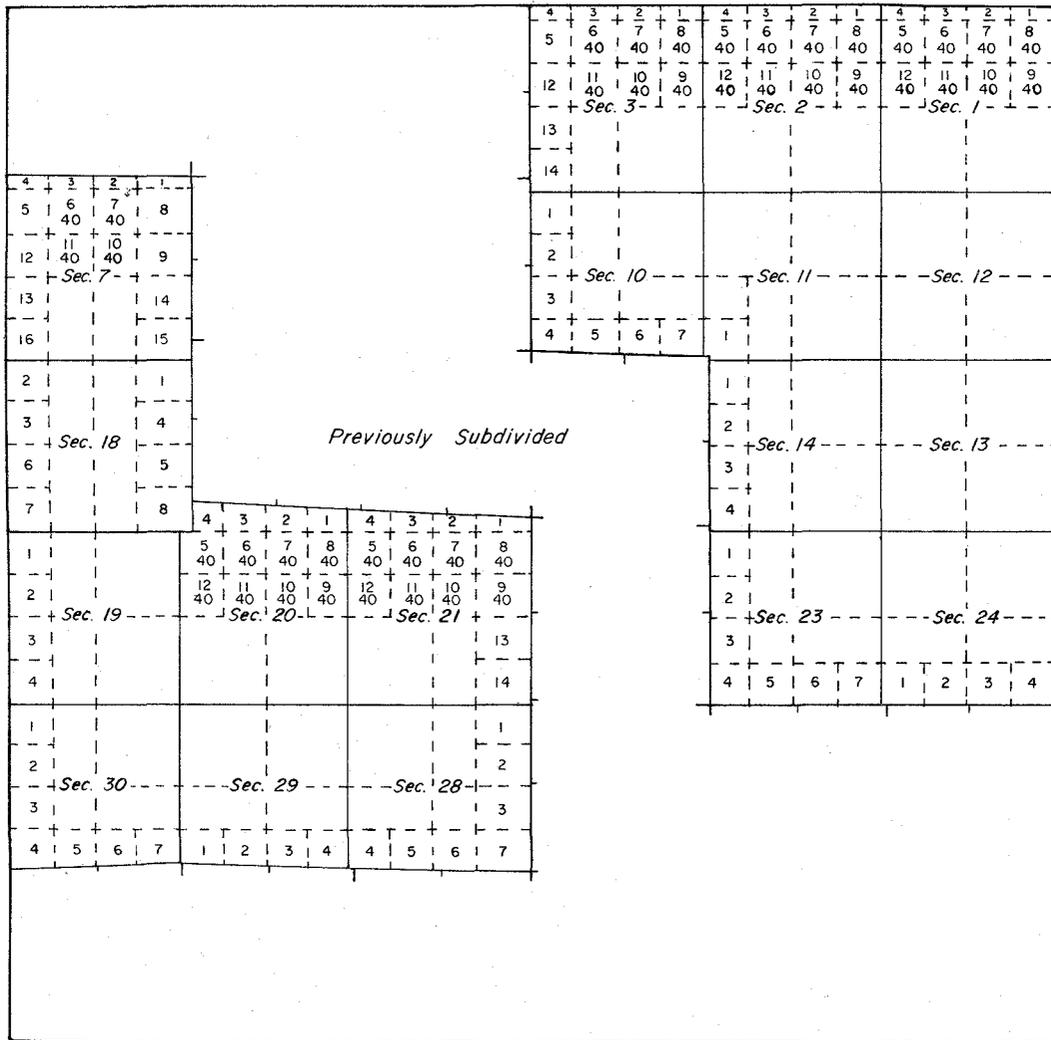


FIGURE 60.—Example showing completion of subdivisional lines of a township where outlying parts of sections returned earlier have been cancelled.

mean high-water elevation is the evidence made by the water's action at its various stages, which are generally well marked in the soil. In timbered localities a very certain indication of the locus of the various important water levels is found in the belting of the native forest species.

Mean high-water elevation is found at the margin of the area occupied by the water for the greater portion of each average year. At this level a definite escarpment in the soil is generally traceable, at the top of which is the true position for the meander line. A pronounced

escarpment, the result of the action of storm and flood waters is often found above the principal water level, and separated from the latter by the storm or flood beach. Another, less evident, escarpment is often found at the average low-water level, especially of lakes, the lower escarpment being separated from the principal escarpment by the normal beach or shore. While these questions properly belong to the realm of geology, they should not be overlooked in the survey of a meander line.

Where native forest trees are found in abundance bordering bodies of water, those trees

showing evidence of having grown under favorable site conditions will be found belted along contour lines. Certain mixed varieties common to a particular region are found only on the lands seldom if ever overflowed. Another group are found on the lands which are inundated only a small portion of the growing season each year, and indicate the area which should be included in the classification of the uplands. Other varieties of native forest trees are found only within the zone of swamp and overflowed lands. All timber growth normally ceases at the margin of permanent water.

3-117. A meander corner is established at every point where a standard, township, or section line intersects the bank of a navigable stream or other meanderable body of water. No monument should be placed in a position exposed to the beating of waves and the action of ice in severe weather. In such cases a witness corner should be established on the line at a secure point near the true point for the meander corner. The distance across a body of water is ascertained by triangulation or direct measurement, and the full particulars are given in the field tablets.

3-118. Inasmuch as it is not practicable in public-land surveys to meander in such a way as to follow and reproduce all the minute windings of the high-water line, the United States Supreme Court has given the principles governing the use and purpose of meandering shores in its decision in a noted case as follows:

Meander lines are run in surveying fractional portions of the public lands bordering on navigable rivers, not as boundaries of the tract, but for the purpose of defining the sinuosities of the banks of the stream, and as the means of ascertaining the quantity of land in the fraction subject to sale, which is to be paid for by the purchaser. In preparing the official plat from the field notes, the meander line is represented as the border line of the stream, and shows to a demonstration that the watercourse, and not the meander line as actually run on the land, is the boundary. *Railroad Co. v. Schurmeier*, 74 U.S. 272 (1868).

3-119. The surveyor commences at one of the meander corners, follows the bank or shore line, and determines the length and true bearing of each course, from the beginning to the next meander corner. All meander courses refer to the true meridian and are determined with precision. "Transit angles" showing only the

amount of the deviation from the preceding course are not acceptable in field notes of meanders. Where it is impossible to survey the meander line along mean high-water mark, the notes should state the distance therefrom and the obstacles which justify the deviation. A table of latitudes and departures of the meander courses should be computed before leaving the vicinity, and if misclosure is found, indicating error in measurement or in reading courses, the lines should be rerun.

The following items will be noted along the meander line: (1) all streams flowing into a river, lake, or meanderable bayou, with the width at their mouths; (2) the position, size, and depth of springs, and whether the water is pure or mineral; (3) the heads and mouths of all bayous; (4) all rapids and bars, with intersections to the upper and lower ends; (5) the elevation of the banks of lakes and streams, the height of falls and cascades, and the length and fall of rapids; and (6) artificial structures in both land and water areas.

The field notes of meanders show the corners from which the meanders commenced and upon which they closed, and exhibit the meanders of each fractional section separately. Following, and composing a part of the notes, should be given a description of the adjoining land, soil and timber, and the estimated depth of inundation to which the bottom land is subject.

## Rivers

3-120. Facing downstream, the bank on the left hand is termed the left bank and that on the right hand the right bank. These terms will be universally used to distinguish the two banks of a river or stream.

Navigable rivers and bayous, as well as all rivers not navigable, the right-angle width of which is 3 chains and upwards, are meandered on both banks, at the ordinary mean high-water mark, by taking the general courses and distances of their sinuosities. Rivers not classed as navigable are not meandered above the point where the average right-angle width is less than 3 chains, except when duly authorized.

Shallow streams and intermittent streams without well defined channel or banks are not meandered, even when more than 3 chains wide.

Tidewater streams are meandered at ordinary mean high tide as far as navigable, even when less than 3 chains wide. Tidewater inlets and bayous are recorded, and are meandered if more than 3 chains in width, but when nonnavigable are not meandered when less than 3 chains wide.

### Lakes

3-121. All lakes of the area of 50 acres and upwards, are meandered.

In the case of lakes which are located entirely within the boundaries of a section, a quarter-section line, if one crosses the lake, is run from one of the quarter-section corners, on a theoretical course to connect with the opposite quarter-section corner, to the margin of the lake, and the distance is measured. At the point thus determined a "special meander corner" is established.

Where one or both of the opposite quarter-section corners cannot be established, and in all cases where the distance across a lake exceeds 40 chains or the physical crossing is difficult, a temporary special meander corner is established at the computed intersection with the center line of the section when surveying the meander line. The temporary point is later corrected to the true center line position for monumentation, at midpoint in departure (or latitude), or at proportionate distance in a fractional section.

If a meanderable lake is found to be located entirely within a quarter section, an "auxiliary meander corner" is established at some suitable point on its margin, and a connecting line is run from the monument to a regular corner on the section boundary. A connecting traverse line is recorded, if run, but it is also reduced to the equivalent direct connecting course and distance, all of which is stated in the field notes. Only the course and length of the direct connecting line are shown on the plat of the survey.

The meander line of a lake lying within a section is initiated at the established special or auxiliary meander corner, as the case may be, and continued around the margin of the normal lake at its mean high-water level, to a closing at the point of beginning. All proceedings are fully entered in the field notes.

Artificial lakes and reservoirs are not segregated from the public lands, unless specially provided in the instructions, but the true position and extent of such bodies of water are determined in the field and shown on the plat.

Other exceptions to the general rule are shallow or poorly defined "lakes" which are actually pools that collect because of permafrost and lack of drainage or which are ephemeral desert playas formed seasonally or in wet years. These "lakes" should not be meandered even when larger than 50 acres.

### Islands

3-122. Every island above the mean high-water elevation of any meanderable body of water, except islands formed in navigable bodies of water after the date of the admission of a State into the Union, is located by triangulation or direct measurement or other suitable process, and is meandered and shown upon the official plat.

Even though the United States has parted with its title to the adjoining mainland, an island in a meandered body of water, navigable or nonnavigable, in continuous existence since the date of the admission of the State into the Union, and omitted from the original survey, remains public land of the United States. As such the island is subject to survey. This is because such islands were not a part of the *bed* of the stream at the date of Statehood, and therefore their title remained in the United States, subject to survey and disposal when identified. The riparian right that attaches to the lottings along the meander line of the mainland pertains only to the bed of the stream, and to such islands as may form within the bed subsequent to the disposal of the title. The proof of the time of the formation of islands is often difficult. It is the practice to make a careful examination of the history of an island in relation to the question of its legal ownership.

Islands that have been given well-known proper names are so identified, both in the field notes and on the plat. Sometimes there are a number of islands in the same section without proper names. Some may have been surveyed, others omitted. Of the latter, some may rightfully belong to the State, some to a riparian

proprietor, so that any system of numbering may be uncertain, and if used may still be confused with a lot number, if and when surveyed. For these reasons their identification may be uncertain unless the following rule is applied:

Where there are several unnamed islands within the same section, these will be referred to in the field notes (when surveyed) according to the lot number (Island designated as lot No. —) that is assigned on the plat, excepting that islands which are crossed by section line boundaries, or by a center line of the section, are readily identified by location.

Any township boundary or section line which will intersect an island is extended as nearly in accordance with the plan of regular surveys as conditions permit, and the usual township, section, quarter-section, and meander corners are established on the island. If an island falls in two sections only, the line between the sections should be established in its proper theoretical position based upon suitable sights and calculations. If an island falls entirely in one section, and is large enough to be subdivided (over 50 acres in area), a suitable sight or calculation is made to locate on the margin of the island an intersection with the theoretical position of any suitable subdivision-of-section line. At the point thus determined a "special meander corner" is established. In the case of an island falling entirely in one section and too small to be subdivided, an 'auxiliary meander corner' is established at any suitable point on its margin, which is connected with any regular corner on the mainland. The direct course and length of the connecting line is given in the field notes and shown on the plat.

The meander line of an island is surveyed in harmony with principles and rules heretofore stated. All township and section lines crossing the island are shown on the plat. If the island is large enough to be subdivided, the subdivision is accomplished by the protraction of suitable subdivision-of-section lines in their correct theoretical position.

Under special circumstances where administration or disposal requires no subdivision, an island is given a tract number within a township. In such cases, the section lines need not be extended to the island.

Agricultural upland within the limits of swamp and overflowed lands should be so classified and shown upon the plat accordingly, but such land is not meandered as an island.

### Use of Photogrammetry

3-123. Where conditions are favorable, meander lines may be surveyed by the process of photogrammetry after the meander corners have been established in the regular manner. The field notes will state what lines were so determined and the date and identification of the photography.

### LIMITS OF CLOSURE

3-124. The "error of closure" of a survey is defined in general terms as the ratio of the length of the line representing the equivalent of the errors in latitude and departure to the length of the perimeter of the figure constituting the survey. However, with due regard for the controlling coordinate governing lines of a rectangular survey, accuracy in latitude is not permitted to offset gross error in departure, or vice versa. A double test is therefore applied to United States rectangular surveys in place of the one expressed in general terms.

The "limit of closure" set for the public land surveys may now be expressed by the fraction  $1/905$ , provided that the limit of closure in neither latitude nor departure exceeds  $1/1280$ . Where a survey qualifies under the latter limit, the former is bound to be satisfied. An accumulative error of  $6\frac{1}{4}$  links per mile of perimeter, in either latitude or departure, will not be exceeded in an acceptable survey.

The latitudes and departures of a normal section shall each close within 25 links, of a normal range or tier of sections within 88 links, and of a normal township within 150 links. The boundaries of each fractional section including irregular claim lines or meanders, or the meanders of an island or lake in the interior of a section, should close within a limit to be determined by the fraction  $1/1280$  for latitude or departure considered separately. The same rule applies to all broken or irregular boundaries. All closings will be computed in the field.

Stricter limits of closure will be specified in the special instructions for classes of surveys where higher precision is indicated by the values involved.

### MARKING LINES BETWEEN CORNERS

3-125. The survey is marked upon the ground in the following ways:

(a) The regular corners of the public-land surveys are marked by fixed official monuments as described in chapter IV.

(b) The relation to natural topographic features is recorded in detail in the field notes. (chapter VIII).

(c) The locus of the lines is marked upon forest trees by blazing and by hack marks. Figures 61 and 62. However, in conformity with the National Environmental Policy Act of 1969, the operational need for the marking of lines should be weighed against possible esthetic damage. If special precautions are to be taken in this regard, they should be set out in the special instructions. Also, in the case of resurveys in areas of mixed public and private lands, it may be necessary to restrict the blazing to trees on public land. The surveyor on the ground should apply good judgment in particular cases not covered by his instructions. Where it has been determined that lines will be marked, the methods discussed here are intended to fix the lines permanently with the minimum environmental effect.

A *blaze* is a smoothed surface cut upon a tree trunk at about breast height. The bark

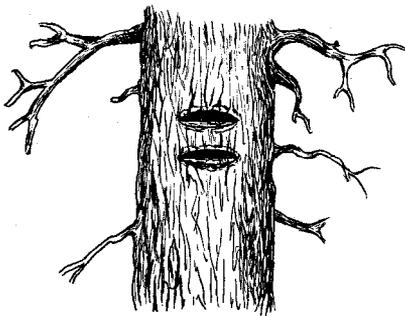


FIGURE 61.—Hack marks on a line tree.

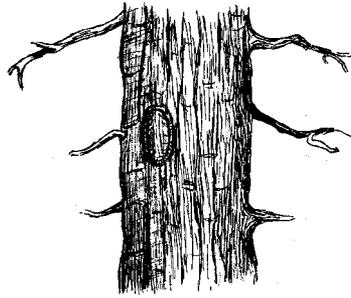


FIGURE 62.—A line blaze.

and a small amount of the live wood tissue are removed with an axe or other cutting tool, leaving a flat surface which forever brands the tree. The size of the blaze depends somewhat upon the size of the tree, but should not be made larger than the surface of an axe blade. A blaze five or six inches in height and from two to four inches in width is usually ample.

A *hack* is a horizontal notch cut well into the wood, also made at about breast height. Two hacks are cut to distinguish them from other, accidental marks. A vertical section of the finished hack marks resembles a double-V extending across a tree from two to six inches depending upon the diameter of the tree.

The blaze and hack mark are equally permanent, but so different in character that one mark should never be mistaken for the other. The difference becomes important when the line is retraced in later years.

Trees intersected by the line have two hacks or notches cut on each of the sides facing the line, without any other marks whatever. These are called sight trees or line trees. A sufficient number of other trees standing within 50 links of the line, on either side of it, are blazed on two sides quartering toward the line, in order to render the line conspicuous and readily to be traced in either direction. The blazes are made opposite each other coinciding in direction with the line where the trees stand very near it and approaching nearer each other toward the line the farther the line passes from the blazed trees. Figure 63.

The lines should be so well marked as to be readily followed and the blazes plain enough to leave recognizable scars as long as the trees stand. This can be accomplished by blazing just



FIGURE 63.—Marking a line through timber.

through the bark into the live wood tissue. The blazes should be narrow so that they will heal before decay begins, and special care should be taken not to loosen the cambium layer around the blaze, since this will prevent overgrowth. Where trees have branches growing to the ground, the blazes may be omitted unless it is necessary to remove the branches to permit sighting.

Lines are also marked by cutting away enough of the undergrowth to facilitate cor-

rect sighting of instruments. Where lines cross deep wooded valleys, by sighting over the tops, the usual blazing of trees in the low ground when accessible will be performed. The undergrowth will be especially well cut along all lines within distances of 5 chains of corner monuments and within 2 chains of arteries of travel, but the cutting of the undergrowth may be omitted in deep untraveled ravines unless necessary for accurate sighting or measurement.

Line trees and blazing are marked only with

reference to the established true line. Where lines are run by the "random and true" line method, the marking of line trees and the blazing is accomplished by returning over the line after all corrections or adjustments to the final line are definitely known. A sufficient number of temporary stakes should be set along a random line to render it generally unnecessary to rerun the true line instrumentally merely for the purpose of blazing the line through timber. This can usually be accomplished by properly estimating the distance from the temporary stakes, but intersections with line trees will be made with precision, and distances thereto accurately measured.

### SUMMARY OF OBJECTS TO BE NOTED, AND SKETCHES

3-126. The field notes and plat of a survey furnish not only a technical record of the procedure, but also a report upon the character of the land, soil and timber traversed by the survey, and the topographical features along line, with accurate connections showing the relation of the rectangular surveys to other surveys, to natural objects, and to improvements. A triple purpose is thus served: (1) the technical procedure is made a matter of official record; (2) general information relating to a region is gathered; and, (3) the "calls" of the field notes and the representations of the plat in respect to objects along the surveyed lines furnish important evidence by which the locus of the survey becomes practically unchangeable as contemplated by law.

The specimen field notes and plats are intended to standardize the form of record. Special matters relating to these subjects are discussed in chapters VIII and IX. The technical and topographical features which are to be carefully observed and recorded in the field during the progress of the public-land surveys are:

(1) The course and length of every line run, all necessary offsets therefrom, the reason for making them, and the method employed.

(2) The kind and diameter of bearing trees, the course and distance from their respective corners, and the markings; all bearing objects and marks thereon, if any; and the position of witness corners relative to the true corners.

(3) The kind of material of which corner monuments are constructed, their dimensions and markings, depth set in the ground, and their accessories.

(4) Trees on line. The name, diameter and distance on line to trees which it intersects, and their markings.

(5) Intersections by line of land objects. The distance at which the line intersects the boundary lines of a reservation, townsite, or private claim, noting the exact bearing of such boundary lines, and the distance to the nearest boundary corner; the center line of a railroad, canal, ditch, electric transmission line, or other right-of-way across public lands, noting the width of the right-of-way and the bearing of the center line; the change from one character of land to another, with the approximate bearing of the demarcation, and the estimated height in feet of the ascents and descents over the principal slopes traversed, with the slope direction; the distance to and the direction of the principal ridges, spurs, divides, rimrock, precipitous cliffs, etc.; the distance to where the line enters or leaves heavy or scattering timber, with the approximate bearing of the margin of heavy timber, and the distance to where the line enters or leaves dense undergrowth.

The amount of ascent or descent is only required in rough country where it will be of significant value to later surveyors. Where it is omitted the slope on which a corner is situated must be shown. The same requirement applies where the slope is given as general or broken and the slope at the corner differs from the general slope.

(6) Intersections by line of water objects. Unmeandered rivers, creeks and smaller watercourses which the line crosses; the distance measured on the true line to the center in the case of smaller streams, and to both banks in the case of larger streams, the course down stream at points of intersection, and their widths on line, if only the center is noted. Intermittent watercourses, such as ravines, gulches, arroyos, draws, dry-drains, etc.

(7) The land's surface; whether level, rolling, broken, hilly or mountainous.

(8) The soil; whether rocky, stony, gravelly, sandy, loam, clay, etc.

(9) Timber; the several kinds of timber and undergrowth, in the order in which they predominate. Items (7), (8), and (9) are summarized at the end of each mile in field notes of original survey. See sample notes.

(10) Bottom lands to be described as upland or swamp and overflowed, as contradistinguished under the law, noting the extent and approximate position of the latter and depth of overflow at seasonal periods. Sections 7-95 to 7-99.

(11) Springs of water, whether fresh, saline, or mineral, with the course of the stream flowing therefrom. The location of streams, springs, or water-holes, which because of their environment may be of value in connection with the utilization of public grazing lands, and which may be designated as public watering places, will be specially noted.

(12) Lakes and ponds, describing their banks, tributaries and outlet, and whether the water is pure or stagnant, deep or shallow.

(13) Improvements; towns and villages; post offices; occupancy; houses or cabins, fields, or other improvements; mineral claims; mill-sites. United States location monuments and all other official monuments not belonging to the system of rectangular surveys to be located by bearing and distance or by intersecting bearings from given points.

(14) Coal banks or beds, ore bodies, with description as to quality and extent; mining surface improvements and underground workings; and salt licks. Reliable information that can be obtained respecting these objects, whether on the line or not, should appear in the general description.

(15) Roads and trails, with their directions, whence and whither.

(16) Rapids, cataracts, cascades, or falls of water, in their approximate position and estimated height of fall in feet.

(17) Stone quarries and ledges of rocks, with the kind of stone they afford.

(18) Natural curiosities, petrifications, fossils, organic remains, etc.; also all archaeological remains, such as cliff dwellings, mounds, fortifications, or objects of like nature.

(19) *The magnetic declination.*—To be included in the transcribed field notes, in the gen-

eral description (item 20), including the observed local attraction within the area of the survey. The average value over the area surveyed will be shown on the plat.

(20) *General Description.*—The above information is summarized by townships in a general description which concludes the field notes of every survey. The general description embraces more comprehensive details of the characteristics of the region than is feasible to cover as an intimate part of the technical record of the survey, as follows:—

*Land.*—A general outline of the drainage and topographical features of the township and approximate range of elevation above sea level.

*Soil.*—The prevailing and characteristic soil types. (See special reference to soil classification, chapter VII).

*Timber.*—The predominant forest species, age, size, condition, etc.

*Evidence of mineral.*—Known bodies of mineral, and lands whose formation suggests mineral-bearing characteristics, especially with reference to lands of volcanic or igneous origin, are listed by appropriate legal subdivision, with brief description of the mineral indications. If there is no apparent indication of mineral deposits, a report to that effect is embodied in the general description.

*Watering places.*—The areas embracing all streams, springs, or water holes as may be of special value as public watering places, in connection with the utilization of public grazing lands, are listed by appropriate legal subdivision, with brief description of the nature of such water supply.

*Settlement.*—The extent of the settlement at the time of the survey.

*Industry.*—The industrial possibilities of the township, especially as to the adaptability of the region to agricultural pursuits, stock raising, lumbering, mining, or other profitable enterprise.

### *Sketch Plat*

3-127. In addition to the field notes the surveyor is required to prepare an outline diagram showing the course and length of established lines with connections, and a topographical sketch embracing the features usually shown

upon the official township plat. These maps are made to scale, drawn in pencil only, if desired, and are kept up with the progress of the field work. If the area of the survey is covered by accurate maps or recent aerial photographs, the topographic detail may be omitted from the sketch except in the immediate vicinity of the lines; otherwise, the interiors of the sections should be completed. The topographical features are sketched while in view, and the position of the details to be shown on the completed plat are located with an accuracy commensurate

with their relative importance. The design of the specimen township plat should be followed closely in preparing the sketch plat. It is generally desirable to use separate sheets for the line diagram and the topography. These maps form the basis of the official plat, the ultimate purpose of which is a complete graphic representation of the public lands surveyed.

The subjects of the field sketches; accuracy of detail in special cases; use of aerial photographs; map features within the interior of sections; etc., are enlarged in chapter IX.

## Monumentation

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4-1. This chapter describes the procedure for monumenting a public land survey. The monumentation is intended to establish a permanent marking of the lines and to fix the corner positions so that the location of the surveyed lands may always be definitely known.

### LEGAL SIGNIFICANCE OF THE MONUMENT

4-2. The law provides that the original corners established during the process of the survey shall forever remain fixed in position, even disregarding technical errors which may have passed undetected before acceptance of the survey.

The courts attach major importance to evidence relating to the original position of the corner, such evidence being given far greater weight than the record relating to bearings and lengths of lines. The corner monument is direct evidence of the position of the corner.

Section 57 of the Criminal Code of 1909, as slightly modified in 18 U.S.C. 1858, provides a penalty for the unauthorized alteration or removal of any Government survey monument or marked trees:

Whoever willfully destroys, defaces, changes, or removes to another place any section corner, quarter-section corner, or meander post, on any Government line of survey, or willfully cuts down any witness tree or any tree blazed to mark the line of a Government survey, or willfully defaces, changes or removes 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.

The legal importance of the corner makes mandatory the workmanlike construction of lasting monuments skillfully related to natural objects or improvements so that the greatest practicable permanence is secured.

4-3. If it is necessary to alter the condition of a previously established monument, the utmost regard should be shown for the evidence of the original location. The monument should be carefully reconstructed by such additional means as may be appropriate, *without destroying the evidence which served to identify that position*. A complete record will be kept of the description of the old monument as identified, and all alterations and additions will be specifically noted as such.

### GENERAL REQUIREMENTS

4-4. Prescribed monuments are used to mark the position of the quarter-section, section, township, and meander corners; such sixteenth-section corners as the special instructions or exigencies of the survey of fractional sections require; and all angle points and points at intervals of 40 and 80 chains along an irregular boundary. Additionally, when stipulated in the special instructions, monumentation is established as needed down to the corners of  $2\frac{1}{2}$ -acre aliquot parts as required in the subdivision of sections into units smaller than the regular quarter-quarter section.

When it is necessary or desirable to establish special purpose monuments the regulation post is the first choice under usual conditions.

4-5. The position of a corner monument is evidenced by the best accessories available; if the corner point itself cannot be marked in the usual manner, an appropriate witness corner or

reference monument is established. A witness meander corner is established upon secure ground wherever the true position falls at a point where the monument would be liable to destruction.

4-6. The field notes relating to the establishment of a monument are introduced at the logical place where the true position for the corner is indicated.

The description of the monument will embrace: (1) the significance of its position; (2) its type and dimensions, including those of any special monumentation; (3) the depth set in the ground, with mention of any additional support; (4) the markings upon the monument; and (5) the nature of the accessories, including character, size, position, and markings.

### CORNER MATERIAL

4-7. The Bureau of Land Management has adopted a regulation post for monumenting the public surveys, which is used generally unless exceptional circumstances warrant the use of other material. Substitutions are permitted only when authorized in the special instructions. In such cases a statement should be given in the field notes explaining why regulation posts were not employed.

The regulation post is made from alloyed iron pipe, zinc-coated,  $2\frac{1}{2}$  inches outside diameter, which is cut into lengths of 30 inches. One end of the pipe is split for several inches, and the two halves are spread to form flanges. A brass cap is securely fastened to the top. Brass tablets are supplied for placing in rock outcrop and for imbedding in concrete monuments. The tablet is  $3\frac{1}{4}$  inches in diameter and has a stem  $3\frac{1}{2}$  inches long. The top bears the same official inscription as that of the cap of the iron post.

4-8. General departures from the use of the regulation monument may be authorized where there is need for more durable monumentation in important areas, where conditions at the time of survey make it impracticable to procure a sufficient number of regulation monuments within the available time limit, or where difficulties of transportation to the point of use make it more practicable to adopt an approved substitute. Trials of experimental monuments

are authorized from time to time where this can be done without risk of losing corner point locations. Limited departures because of site conditions may be made as approved by the officer in administrative charge.

Native stone may be substituted for the iron post, provided it has been authorized, is durable against prolonged weathering, has a volume of at least 1,000 cubic inches, and dimensions suitable for permanent monumentation and appropriate markings. Stone will not be used as a corner monument where its position falls among large quantities of loose surface stone or slide rock.

### CONSTRUCTION OF MONUMENTS

4-9. The caps of the iron posts are marked with steel dies at the time when used. The posts are set in the ground about three-fourths of their length, and earth and stone, if the latter is at hand, are tamped into the excavation to give the post a solid anchorage.

4-10. A stone monument is marked with a steel chisel or punch with such letters, figures, grooves, or notches as may be required, and is firmly set in the ground about three-fourths of its length.

4-11. Both iron posts and stone monuments will always be set a depth of three-fourths their length unless it is impossible to complete the excavation, in which case the monument will be planted as deep as conditions will permit, and the necessary support will be secured by a stone mound.

In loose, wind-blown soil, the monument is much more stable if surrounded with stone, the mound being built with a wide base, and up to the height of the post. This will be even more secure if clay soil can be procured for filling the voids. The location may be of enough importance to justify the construction of a concrete base surrounding the iron post to prevent the blowing of the soil.

Underpinning or other special means for supporting the iron post may be required when constructing a stable monument in marshland. Encasement of the post in concrete to prevent corrosion may be necessary in the case of alka-

line soils, salts, salt-water marshes, organic-acid water in swamp areas, or similar situations.

4-12. Where the corner point falls upon surface rock, preventing excavation, a cross (X) is cut at the exact corner point, and, if feasible, the monument is erected in the same position, supported by a large mound of stone with broad base, so well constructed that it will possess thorough stability.

The tablet is used for marking corners which fall upon rock outcrop on slopes where a stable mound would be impracticable. A drill hole is made to receive the stem, and a recess is made for the top so that the tablet may be securely cemented in place and sealed against moisture. To be permanent the cementing must be done with clean first-class materials, carefully proportioned. The tablet is marked in the same manner as the iron-post monument.

On slopes too steep to allow construction of a

stable mound, but covered with a thin layer of soil which would hide the tablet if it were set directly in the bedrock, a short length of zinc-coated iron pipe of 1-inch outside diameter is forced into the drill hole. The stem of the tablet is then wedged securely into the top of the pipe in a position above the layer of soil.

4-13. Where the corner point falls at the position occupied by a tree, the tree is marked as the corner monument, even if fully matured. The full quota of accessories should be secured, including reference monuments.

A tree too small to receive the usual marks without injury is marked with an "X" only at breast height on the *south* side. The X should be scribed in the bark on smooth-barked trees. On rough-barked trees the X should be made by two axe cuts reaching just into the live wood tissue. It is advantageous to clear out nearby trees of similar size in order that the marked tree will not be smothered by faster growing uninjured trees.

4-14. Monuments marking corners that fall in cultivated fields or meadows are so constructed as to interfere with farming operations as little as possible and conform to the wishes of the owner insofar as practicable.

Generally an iron post, brass tablet in a concrete block, a marked stone, or some suitable article may be buried at the corner point and witnessed by a substantial guard post. Bearing objects or bearing trees within a reasonable distance are employed, and accurate bearings to one or more available distant objects are recorded.

## SPECIAL-PURPOSE MONUMENTS

### Witness Corners

4-15. A *witness corner* is a monumented point usually on a line of the survey and near a corner. It is established only in situations where it is impracticable to occupy the site of a corner.

When the true point for a corner falls at an inaccessible place, such as within an unmeandered stream, lake, or pond, or in a marsh, or upon a precipitous slope or cliff where the corner cannot be occupied, a witness corner is

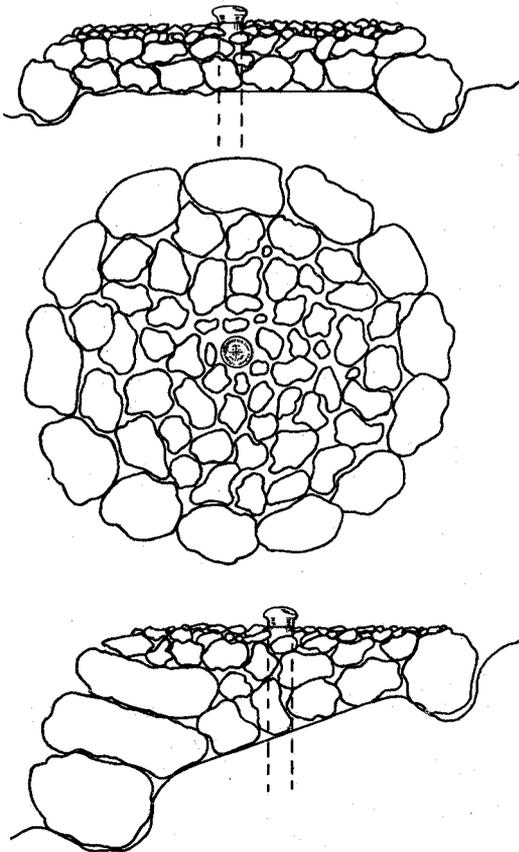


FIGURE 64.—A mound of stone. Base should be not less than 3 ft. diameter.

established at some suitable point where the monument may be permanently constructed, but preferably on a line of survey.

Usually only one witness corner is established, and it should be located upon one of the lines leading to a corner if a secure place within a distance of 10 chains is available. If there is no place to be found on a surveyed line within that distance, a witness corner may be located in any direction within a distance of 5 chains.

The field notes show the relation of the witness corner to the true point for the corner. The direct connecting course and distance *from* the true point *to* the witness corner are shown on the plat. If there are many witness corners, and in cases of difficult plat lettering, where it may interfere with the other showings of the plat, the data relating to the direction and distance may be indicated by marginal memorandum or tabulation.

### Reference Monuments

4-16. A *reference monument* is an accessory and is employed in situations where the site of a corner is such that a regular permanent monument cannot be established or where the monument would be liable to destruction, and bearing trees or a nearby bearing object are not available.

Where the true point for a corner falls within an unimproved roadway in such a place as to interfere with travel, an iron post, a tablet in a concrete block, or a marked (X) stone or some suitable article will be buried in the ground at the true corner point. At least two reference monuments are established at suitable places outside of the roadway, if bearing trees or a nearby bearing object are not available. Allowance should be made for grading, cuts, fills, or other road improvement when placing the reference monuments.

The surface of gravel, macadam, or bituminous-topped roads should not be dug into without the approval of the proper authority. If permission is granted, a deposit may be made at the true corner point. In the case of a hard surface, a tablet, copper bolt, large nail, or cross (X) may be placed at the true point. In any event the corner point can be occupied and

may be marked temporarily by paint or scratching. Two reference monuments, established following the practice for highway surveys to the extent that is feasible, ordinarily suffice in public survey practice, but four may be employed if desirable. When two monuments are used, they are usually placed equidistant and in opposite directions; an acceptable alternative is placement of the monuments so that the lines connecting them with the corner point are approximately perpendicular to each other. Four monuments are placed in opposite directions in the four quadrants.

Reference monuments are described with other accessories to the corner in the field notes but are not shown on the plat.

### Witness Points

4-17. A *witness point* is a monumented station on a line of the survey that is used to perpetuate an important location more or less remote from and without special relation to any regular corner.

The station may be near a road or stream crossing, valuable improvements, the border of a large cultivated field or meadow, an important unmeandered stream or lake, or the border of a reservoir; at the summit of an important slope, ridge, or mountain; or at end stations of a long triangulation, offset, or traverse that passes over the point for a normal corner, where one or both stations are beyond the limiting distance of 10 chains prescribed for setting witness corners.

The establishment of a witness point is described in the field notes but not usually shown on the plat.

### Location Monuments

4-18. A *location monument* is most frequently used as a reference for one or more mineral surveys, and its use is described in detail in sections 10-32 through 10-34. It may also be used in any situation where no corner of an existing survey is available to provide a satisfactory connection for an isolated special survey. The monument is generally established in a conspicuous position with good visibility from every direction. A corner of the special survey

may be designated as a location monument if it meets this qualification.

**Control Points**

4-19. A *control point* serves a purpose similar to that of a location monument in connection with photogrammetric surveys, electronic surveys, or surveys established by use of airborne control. It may be connected directly to a corner or may be related through coordinates.

**SYSTEM OF MARKING**

**Making the Marks**

4-20. Monuments are marked in accordance with a system that furnishes a ready identification of the position of the monument which bears the marks. Capital letters and Arabic figures are used to mark iron posts and tree monuments. The letters and figures relate to the township, range, and section to which the corner belongs. On stone corner monuments marks termed notches and grooves are used to convey the information. The notches and grooves relate, in the case of an exterior corner, to the number of miles from the monument to the adjoining township corners. In the case of a subdivisinal corner, they relate to the normal number of miles from the monument to the east and south boundaries of the township.

4-21. The marks should be carefully arranged, neat, distinct, and durable. An assortment of steel dies, stone chisels and punches, and timber scribes, in good condition for use, should always be available.

4-22. An index of the ordinary markings common to all classes of monuments and corner accessories is given below.

<i>Marks</i>	<i>To indicate—</i>
A M.....	Amended monument
A M C.....	Auxiliary meander corner
A P.....	Angle point
B O.....	Bearing object
B T.....	Bearing tree
C.....	Center
C C.....	Closing corner
E.....	East
E C.....	Electronic control
L M.....	Location monument
M.....	Mile
M C.....	Meander corner

N.....	North
NE.....	Northeast
NW.....	Northwest
R.....	Range
R M.....	Reference monument
S.....	Section
S.....	South
S C.....	Standard corner
SE.....	Southeast
S M C.....	Special meander corner
SW.....	Southwest
T.....	Township
TR.....	Tract
W.....	West
W C.....	Witness corner
W P.....	Witness point
1/4.....	Quarter section
1/16.....	Sixteenth section

**MARKS ON CORNER MONUMENTS**

**Marks on Iron Post Monuments and Brass Tablets**

4-23. The markings on the brass cap of the regular corner monument are always made to be read from the south side of the monument. The year number of the date when established is placed on the south. If the marks or accessories are changed or added to in the course of a re-survey, the new year number is marked above or below the original number without destroying the former marks.

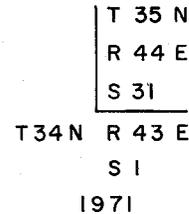
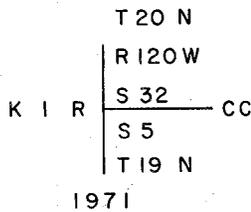
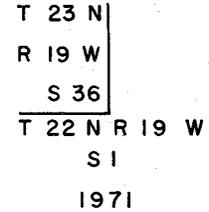
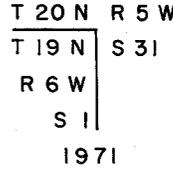
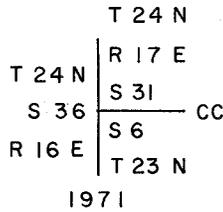
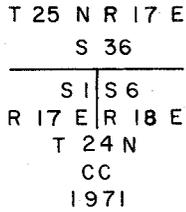
4-24. *Standard township corners* are marked "S C" and the township on the north half, and the ranges and sections in the proper quadrants:

S C			
T 25 N			
R 17 E	R 18 E		
S 36	S 31		

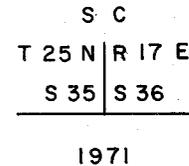
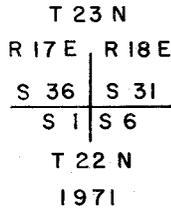
1971

4-25. *Closing township corners* are marked "C C" on the half from which the closing line approaches the monument, with the township (or range) on the same half, and the ranges (or townships) and sections in the proper quadrants; also (as far as known at the time) the township, range, and section, or the initials or abbreviation of the reservation, grant, or private claim upon which the township exterior closes. The name of a State is not placed on the

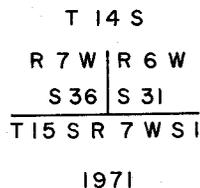
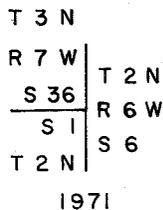
monument of a closing corner even though the monument is intended to be placed on the State boundary. See section 5-19, State Boundary Monuments.



4-26. *Corners common to four townships* are 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:



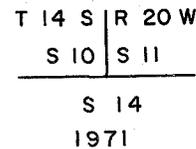
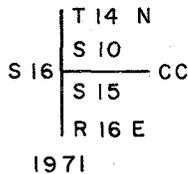
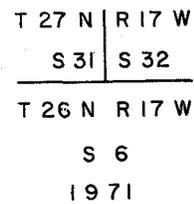
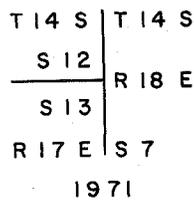
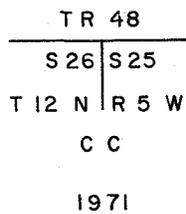
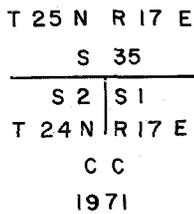
4-27. *Corners common to two townships only* are marked with the township (or range) common to both on the proper half, and the ranges (or townships) and sections in the proper quadrants; also (as far as known at the time) the township, range, and section upon the opposite half:



4-28. *Corners referring to one township only* are 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:

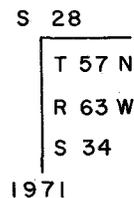
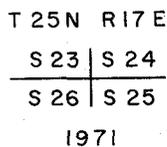
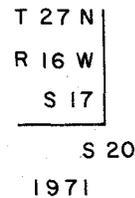
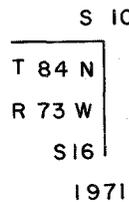
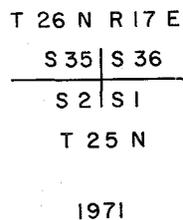
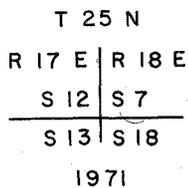
4-29. *Standard section corners* are marked "S C" and the township and range on the north half, and the sections in the proper quadrants:

4-30. *Closing section corners* are marked "C C" and the township and range on the half from which the closing line approaches the monument, and the sections in the proper quadrants; also (as far as known at the time) the township, range, and section, or the initials or abbreviation of the reservation, grant, or private claim, upon which the section line closes, with the exception that in the case of an interior closing section corner, the township and range numbers are not repeated:



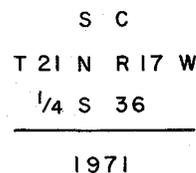
4-31. *Corners common to four sections are marked: (a) On an exterior, with the township (or range) common to the adjoining townships, the ranges (or townships) upon the opposite sides of exterior, and the sections; and (b) a subdivisional corner, with the township, range, and sections:*

4-33. *Section corners referring to one section only are marked with the township, range, and section in the particular quadrant which is concerned; also (if known at the time) the section upon the opposite part:*



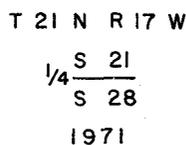
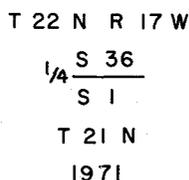
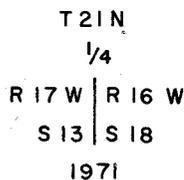
4-32. *Section corners common to two sections only are marked with the township and range on the half facing the sections to which the corner belongs, and the sections in the proper quadrants; also (as far as known at the time) the township, range, and section upon the opposite half, except that in the case of an interior corner, the township and range numbers are not repeated:*

4-34. *Standard quarter-section corners are marked with "S C", the township, range, "1/4", and the section, all on the north half:*

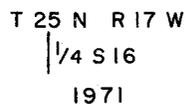
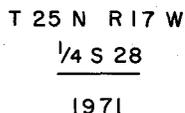
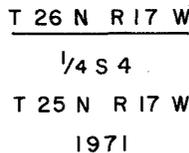
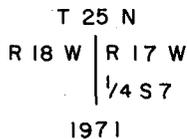


4-35. *Quarter-section corners of maximum control are marked (a) on a meridional exterior, with the township and "1/4" on the north,*

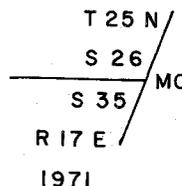
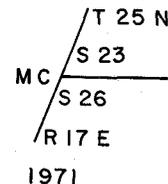
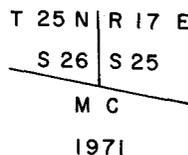
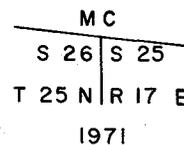
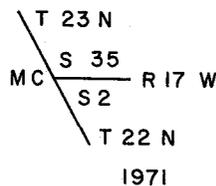
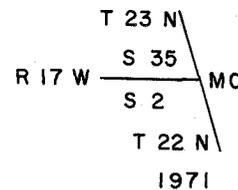
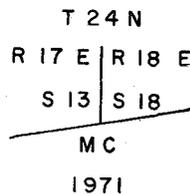
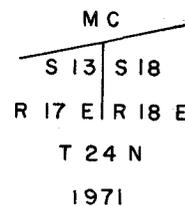
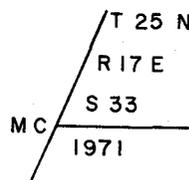
and the ranges and sections on the east and west halves; (b) on a latitudinal exterior, "1/4" on the west, the range on the north, and the townships and sections on the north and south halves; (c) on a meridional subdivisional line, with the township and range on the north, "1/4" on the north, and the sections on the east and west halves; and, (d) on a latitudinal subdivisional line, with the township and range on the north, "1/4" on the west, and the sections on the north and south halves:



4-36. Quarter-section corners of minimum control are marked (a) on a meridional exterior with the township on the north, ranges on the east and west, and "1/4" and the section on the half toward the particular section which is concerned; (b) on a latitudinal exterior, with the township and range on the north and south halves, and "1/4" and the section on the half toward the particular section which is concerned; and, (c) on a subdivisional line, with the township and range on the north, and "1/4" and the section on the half toward the particular section which is concerned:



4-37. Meander corners are marked "M C" on the half toward the meanderable body of water, and the additional marks (a) on a standard parallel or other line controlling surveys to one side only, with the township, range, and section toward the surveyed land; (b) on an exterior, with the township (or range) common to the adjoining townships, the ranges (or townships) upon the opposite sides of the exterior, and the sections; and, (c) on a subdivisional line, with the township, range and sections:



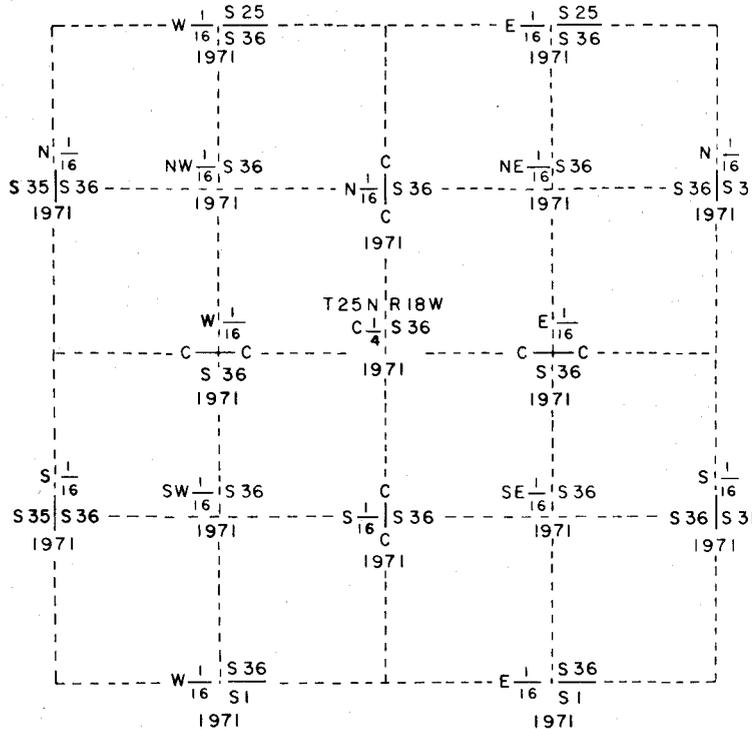


FIGURE 65.—Marks on monuments at interior quarter-section corner and all sixteenth-section corners.

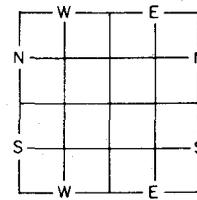
4-38. Interior quarter-section corner and all sixteenth-section corners, when required by the special instructions are marked in accordance with the scheme shown in figure 65.

4-39. Corners of minor subdivisions. Where a quarter-quarter section is subdivided into quarter-quarter-quarter sections (1/64 or 10-acre units), or aliquot parts as small as 1/256 (2.5 acres), the monuments on the boundaries of the quarter-quarter section, and those needed for the perimeter lines within the quarter-quarter section, are marked on the plan indicated in figure 66.

The diagram shows the marking for the monuments at corners of 2.5-acre units within one regular quarter-quarter section. If those units, or any one of them, are quartered, only the fraction 1/1024 is used for marking whatever monuments may be required of that order, including also the year number.

Markings on monuments at the corners of 1/64 and 1/256 of a section, when subdivided as aliquot parts, for example on the boundaries of and within the SE $\frac{1}{4}$ , SE $\frac{1}{4}$  sec. 36 are shown in figure 66.

4-40. Sixteenth-section corners of minimum control are marked with a key letter (N, E, S, or W) to indicate the position of the monument, and "1/16" and the section, all on the half toward the particular section which is concerned:



Key

S 1/16  
S 36  
1971

E 1/16  
S 22  
1971

4-41. Corners of Elongated Sections. Additional monuments are required on section boundaries where the length of the closing line exceeds 85 chains. These are placed at inter-

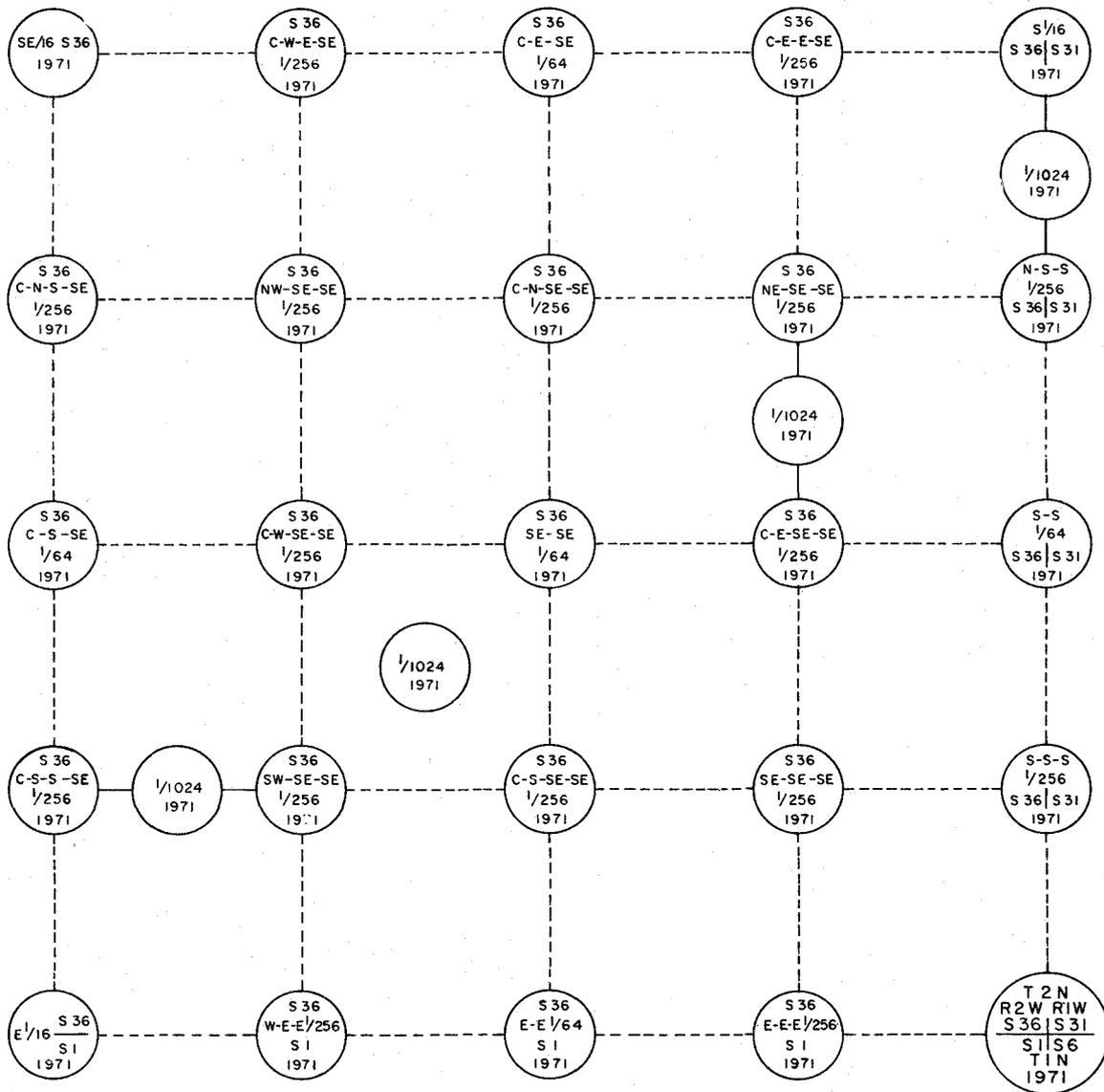


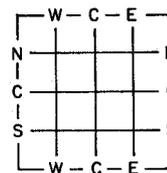
FIGURE 66.—Marks on monuments at corners of minor subdivisions. If 1/1024 section corners are established, only "1/1024" and the date are marked on the brass cap.

vals of 40 chains counting from the regular quarter-section corner. The plan for the special marking is based upon the distance each monument is established from the regular governing boundary, generally the south or east. In cases where special circumstances call for the establishment of corners within the section, the monuments are also marked with reference to the subdivision-of-section lines upon which they are placed. The markings are illustrated by figures 67 and 68. Special attention should be given to whether the markings of monuments

on the section boundaries are to show maximum or minimum control.

4-42. *Special meander corners* are marked in accordance with the following scheme:

Key letters (N, E, S, W, or C) are used in pairs to indicate the position of the subdivision-of-section line.



Key

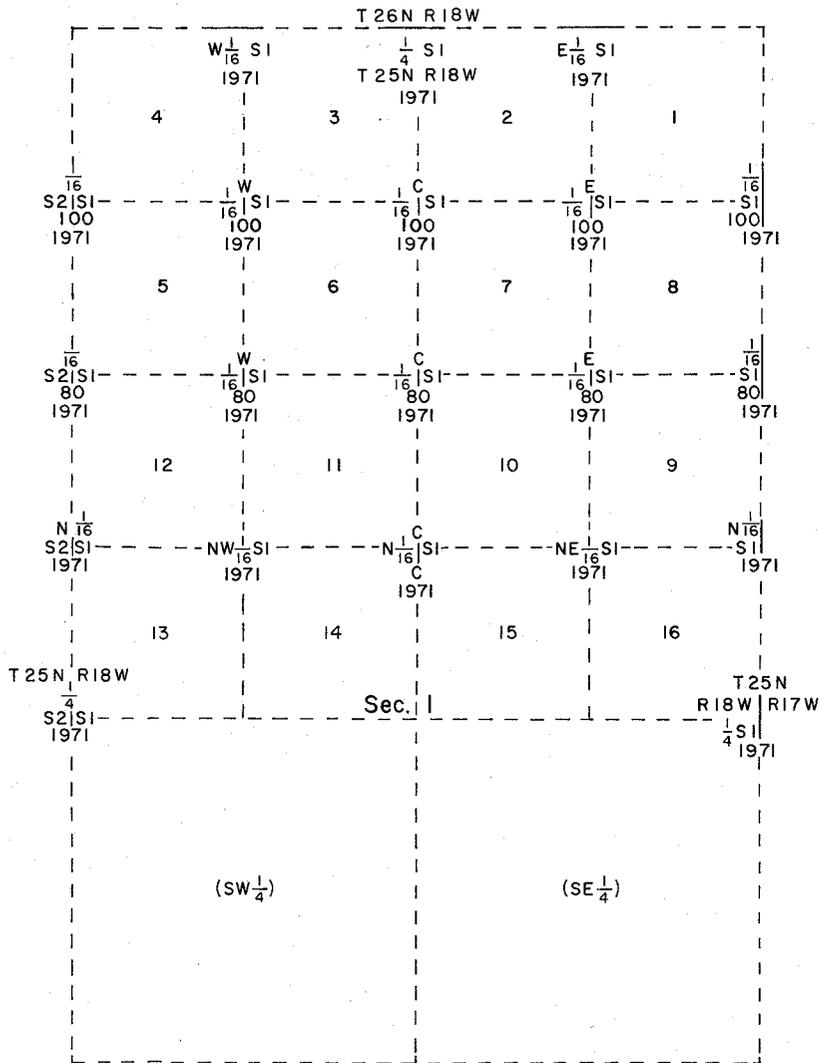
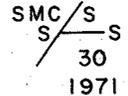
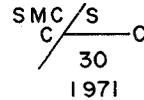
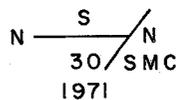
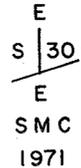
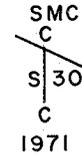
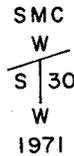


FIGURE 67.—Marks on monuments at corners of an elongated section.

The marks "S M C" are placed on the half toward the meanderable body of water, and the section on the opposite half:



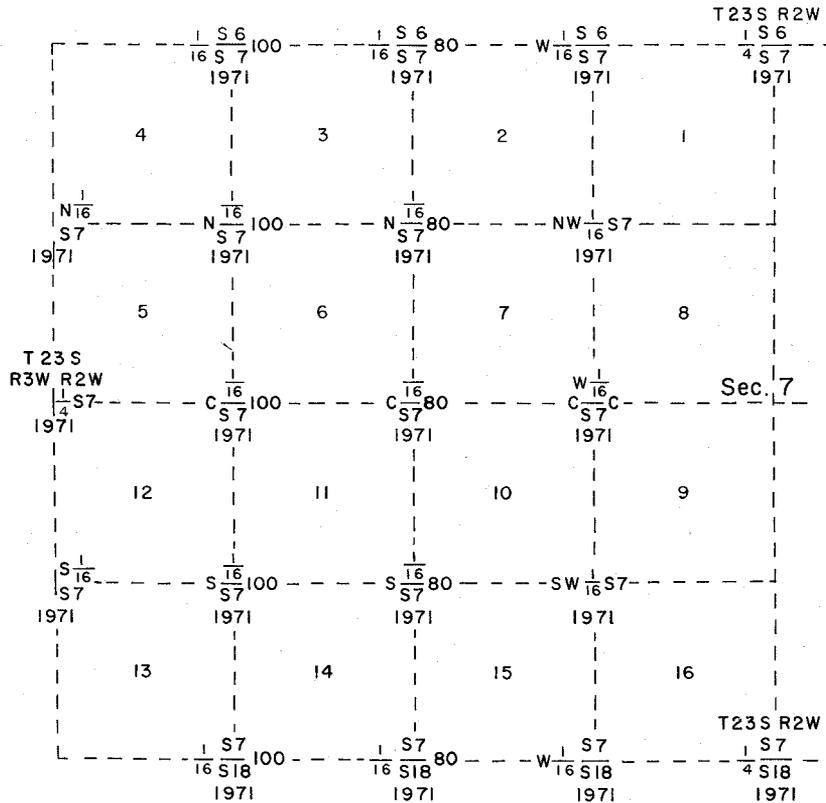


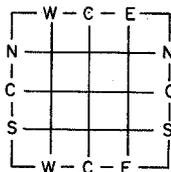
FIGURE 68.—Marks on monuments at corners of an elongated section.

4-43. *Auxiliary meander corners* are marked "A M C" and the township, range, and section:

AMC  
T 64 N R 37 W  
S 29  
1971

When *two or more* auxiliary meander corners are required for islands in the same section, they should be identified by lot or tract number, not by serial number.

4-44. *Closing subdivision-of-section corners* are marked in accordance with the following scheme:



Key

Key letters (N, E, S, W, or C) are used in pairs to indicate the position of the subdivision-of-section line.

The marks "C C" and the section are placed on the half from which the closing line approaches the monument.

(The marks "B I R" indicate "Blackfeet Indian Reservation.")

PL  
E  
CC | S 28  
E  
B I R  
1971

PL  
C  
CC | S 28  
C  
B I R  
1971

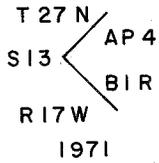
PL / CC  
C / S 28  
B I R  
1971

PL  
W  
CC | S 28  
W  
B I R  
1971

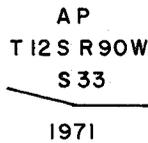
PL / CC  
N / S 28  
B I R  
1971

PL / CC  
S / S 28  
B I R  
1971

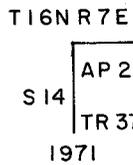
4-45. Markings for *miscellaneous angle points* on irregular boundaries:



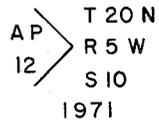
For "angle point No. 4" on the boundary of the "Blackfeet Indian Reservation," falling on surveyed land.



For "angle point" on the south boundary of section 33, superseding an old standard corner on a defective line, not subject to rectification.

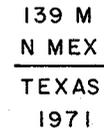


For "angle point No. 2" on the boundary of a private claim ("Tract No. 37") falling on surveyed land.



For "angle point No. 12" on a reestablished non-riparian meander line; the marks "AP" and the serial number are placed on the half toward the land erroneously omitted from the original survey.

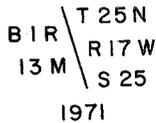
4-46. Markings for *intermediate corners* along boundaries:



For "139th mile corner" on the boundary line between the States of "New Mexico and Texas."



For "3d mile corner" on the boundary of the "Blackfeet Indian Reservation," falling on unsurveyed land.



For "13th mile corner" on the boundary of the "Blackfeet Indian Reservation," falling on surveyed land.

Marks on Stone Monuments

4-47. Where a stone monument is established, the letters, figures, and grooves are cut on the exposed faces or sides of the stone, but not on its top or end; the notches are cut upon the exposed vertical edges. Grooves are employed where the faces of a stone are oriented to the cardinal; notches where the vertical edges are turned to the cardinal. Letters and figures are made 1 to 1½ inches high. Grooves and notches are of comparable size but are always horizontal to the face or edge on which they are

made. All marks should be plainly and permanently chiseled into the stone.

4-48. *Standard township corners* (oriented with the faces to the cardinal) are marked "S C" on the north face, with the township on the same face, and the ranges on the adjoining faces:

- S C 25 N on N.,
- 18 E on E., and
- 17 E on W. face.

4-49. *Closing township corners* (oriented with the faces to the cardinal are marked "C C" and with six (or fewer) grooves on the face from which the closing line approaches the monument—the grooves to indicate the normal number of miles (or fractional parts) from the monument to the adjoining township corner—with the township (or range) on the same face, and the ranges (or townships) on the adjoining faces; also the initial or abbreviation of the reservation, grant, or private claim, on the face toward such irregular tract as may be closed upon:

- 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
- B I R on W. face.

4-50. *Corners common to four townships* (oriented with the edges to the cardinal) are marked with the townships on the northeast and southwest faces, and the ranges on the southeast and northwest faces:

- 23 N on NE.,
- 18 E on SE.,
- 22 N on SW., and
- 17 E on NW. face.

4-51. *Corners common to two townships only* (oriented with the faces to the cardinal) are marked with the township (or range) common to both on the face toward the townships, and the range (or townships) on the adjoining faces:

- 3 N on N.,
- 2 N on S., and
- 7 W on W. face.

4-52. *Corners referring to one township only* (oriented with the edges to the cardinal)

are marked with the township and range on the face toward the particular township:

23 N 7 W on NW. face.

4-53. *Standard section corners* (oriented with the faces to the cardinal) are marked "S C" on the north face, and with from one to five grooves on the east and west faces, the grooves to indicate, respectively, the number of miles from the monument to the adjoining (regular) township corner:

S C on N.,

1 groove on E., and

5 grooves on W. face (standard corner of sections 35 and 36)

4-54. *Closing section corners* (oriented with the faces to the cardinal) are marked "C C" and with from one to six grooves on the face from which the closing line approaches the monument, and from one to five grooves on each of the adjoining faces—the grooves to indicate the number of miles (or fractional parts) from the monument to each of the three (regular) township boundary lines in the same directions, respectively—also the initials or abbreviation of the reservation, grant, or private claim, on the face toward such irregular tract as may be closed upon:

2 grooves on E.,

C C and 6 grooves on S., and

4 grooves on W. face (on line between sections 2 and 3 closing on a standard parallel).

4-55. *Corners common to four sections* (oriented with the edges to cardinal) are marked (a) on an exterior, with from one to five notches each on two opposite edges, north and south on a meridional line, and east and west on a latitudinal line, each to indicate, respectively, the number of miles from the monument to the adjoining (regular) township corner; and (b) a subdivisional corner, with from one to five notches on the east and south edges, each to indicate, respectively, the number of miles from the monument to the (regular) east and south township boundary lines. The subdivisional section corners of a fractional township are marked with reference to the theoretical position of normal east and south boundaries, whether surveyed or not:

2 notches on N. and 4 notches on S. edge (for corner of sections 7, 12, 13 and 18 on a range line).

2 notches on E. and 4 notches on W. edge (for corner of section 2, 3, 34 and 35 on a township line).

2 notches on E. and 4 notches on S. edge (for corner of sections 10, 11, 14 and 15, of a subdivisional survey).

4-56. *Section corners common to two sections only* (oriented with the edges to the cardinal) are marked with the sections on the faces toward the particular sections to which the corner belongs:

S 13 on SW., and

S 12 on NW. face (for corner of sections 12 and 13 on the east boundary of a township).

S 11 on NE., and

S 10 on NW. face (for corner of sections 10 and 11 of a subdivisional survey running north from monument).

4-57. *Section corners referring to one section only* (oriented with the edges to the cardinal) are marked with the section on the face toward the particular section which is concerned:

S 17 on NW. face (for southeast corner of section 17).

4-58. *Standard quarter-section corners* (oriented with the faces to the cardinal) are marked "S C $\frac{1}{4}$ " on the north face.

4-59. *Quarter-section corners of maximum control* (oriented with the faces to the cardinal) are marked (a) on a meridional line, " $\frac{1}{4}$ " on the west face; and (b) on a latitudinal line, " $\frac{1}{4}$ " on the north face.

4-60. *Quarter-section corners of minimum control* (oriented with the faces to the cardinal) are marked " $\frac{1}{4}$ " and the section, all on the face toward the particular section which is concerned:

$\frac{1}{4}$  S on S. face (for quarter-section corner on the north boundary of section 4).

4-61. *Meander corners* (oriented with the faces to the cardinal) are marked "M C" on the face toward the meanderable body of water, and with from one to six grooves on each of the other faces, each to indicate the number of miles (or fractional parts) from the monument

to the (regular) township boundary line in the same direction, respectively:

M C on N.,

6 grooves on E.,

4 grooves on S., and

6 grooves on W. face (for meander corner of fractional sections 13 and 18, on the south side of a meanderable body of water).

4-62. *Special and auxiliary meander corners* (oriented with the faces to the cardinal) are marked "S M C" or "A M C", as the case may be, on the face toward the meanderable body of water, and the section on the opposite face:

S M C on N., and

S 19 on S. face (for special meander corner on a meridional subdivision-of-section line in section 19, on the south side of a meanderable body of water).

S 20 on E., and

A M C on W. face (for auxiliary meander corner in section 20, on the east side of a meanderable body of water).

### Marks on Tree Monuments

4-63. Where the true point for a corner is found to fall in the position occupied by a sound living tree, the tree is made the monument. A tree is removed if it is too small to be marked.

4-64. Where a tree is to be made a monument, the species of the tree and its diameter at breast height are noted. The appropriate marks are made upon the trunk of the tree immediately above the root crown. A series of marks to be made upon a particular side of a tree are scribed in a vertical line reading downward.

If the corner point differs significantly from the center of the tree, the field notes will so state. Consideration will be given to using reference monuments to indicate the corner point exactly.

4-65. In the case of certain trees, including the aspen, beech and locust (smooth and thin-barked), the marks may be made preferably by scribing lightly into the bark without blazing; the marks thus made will remain as long as the tree is sound. On the rough-barked trees, the marks should be scribed into a smooth, narrow, vertical blaze, specially prepared by re-

moving just enough of the outer growth to expose a flat surface of the live wood tissue immediately underneath the bark. The marks thus made will remain as long as the tree is sound, but the blaze and marks will be covered by a gradual overgrowth, showing an outward scar for many years. In regions subject to heavy snowfall it is desirable to make a small additional blaze at a height of 6 or 8 feet above the ground, which will serve to attract attention to the tree during the winter season. The ends of the blaze should be smoothed off gradually without making a sharp cut into the live wood tissue. The lower end of the blaze upon which the marks are placed should be about 6 inches above the root crown, and its length should be just sufficient to take the marks.

Trees should always be marked in a way that will cause the least possible injury and enable rapid overgrowth. Placing the marks at the bottom ensures that they will remain on the stump if the tree is cut down.

4-66. The above caution applies equally to the marking of bearing trees, and the surveyor should not remove the overgrowth on a tree monument or bearing tree unless it is absolutely necessary to do so in order to identify the tree. The marks on old bearing trees should not be disturbed or added to. New trees may be marked, which will be recorded in the field notes.

In the case of trees which have been blazed before marking, the number of rings contained in the overgrowth (or its equivalent on the adjoining sections of the tree) furnish count of the number of years (one annual ring for each growing season) from the date of original marking to the date when uncovered. Uncovering an old blaze leaves it subject to decay, and the surveyor should adopt additional means to evidence the position of the corner.

4-67. *Standard township corners* are marked "SC" and the township on the north side, and the ranges and sections on the east and west sides:

SC T25N on N.,

R18E S31 on E., and

R17E S36 on W. side.

4-68. *Closing township corners* are marked "CC" and the township (or range) on the side from which the closing line approaches the

monument, and the ranges (or townships) and sections on the adjoining sides; also the initials or abbreviation of the reservation, grant, or private claim, on the side toward any irregular tract which may be closed upon:

R18E S6 on E.,  
CC T24N on S., and  
R17E S1 on W. side.

4-69. *Corners common to four townships* are marked with the township and section on the northeast and southwest sides, and the range and section on the southeast and northwest sides:

T23N S31 on NE.,  
R18E S6 on SE.,  
T22N S1 on SW., and  
R17E S36 on NW. side.

4-70. *Corners common to two townships only* are marked with the township, range, and section on the sides toward the particular townships:

T2N R7W S1 on SW., and  
T3N R7W S36 on NW. side.

4-71. *Corners referring to one township only* are marked with the township, range, and section on the side toward the particular township which is concerned:

T23N R7W S36 on NW. side.

4-72. *Standard section corners* are marked "SC" and the township and range on the north side, and the sections on the east and west sides:

SC T25N R17E on N.,  
S36 on E., and  
S35 on W. side.

4-73. *Closing section corners* are marked "CC" and the township and range on the side from which the closing line approaches the monument, and the sections on the adjoining sides; also the initials or abbreviation of the reservation, grant, or private claim on the side toward any irregular tract which may be closed upon:

S1 on E.,  
CC T24N R17E on S., and  
S2 on W. side.

4-74. *Corners common to four sections* are marked (a) on an exterior, with the township (or townships), ranges (or range) and sections; and (b) a subdivisational corner, with the township, range and section:

(a) T25N S7 on NE.,  
R18E S18 on SE.,  
R17E S13 on SW., and  
S12 on NW. side.

(a) T26N S36 on NE.,  
R17E S1 on SE.,  
T25N S2 on SW., and  
S35 on NW. side.

(b) T25N S24 on NE.,  
R17E S25 on SE.,  
S26 on SW., and  
S23 on NW. side.

4-75. *Section corners common to two sections only* are marked with the township and section, and the range and section, on the sides toward the particular sections to which the corner belongs:

T14S S11 on NE., and  
R20W S10 on NW. side.

4-76. *Section corners referring to one section only* are marked with the township, range and section on the side toward the particular section which is concerned:

T27N R16W S17 on NW. side.

4-77. *Standard quarter-section corners* are marked "SC $\frac{1}{4}$ " and the section, all on the north side:

SC $\frac{1}{4}$  S36 on N. side.

4-78. *Quarter-section corners of maximum control* are marked (a) on a meridional line, " $\frac{1}{4}$ " and the section on the west side, and the section on the east side; and (b) on a latitudinal line, " $\frac{1}{4}$ " and the section on the north side, and the section on the south side:

(a) S18 and E., and  
 $\frac{1}{4}$  S13 on W. side.

(b)  $\frac{1}{4}$  S21 on N., and  
S28 on S. side.

4-79. *Quarter-section corners of minimum control* are marked " $\frac{1}{4}$ " and the section, all on the side toward the particular section which is concerned:

$\frac{1}{4}$  S7 on E. side (for quarter-section corner on the west boundary of section 7).

4-80. *Meander corners* are marked "MC" on the side toward the meanderable body of water, and the additional marks (a) on a standard parallel or other line controlling surveys to one side only, with the township, range and section on the side toward the surveyed land; (b)

on an exterior, with the township (or range) common to the adjoining townships on the side opposite the meanderable body of water, and the ranges (or townships) and the sections on the adjoining sides; and, (c) on a subdivisional line, with the township and range on the side opposite the meanderable body of water, and the sections on the adjoining sides:

- (a) MC on E., and  
T25N R17E S33 on NW. side (for meander corner on a standard parallel, on the west side of a meanderable body of water).
- (b) T24N on N.,  
R18E S18 on E.,  
MC on S., and  
R17E S13 on W. side (for meander corner on a range line, on the north side of a meanderable body of water).
- (b) T23N S35 on N.,  
MC on E.,  
T22N S2 on S., and  
R17W on W. side (for meander corner on a township line, on the west side of a meanderable body of water).
- (c) S23 on N.,  
T25N R17E on E.,  
S26 on S., and  
MC on W. side (for meander corner on a latitudinal section line, on the east side of a meanderable body of water).
- (c) MC on N.,  
S9 on E.,  
T4N R7W on S., and  
S8 on W. side (for meander corner on a meridional section line, on the south side of a meanderable body of water).

4-81. *Special and auxiliary meander corners* are marked "SMC" or "AMC", as the case may be, on the side toward the meanderable body of water, and the section on the opposite side:

- SMC on E., and  
S14 on 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).

AMC on N., and

S9 on S. side (for auxiliary meander corner in section 9, on the south side of a meanderable body of water).

#### MARKS ON SPECIAL-PURPOSE MONUMENTS

4-82. At a witness corner the marks on an iron post monument are arranged as on a regular corner monument with the addition of the letters "W C" on the north and an arrow pointing to the true point for the corner. A stone is marked with the letters "W C" only, on the south face if the true line field notes are to read running north, or on the east face if the notes are to read running west. On a tree, two hacks are made on the north and south sides on a meridional line or two hacks on the east and west sides on a latitudinal line. The marks are the same as on a line tree, which serves the same purpose.

A reference monument normally is marked the same as a bearing tree located in a similar position with the addition of an arrow pointing to the corner point, and the date, and substituting the letters "R M" for "B T". Where reference monuments are established at corners of minimum control, including corners on standard lines, the monument established in the section to which the corner does not refer is marked only with the letters "R M", an arrow pointing to the corner point, and the date. If there is sufficient space on the brass cap or tablet, the distance to the true corner may be stamped beside the arrow.

At a witness point the brass cap is marked "W P" at the top, the date at the bottom, and "S" with the section number on each of the halves appropriate for the line of survey. Monuments at witness points situated on subdivision-of-section lines or at other unusual places are marked as provided for in the special instructions. A stone is marked "W P" only on the face as in marking a witness corner monument. A tree intersected by the true line is marked as a line tree, which has the same function as a witness point.

The markings on a location monument are described in section 10-33.

Control point monuments established by electronic methods are marked "E C", with a serial number, the year date, and the group number or survey number in the course of which they are established.

### CORNER ACCESSORIES

4-83. The purpose of an accessory is to evidence the position of the corner monument. A connection is made from the corner monument to fixed natural or artificial objects in its immediate vicinity, whereby the corner may be relocated from the accessory. Thus, if the monument is destroyed or removed, its position may be identified by any remaining evidence of the accessories. One or more kinds of accessory are employed at each corner established in the public-land surveys (except for corners of minor subdivisions and where specifically not required by the Manual, or omitted by the special instructions).

Accessories consist of (1) bearing trees or other natural objects such as notable cliffs and boulders, permanent improvements, reference monuments; (2) mounds of stone; or (3) pits and memorials. Aside from availability, selection is based on their order of permanence.

4-84. The surveyor cannot perform any more important service than that of establishing permanent and accurate evidence of the location of the corners in his survey. Where the accessories cannot be employed, other means should be adopted that will best serve the purpose.

#### Bearing Trees and Bearing Objects

4-85. Bearing trees are selected for marking when available, ordinarily within a distance of 3 chains of the corner; a greater distance if important. One tree is marked in each section unless a tree in one or more positions may not be available. A full description of each bearing tree is given in the field notes. This includes the species of each tree, its diameter at breast height, the exact direction from the monument, the horizontal distance counting to the center of

the tree at its root crown; and, the exact marks scribed for the identification of the corner.

Almost any nearby natural object that can be readily identified should be recorded by description, course, and distance. Such objects may not be of a character that can be marked, excepting in the case of a rock cliff or boulder. These are supplemental to the marking of bearing trees, or to fill out a quota where trees are not available in some sections. The description of the cliff or boulder should provide ready identification, including the marking of a cross (X) plainly and deeply chiseled at the exact point to which the direction and distance are recorded.

Another desirable accessory, especially where the usual types are not available, nor suitable on account of the site conditions, such as at a corner that falls in cultivated land, is to record accurate bearings to two or more prominent landmarks.

4-86. The marks upon a bearing tree are made upon the side facing the monument, scribed in the manner already outlined for marking tree corner monuments. The marks embrace the information suggested in the schedule hereinafter given, with such letters and figures as may be appropriate for a particular corner, and will include the letters "BT". A tree will always be marked to agree with the section in which it stands, and will be marked in a vertical line reading downward, ending in the letters "BT" at the lower end of the blaze approximately 6 inches above the root crown.

4-87. There is a great difference in the longevity of trees, and in their rate of decay; trees should therefore be selected, if possible, with a view to the length of their probable life, their soundness, favorable site conditions and size. Sound trees, not matured, of the most hardy species, favorably located, are preferred for marking. Trees 5 inches or less in diameter should not be selected for marking if larger trees are available, and it is generally better to avoid marking fully matured trees, especially those showing signs of decay. Trees 4 inches in diameter, or less, if no better trees are available, are marked with the letter "BT" only at the base, and an "X" at breast height, facing the monument. The species, size and exact position of the bearing trees are of vital importance,



Marking a bearing tree.

as this data will generally serve to identify a bearing tree without uncovering the marks, or even to identify two or more stumps after all evidence of the marks has disappeared.

4-88. Generally only one tree is marked in each section at a particular corner, but in certain instances two trees are required in a section. In such cases it is better to select trees of different species or of widely different size, direction or distance. If the trees are of the same species, in order that confusion may be avoided in the future identification of a remaining tree where the companion tree has disappeared, one is marked with an "X" only (and "BT" at the base).

4-89. A cross (X) and the letters "BO" are chiseled into a bearing object, if it is a rock cliff or boulder; the record should enable another surveyor to determine just where the marks will be found. The rock bearing object is the most permanent of all accessories; it is used wherever practicable, and within a distance of 5 chains.

4-90. A connection to any permanent artificial object or improvement may be included in this general class of corner accessories. The field notes should be explicit in describing such objects, and should indicate the exact point to which a connection is made, as "southwest corner of foundation of Smith's house," "center of Smith's well," "pipe of Smith's windmill," etc. No marks will be made upon private property without the consent of the owner.

### Memorials

4-91. Where there is no tree or other bearing object, as above described, and where a mound of stone or pits are impracticable, a suitable memorial is deposited alongside the monument. A memorial may consist of any durable article which will serve to identify the location in case the monument is destroyed. Such articles as glassware, stoneware, a marked (X) stone, a charred stake, a quart of charcoal, or pieces

of metal constitute a suitable memorial. A full description of such articles is embodied in the field notes wherever they are employed as a memorial. When replacing an old monument with a new one, such as substituting an iron post for an old marked stone, the old marker is preserved as a memorial.

### Mound of Stone

4-92. Where native stone is available and the surface of the ground is favorable, a mound of stone is employed as an accessory to a corner monument, or to surround it, even though a full quota of trees or other bearing objects can be utilized. A mound of stone erected as a corner accessory should be built as stable as possible, should consist of not fewer than five stones, and should be not less than 2 feet base and 1½ feet high. Where the ground is suitable, the stone mound is improved by first digging a circular trench, 4 to 6 inches deep, for an outer ring, then placing the base of the larger stones in the trench. In stony ground the size of the mound is sufficiently increased to make it conspicuous. The position of the accessory mound is shown in the schedule following. The nearest point on its base should be about 6 inches distant from the monument. The field notes show the size and position of the mound.

4-93. Where it is necessary to support a monument in a stone mound, and if bearing trees or other objects are not available, a marked (X) stone or other memorial is deposited alongside the monument.

A stone mound accessory, in addition to the mound surrounding a monument, is built wherever this will aid materially in making the location conspicuous.

### Pits

4-94. Where the full quota of trees or other bearing objects are unavailable for marking, the position of the monument is, under favorable conditions, evidenced by pits. No pits should be dug in a roadway, or where the ground is overflowed for any considerable period, or upon steep slopes, or where the earth will wash, or in loose or light soil, or where there is no native

sod, or where suitable stone for a mound is at hand.

A firm soil covered with a healthy native sod is most favorable for a permanent pit. Under such conditions the pits will gradually fill with a material slightly different from the original soil, and a new species of vegetation will generally take the place of the native grass; these characteristics, under favorable conditions, make it possible to identify the original location of the pits after the lapse of many years.

4-95. All pits should be dug 18 inches square and 12 inches deep, with the nearest side 3 feet distant from the corner monument, oriented with a square side (and not a corner) towards the monument, arranged as shown in the schedule following. The earth removed is scattered in such a way that it will not again fill the pits. A description of the pits is embodied in the field notes, and should include a statement of their size and position.

### Accessories to Special-Purpose Monuments

4-96. The accessories to special-purpose monuments are selected and marked as follows:

*Witness Corners:* Formerly the accessories for witness corners were the same as though the monument had been established at its true point, but the marks upon the bearing trees or other objects were preceded by the letter "WC", and the section number was made to agree with the section in which the tree or object actually stood. The rule now is that bearing objects, if available, are treated as for a regular corner. Bearing trees, with direction and distance from the monument, are marked with an "X" at breast height, on the side facing the monument, and the letters "BT" at the base. Mounds of stone are treated as though the monument were located at the true corner.

*Reference Monument:* All bearing objects and bearing trees, including marks, refer to the position of the regular corner, as that location will be occupied as an instrument station.

*Witness Point:* No requirements are set up as to the accessories for a witness point other than to mark a bearing tree or a bearing object, if available, at important locations or to record

bearings to more distant natural objects or improvements.

### ARRANGEMENT AND MARKING OF CORNER ACCESSORIES

#### 4-97. *Standard township corners. Standard section corners.*

Two bearing trees, one in each section north of the standard parallel, each marked "SC" and the township, range and section; as

T25N R18E S31 SC BT.

Mound of stone, north of corner.

Three pits, one each on line north, east and west.

#### 4-98. *Closing township corners. Closing section corners.*

Two bearing trees, one in each section to the right and left of the closing line, each marked "CC" and the township, range and section; as

T24N R18E S6 CC BT.

Mound of stone, on the closing line.

Three pits, one on the closing line and one each to the right and left on the line closed upon.

#### 4-99. *Corners common to four townships.*

Four bearing trees, one in each section, each marked with the township, range and section; as

T22N R17E S1 BT.

Mound of stone, south of corner.

Four pits, one each on line north, east, south and west.

#### 4-100. *Corners common to two townships only.*

Two bearing trees, one in each section cornering at the monument, each marked with the township, range and section; as

T2N R7W S1 BT.

Mound of stone, on the line between the two townships cornering at the monument.

Three pits, one each on the three lines connecting at the monument.

#### 4-101. *Corners referring to one township only.*

Two bearing trees, both in the township cornering at the monument, each marked with the township, range and section; as

T23N R19W S36 BT.

Mound of stone, in the township cornering

at the monument, at 45° from cardinal direction at the monument.

Two pits, one each on the two lines connecting at the monument.

#### 4-102. *Corners common to four sections.*

Four bearing trees, one in each section, each marked with the township, range and section; as

T26N R17E S35 BT.

Mound of stone, west of corner.

Four pits, one in each section northeast, southeast, southwest and northwest.

#### 4-103. *Section corners common to two sections only.*

Two bearing trees, one in each section cornering at the monument, each marked with the township, range and section; as

T14S R17E S12 BT.

Mound of stone, on the line between the two sections cornering at the monument.

Two pits, one in each section at 45° from cardinal direction at the monument.

#### 4-104. *Section corners referring to one section only.*

Two bearing trees, both in the section cornering at the monument, each marked with the township, range and section; as

T27N R16W S17 BT.

Mound of stone, in the section cornering at the monument, at 45° from cardinal direction at the monument.

Two pits, one 3 feet and one 6 feet distant, both in the section cornering at the monument, at 45° from cardinal direction at the monument.

#### 4-105. *Standard quarter-section corners.*

Two bearing trees, both north of the standard parallel, each marked "1/4" and "SC" and the section; as

1/4 S36 SC BT.

Mound of stone, north of corner.

Two pits, one each on line east and west.

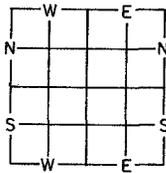
#### 4-106. *Quarter-section corners of maximum control.*

Two bearing trees, one in each section, each marked "1/4" and the section; as

1/4 S16 BT.

Mound of stone: (a) on a meridional line, west of corner; and, (b) on a latitudinal line, north of corner.





Key

Mound of stone, in the particular section which is concerned, in a cardinal direction from the monument.

Two pits, one in each direction on the section line passing through the monument.

4-111. *Special and auxiliary meander corners.*

Two bearing trees, each marked "SMC" or "AMC", as the case may be, and the section; as

S14 SMC BT or

S14 AMC BT.

Mound of stone, on the opposite side of the monument from the meanderable body of water.

Two pits, one 3 feet and one 6 feet distant, on the opposite side of the monument from the meanderable body of water.

4-112. *Closing subdivision-of-section corners.*

Two bearing trees, both in the particular section which is concerned, each marked "CC" and the section; as

S9 CC BT.

Mound of stone, on the closing line.

Three pits, one on the closing line and one each to the right and left on the line closed upon.

4-113. *Miscellaneous angle points along irregular boundaries.*

(a) Two bearing trees, where the monuments are less than 1 mile apart, one on each side of the boundary; and (b) four bearing trees, where the monuments are 1 mile or more apart, two on each side of the boundary; each marked "AP" and a serial or section number, or

both, also the initials or abbreviation of the State, reservation, grant, private claim or public land, as appropriate; as

AP2 TR37 BT, and

AP S14 BT (for "angle point No. 2" on the boundary of a private claim "Tract No. 37" falling on surveyed land).

Mound of stone, on the medial line between the boundary lines intersecting at the monument, and in the direction toward the reservation, grant or private claim.

The placing of a stone mound on a State boundary is *on the line*, north from the monument if the field notes of the survey or retracement are written to read running north; to the east, if running east, etc. In the boundary surveys, where stone is available, it is good practice to build a substantial stone and earth mound surrounding and to the top of the monument; this will usually be conspicuous without an additional stone mound.

Two pits, one in each direction on the lines intersecting at the monument.

4-114. *Intermediate corners along irregular boundaries.*

(a) Two bearing trees, where the monuments are less than 1 mile apart, one on each side of the boundary; and (b) four bearing trees, where the monuments are 1 mile or more apart, two on each side of the boundary; each marked with the number of the mile or half-mile corner and the letter "M" to (indicate "mile corner"), and the initials or abbreviation of the State, reservation, grant, private claim or public land, as appropriate; as

47 M COLO BT, and

47 M OKLA BT (for "47th mile" corner on the boundary line between the States of "Colorado" and "Oklahoma").

Mound of stone, on a line at right angles to the boundary, and in direction toward the reservation, grant, or private claim.

Two pits, one in each direction on the boundary.

## Restoration of Lost or Obliterated Corners

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5-1. The rules for identifying an approved official survey differ from those under which the survey was originally made. The purpose is not to "correct" the original survey by determining where a new or exact running of the line would locate a particular corner, but rather to determine where the corner was established in the beginning. The methods described here follow leading judicial opinions and approved surveying practice.

5-2. Congress has empowered the Secretary of the Interior, or such officer as he may designate, to perform all executive duties appertaining to the survey of public lands. Where public lands are involved, the final authority to approve or disapprove the procedure for the restoration of a lost or obliterated corner rests with the Secretary, acting through the Director, Bureau of Land Management. If privately owned lands are involved, consideration is given to any protest made by an interested person concerning the work of a surveyor employed by the Bureau of Land Management. However, the Director cannot assume jurisdiction over or responsibility for the acts or results of surveys made by county, local, or private surveyors, or by surveyors or engineers who may be employed by other branches of the Federal Government.

5-3. A boundary dispute between private landowners may be brought before the local court of competent jurisdiction. The Director, Bureau of Land Management, will not be bound by a court decision if the United States is not a party to a suit affecting public lands when evidence of the official survey was disregarded or there was some other departure from good surveying practice.

### IDENTIFICATION OF EXISTENT CORNERS

5-4. The terms "corner" and "monument" are not interchangeable. A "corner" is a point determined by the surveying process. A "monument" is the object or the physical structure which marks the corner point.

The "corners" of the public land surveys are those points that determine the boundaries of the various subdivisions represented on the official plat—the township corner, the section corner, the quarter-section corner, the subdivision corner, or the meander corner. The "mile corner" of a State, reservation, or grant boundary does not mark a point of a subdivision; it is a station along the line, however, and long usage has given acceptance to the term. An "angle point" of a boundary marks a change in the bearing, and in that sense it is a corner of the survey.

"Monuments" of the public land surveys have included the deposit of some durable memorial, a marked wooden stake or post, a marked stone, an iron post having an inscribed cap, a marked tablet set in solid rock or in a concrete block, a marked tree, a rock in place marked with a cross (X) at the exact corner point, and other special types of markers, some of which are more substantial; any of these is termed a "monument." The several classes of accessories, such as bearing trees, bearing objects, reference monuments, mounds of stone, and pits dug in the sod or soil are aids in identifying the corner position. In their broader significance the accessories are a part of the corner monument.

5-5. *An existent corner is one whose position can be identified by verifying the evidence of the monument or its accessories, by reference to the description in the field notes, or located by an acceptable supplemental survey record, some physical evidence, or testimony.*

*Even though its physical evidence may have entirely disappeared, a corner will not be regarded as lost if its position can be recovered through the testimony of one or more witnesses who have a dependable knowledge of the original location.*

5-6. The recovery of previously established corners is simplified by projecting retracements from known points. The final search for a monument should cover the zone surrounding one, two, three, or four points determined by connection with known corners. These corners will ultimately control the relocation in case the corner being searched for is declared lost.

The search for the original monument should include a simultaneous search for its accessories. The evidence can be expected to range from that which is least conclusive to that which is unquestionable; the need for corroborative evidence is therefore in direct proportion to the uncertainty of any feature in doubt or dispute. The evidence should agree with the record in the field notes of the original survey subject to natural changes. Mounds of stone may have become imbedded, pits may have filled until only a faint outline remains, blazes on bearing trees may have decayed or become overgrown.

5-7. After due allowance has been made for natural changes, there may still be material disagreement between the particular evidence in question and the record calls. The following considerations will prove useful in determining which features to eliminate as doubtful:

(1) The character and dimensions of the monument in evidence should not be widely different from the record.

(2) The markings in evidence should not be inconsistent with the record.

(3) The nature of the accessories in evidence, including size, position and markings, should not be greatly at variance with the record.

Allowance for ordinary discrepancies should be made in considering the evidence of a monument and its accessories. No set rules can be

laid down as to what is sufficient evidence. Much must be left to the skill, fidelity, and good judgment of the surveyor, bearing in mind the relation of one monument to another and the relation of all to the recorded natural objects and items of topography.

5-8. No decision should be made in regard to the restoration of a corner until every means has been exercised that might aid in identifying its true original position. The retracements will indicate the probable position and will show what discrepancies are to be expected. Any supplemental survey record or testimony should then be considered in the light of the facts thus developed.

5-9. *An obliterated corner is one at whose point there are no remaining traces of the monument or its accessories, but whose location has been perpetuated, or the point for which may be recovered beyond reasonable doubt by the acts and testimony of the interested landowners, competent surveyors, other qualified local authorities, or witnesses, or by some acceptable record evidence.*

*A position that depends upon the use of collateral evidence can be accepted only as duly supported, generally through proper relation to known corners, and agreement with the field notes regarding distances to natural objects, stream crossings, line trees, and off-line tree blazes, etc., or unquestionable testimony.*

5-10. A corner is not considered as lost if its position can be recovered satisfactorily by means of the testimony and acts of witnesses having positive knowledge of the precise location of the original monument. The expert testimony of surveyors who may have identified the original monument prior to its destruction and recorded new accessories or connections is by far the most reliable, though landowners are often able to furnish valuable testimony. The greatest care is necessary in order to establish the bona fide character of the record intervening after the destruction of an original monument. Full inquiry may bring to light various records relating to the original corners and memoranda of private markings, and the surveyor should make use of all such sources of information. The matter of boundary disputes should be carefully looked into

insofar as adverse claimants may base their contentions upon evidence of the original survey. If such disputes have resulted in a boundary suit, the record testimony and the court's decision should be carefully examined for information which may shed light upon the position of an original monument.

5-11. The testimony of individuals may relate to the original monument or the accessories, prior to their destruction, or to any other marks fixing the locus of the original survey. Weight will be given such testimony according to its completeness, its agreement with the original field notes, and the steps taken to preserve the original marks. Such evidence must be tested by relating it to known original corners and other calls of the original field notes, particularly to line trees, blazed lines, and items of topography.

There is no clearly defined rule for the acceptance or non-acceptance of the testimony of individuals. It may be based upon unaided memory over a long period or upon definite notes and private marks. The witness may have come by his knowledge casually, or he may have had a specific reason for remembering. Corroborative evidence becomes necessary in direct proportion to the uncertainty of the statements advanced. The surveyor should bear in mind that conflicting statements and contrary views of interested parties are fruitful of boundary disputes.

The surveyor will show in the field notes, or in the report of a field examination, the weight given testimony in determining the true point for an original corner. (Section 8-18.) The following points will serve as a guide:

(1) The witness (or record evidence) should be duly qualified: The knowledge or information should be firsthand, not hearsay; it should be complete; it should not be merely personal opinion.

(2) The testimony (or record statement) should be such as can stand an appropriate test of its bona fide character.

(3) The testimony (or the record) must be sufficiently accurate, within a reasonable limit, for what is required in normal surveying practice.

5-12. Any marks made either before or subsequent to the official survey, or at the time of

the survey but not under the direction of the chief of field party, are not to be regarded as evidence of that survey excepting as an appropriate relation is fully authenticated by field notes or qualified testimony. Reference should be made in the field notes, however, if the marks are of a permanent nature. If such marks or monuments are rejected, the reason should be shown by the new record.

5-13. One additional caution, addressed especially to the surveyor employed by the Bureau of Land Management, is to bear in mind that his professional work is technical in character, not legal or judicial. The surveyor is not a referee as to the justice or injustice of a situation, nor is he qualified to act judicially upon the equities or inequities that may appear to be involved.

5-14. The above conditions and procedures are brought out in the leading court opinions in cases available in law libraries. Reference books on the legal elements of surveying and boundaries also cite court opinions and deal with these subjects. The treatment by the authorities of the question of testimony and physical evidence, *as to acceptability*, demonstrates the importance of the principles mentioned: due qualification, bona fide character, accuracy.

5-15. A line tree or a *definite* connection to readily identified natural objects or improvements may fix a point of the original survey. The *mean* position of a blazed line, when identified as the original line, may help to fix a meridional line for departure, or a latitudinal line for latitude. Such blazed lines must be carefully checked, because corrections may have been made before final acceptance of the old survey or more than one line may have been blazed.

5-16. The proper use of topographic calls of the original field notes may assist in recovering the locus of the original survey. Such evidence may merely disprove other questionable features, or it may be a valuable guide to the immediate vicinity of a line or corner. At best, it may fix the position of a line or corner beyond reasonable doubt.

Allowance should be made for ordinary discrepancies in the calls relating to items of topography. Such evidence should be considered more particularly in the aggregate; when it is

found to be corroborative, an average may be secured to control the final adjustment. This will be governed largely by the evidences nearest the particular corner in question, giving the greatest weight to those features that agree most closely with the record, and to such items as afford definite connection.

A careful analysis should be made by the surveyor before using topographic calls to fix an original corner point. Indiscriminate use will lead to problems and disputes where two or more interpretations are possible. Close attention should be given to the manner in which the original survey was made. Instructions for chaining in the earlier manuals indicate that memory was an important factor in recording distances to items of topography. Early field notes often appear to have shown distances only to the nearest chain or even a wider approximation.

In comparing distances returned in the original field notes with those returned in the re-surveys, gross differences appear in a significant number of instances. In some cases the original surveyor apparently surveyed a line in one direction, but then reversed the direction in his record without making corresponding changes in distances to items of topography. These facts have sometimes caused distrust and virtual avoidance of the use of topography in corner restoration where proper application might be extremely helpful. Misapplication usually may be avoided by applying the following tests:

(1) The determination should result in a definite locus within a small area.

(2) The evidence should not be susceptible of more than one reasonable interpretation.

(3) The corner locus should not be contradicted by evidence of a higher class or by other topographic notes.

The determination of the original corner point from even fragmentary evidence of the original accessories, generally substantiated by the original topographic calls, is much stronger than determination from topographic calls alone. In questionable cases it is better practice, in the absence of other collateral evidence, to turn to the suitable means of proportionate measurement.

#### 5-17. *Witness Corners*

Ordinarily a witness corner established in the original survey will fix the true point for the corner at record bearing and distance. Where the witness corner was placed on a line of the survey, if no complications arise, it will be used as control from that direction in determining the proportionate position of the true point. Thus the record bearing and distance would be modified, and the witness corner would become an angle point. Unfortunately, the factual statements of the original field notes are not always clear. The record may indicate that the witness corner was established on a random line, or there may be an apparent error of calculation for distance along the true line. The monument may not have been marked "WC" plainly or at all. In these instances, or where there is extensive obliteration, each corner must be treated individually. The important consideration is to locate the true corner point in its original position.

Since the true point for the corner will usually be of major importance, the surveyor will proceed directly to its determination by the applicable methods if the witness corner is lost. If it is then impracticable to monument the true point, a new witness corner will be established and marked as directed in the sections of chapter IV devoted to corner monuments and accessories.

#### 5-18. *Line Trees*

Under the law, a *definitely identified* line tree is a monument of the original survey. It properly is used as a control point in the reestablishment of lost corners by the appropriate method of proportionate measurement. In this case it is treated just as is a recovered corner, and it becomes an angle point of the line.

A problem arises where, as in some older surveys, line trees were improperly established on a random line (and so recorded in the field notes) rather than on the true line. Each case must be considered on its merits, but such line trees are generally of most value as guides in locating the original corners. It may occasionally be necessary to treat them as control points where there has been extensive obliteration of the corners themselves. The making of proportionate offsets from line trees on the random

line to determine angle points of the true line lends the trees more influence than is warranted. In adopting such a scheme the surveyor would be assuming that if the original surveyor had followed the survey of the random line with a survey of the true line he would have created angles at the same points as on the random line. The fact is that there might well have been angles in the true line, but they would be wherever the line struck trees on the true line—not at the same distances at all. The most probable location of the true line would be on a straight line between the corners, if these corners are recovered, as reported in the record subsequent to the field notes of the random line.

#### 5-19. *State Boundary Monuments*

The Bureau of Land Management has no general authority to survey or resurvey State boundaries. The original survey of certain State boundaries was executed under the former General Land Office when specifically authorized by act of Congress. The resurvey of a State boundary may be made under direction of the Supreme Court or may be authorized by the States involved with the consent of Congress. In connection with the survey or resurvey of public lands it is proper to *retrace* as much of the State boundary as may be needed for a suitable closing. Closing corners are not marked as defining the State boundary. Identified original State boundary corners may properly be remonumented, but lost corners should not be restored unless this is specifically sanctioned by appropriate authority.

### THE RESTORATION OF LOST CORNERS

5-20. *A lost corner is a point of a survey whose position cannot be determined, beyond reasonable doubt, either from traces of the original marks or from acceptable evidence or testimony that bears upon the original position, and whose location can be restored only by reference to one or more interdependent corners.*

5-21. The rules for the restoration of lost corners should not be applied until all original and collateral evidence has been developed. When these means have been exhausted, the

surveyor will turn to proportionate measurement, which harmonizes surveying practice with legal and equitable considerations. This plan of relocating a lost corner is always employed unless outweighed by conclusive evidence of the original survey.

5-22. The preliminary retracements show the discrepancies of courses and distances between the original record and the findings of the retracement. The retracement is based upon the courses and distances of the original survey record, initiated and closed upon known original corners. Temporary stakes for future use in the relocation of all lost corners are set when making the retracements.

5-23. Existing original corners may not be disturbed. Consequently, discrepancies between the new measurements and the measurements shown in the record have no effect beyond the identified corners. The differences are distributed proportionally within the several intervals along the line between the corners.

The retracements will show various degrees of accuracy in the lengths of lines, where in every case it was intended to secure true horizontal distances. Until after 1900 most of the lines were measured with the Gunter's link chain. Such a chain was difficult to keep at standard length, and inaccuracies often arose in measuring steep slopes by this method.

All discrepancies in measurement should be carefully verified with the object of placing each difference where it properly belongs. Whenever it is possible to do so, the manifest errors in measurement are removed from the general average difference and placed where the blunder was made. The accumulated surplus or deficiency that then remains is the quantity that is to be uniformly distributed by the methods of proportionate measurement.

5-24. A proportionate measurement is one that gives equal relative weight to all parts of the line. The excess or deficiency between two existent corners is so distributed that the amount given to each interval bears the same proportion to the whole difference as the record length of the interval bears to the whole record distance. After the proportionate difference is added to or subtracted from the record length of each interval, the sum of the several parts

will equal the new measurement of the whole distance.

The type of proportionate measurement to be used in the restorative process will depend on the method which was followed in the original survey. *Standard parallels will be given precedence over other township exteriors, and ordinarily the latter will be given precedence over subdivisional lines; section corners will be relocated before the position of lost quarter-section corners can be determined.*

## Primary Methods

### Double Proportionate Measurement

5-25. *The term "double proportionate measurement" is applied to a new measurement made between four known corners, two each on intersecting meridional and latitudinal lines, for the purpose of relating the intersection to both.*

In effect, by double proportionate measurement the record directions are disregarded, excepting only where there is some acceptable supplemental survey record, some physical evidence, or testimony that may be brought into the control. Corners to the north and south control any intermediate latitudinal position. Corners to the east and west control the position in longitude. One identified original corner is balanced by the control of a corresponding original corner on the opposite side of a particular missing corner which is to be restored. Each identified corner is given a controlling weight inversely proportional to its distance from the lost corner. *Lengths of proportioned lines are comparable only when reduced to their cardinal equivalents.* The method may be referred to as a "four-way" proportion. The method of double proportionate measurement is generally applicable to the restoration of lost corners of four townships and of lost interior corners of four sections.

5-26. *In order to restore a lost corner of four townships, a retracement will first be made between the nearest known corners on the meridional line, north and south of the missing corner, and upon that line a temporary stake will be placed at the proper proportionate distance; this will determine the latitude of the lost corner.*

*Next, the nearest corners on the latitudinal line will be connected, and a second point will be marked for the proportionate measurement east and west; this point will determine the position of the lost corner in departure (or longitude).*

*Then, through the first temporary stake run a line east or west, and through the second temporary stake a line north or south, as relative situations may determine; the intersection of these two lines will fix the position for the restored corner.*

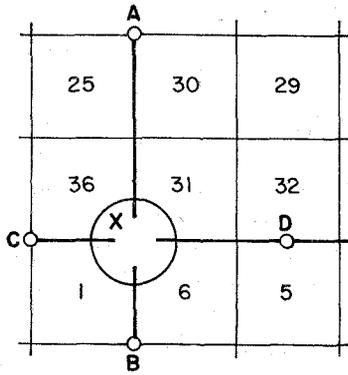
Figure 70 illustrates the plan of double proportionate measurement. Points A, B, C, and D represent four original corners which will control the restoration of the lost corner X. On the large scale diagram the point E represents the proportional measurement between A and B, and, similarly, the point F represents the proportional measurement between C and D. The point X satisfies the first control for latitude and the second control for departure.

5-27. A lost township corner cannot safely be restored, nor the boundaries ascertained, without first considering the field notes of the four intersecting lines. It is desirable also to examine the four township plats. In most cases there is a fractional distance in the half-mile to the east of the township corner, and frequently in the half-mile to the south. The lines to the north and to the west are usually regular, with quarter-section and section corners at normal intervals of 40.00 and 80.00 chains, but there may be closing-section corners on any or all of the boundaries so that it is important to verify all distances by reference to the field notes.

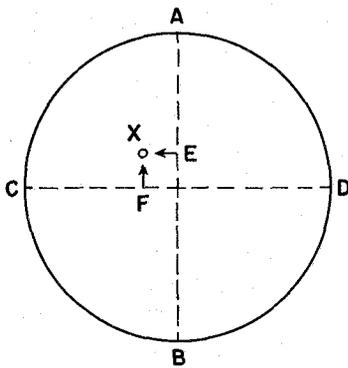
5-28. *Lost interior corners of four sections, where all the lines therefrom have been run, will also be reestablished by double proportionate measurement. The control for such restoration will not extend beyond the township boundary. If the controlling corner on the boundary is lost, that corner must be reestablished beforehand.*

5-29. *Where the line has not been established in one direction from the missing township or section corner, the record distance will be used to the nearest identified corner in the opposite direction.*

Thus, in figure 70, if the latitudinal line in the direction of the point D has not been estab-



Lost township corner in vicinity of X

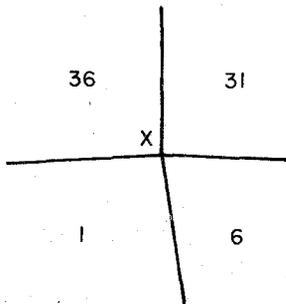


A,B,C,D—Control corners

E—Proportionate point for X in latitude between A and B

F—Proportionate point for X in departure between C and D

Correct position of X is at intersection of lines extended East or West from E, North or South from F.



Restored corner showing true direction of township lines

FIGURE 70.—Double proportionate measurement.

lished, the position of point F in departure would have been determined by reference to the record distance from the point C; the point X would then be fixed by cardinal offsets from the points E and F as already explained.

Where the intersecting lines have been established in only two of the directions, the record distances to the nearest identified corners on these two lines will control the position of the temporary points; then from the latter the cardinal offsets will be made to fix the corner point.

An index correction for average error in measurement, if applicable, should be made in

applying these two rules (see section 5-45). What is intended by *record* distance is the measure established in the original survey. Experience and good judgment are required in applying the rules. If the original survey was carelessly executed, no definite standard can be set up as representing that survey. On the other hand, the work may have been reasonably uniform within its own limits, yet inaccurate with respect to exact base standards. It is the consistent excess or deficiency of the original work that is intended here, if that can be determined within practical limits. Otherwise the only rule that can be applied is that a record of 80.00

chains in distance means just that by exact standards, true horizontal measurement.

### Single Proportionate Measurement

5-30. The term "single proportionate measurement" is applied to a new measurement made on a line to determine one or more positions on that line.

By single proportionate measurement the position of two identified corners controls the direction of that line. The method is sometimes referred to as a "two-way" proportion, such as a north-and-south proportion or an east-and-west proportion. Examples are a quarter-section corner on the line between two section corners, all corners on standard parallels, and all corners occupying intermediate positions on a township boundary line.

5-31. In order to restore a lost corner on a line by single proportionate measurement, a retracement is made connecting the nearest identified corners on the line. These corners control the position of the lost corner. Control corners are usually corners established in the original survey of the line. The lost corner is then reestablished at proportionate distance on the true line connecting the recovered corners. Proper adjustment is made on an east and west line to secure the latitudinal curve. Any number of intermediate lost corners may be located on the same plan.

5-32. Restorations of lost corners of standard parallel are controlled by the regular standard corners. These include the standard township, section, quarter-section, and sixteenth-section corners, and meander corners, and also closing corners which were originally established by measurement along the standard line as points from which to start a survey.

Lost standard corners will be restored to their original positions on a base line, standard parallel, or correction line, by single proportionate measurement on the true line connecting the nearest identified standard corners on opposite sides of the missing corner or corners, as the case may be.

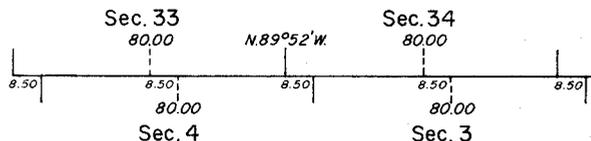
5-33. Corners on base lines are regarded the same as those on standard parallels. In the older practice the term "correction line" was used for what has later been called the standard

parallel. The corners first set in the running of a correction line are treated as original standard corners. Those that were set afterwards at the intersection of a meridional line are regarded as closing corners.

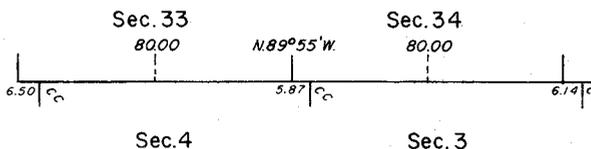
5-34. All lost section and quarter-section corners on the township boundary lines will be restored by single proportionate measurement between the nearest identified corners on opposite sides of the missing corner, north and south on a meridional line, or east and west on a latitudinal line.

5-35. Two sets of corners have been established on many township lines and on some section lines. Each set applies only to sections on its respective side of the line. Which corners control in the restoration of a lost corner will depend on how the line was surveyed. Three common cases are discussed:

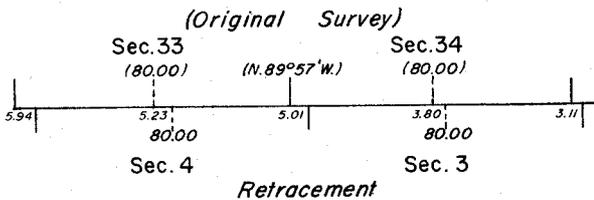
(1) Where both sets of corners have been established by measurement along the line in a single survey, each corner controls equally for both measurement and alignment.



(2) Where a single set of corners was established in the survey of the line and closing corners were subsequently established at intersection of section lines on one side, the corners first established control both the alignment and the proportional measurement along the line. The original quarter-section corners nearly always referred to sections on only one side of the line after the closing corners were established on the other side. The quarter-section corners for sections on the side to which the closing corners refer were not established in older surveys. The correct positions are as protracted on the plat of those sections. (See also section 5-41, Closing Corners.)



(3) Sometimes one set of corners was established for one side of the line, and a second set of corners was established for the other side in the course of a later retracement.



The line is regarded as having been fixed in position by the senior survey unless that survey was officially superseded. If both sets of corners are recovered, a junior corner lying off the line is treated in the same manner as a closing corner insofar as the alinement is concerned. Since it was established in the course of a retracement reporting the most recent measurement of the line, a junior corner properly can be used for control in restoring a lost corner of the line insofar as measurement is concerned. This procedure is not advisable where the corner is far off line because a bearing in the connecting section line would change its true position relative to other corners of the line. That condition can only be shown by retracing enough of the connecting section line to determine its bearing. Where there has been extensive loss of corners, particularly the senior corners, the existent junior corners may also constitute the best available evidence of the line itself. In such a case they will exercise control for both measurement and alinement.

On rare occasions the second surveyor patently established a completely separate line and thereby created a hiatus or overlap. Each set of corners would then control only its respective line. Where complications develop, the surveyor should report to his supervising office the identity and correlation of corners or other evidence recovered before restoring the lost corners. Each such case must be considered individually. The same instruction applies to lines on which the original corners have become angle points and which therefore may have three sets of corners.

5-36. Some township boundaries, not established as straight lines, are termed "irregular" exteriors. Parts were surveyed from opposite

directions and the intermediate portion was completed later by random and true line, leaving a fractional distance. Such irregularity follows some material departure from the basic rules for the establishment of original surveys. A modified form of single proportionate measurement is used in restoring lost corners on such boundaries. This is also applicable to a section line or a township line which has been shown to be irregular by a previous retracement. Figure 71.

In order to restore one or more lost corners or angle points on such irregular exteriors, a retracement between the nearest known corners is made on the record courses and distances to

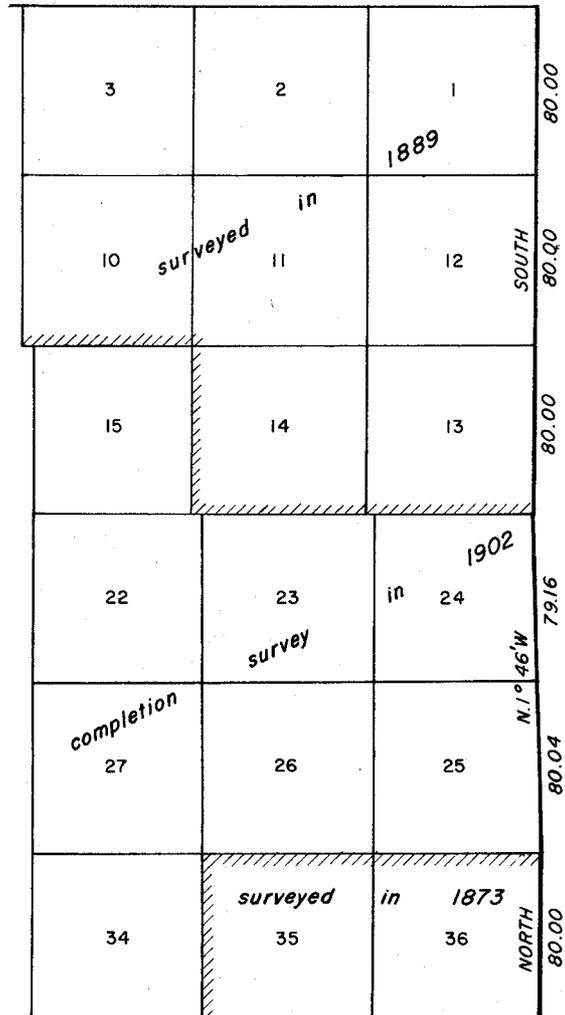


FIGURE 71.—Irregular exterior resulting from the piecemeal survey of a township line.

ascertain the direction and length of the closing distance. A temporary stake is set for each missing corner or angle point. The closing distance is then reduced to its equivalent latitude and departure.

On a meridional line the *latitude* of the closing distance is distributed among the courses in proportion to the *latitude* of each course. The *departure* of the closing distance is distributed among the courses in proportion to the *length* of each course. That is, after the excess or deficiency of latitude is distributed, each temporary stake is moved east or west an amount proportional to the total distance from the starting point.

On a latitudinal line the temporary stakes should be placed to suit the usual adjustments for the curvature. The *departure* of the closing distance is distributed among the courses in proportion to the *departure* of each course. Then each temporary stake is moved north or south an amount proportional to the *total distance* from the starting point.

Angle points and intermediate corners will be treated alike.

5-37. Another exception to the usual application of single proportionate measurement is occasionally important. There may be persuasive proof of a deflection in the alinement of the exterior, though the record shows the line to be straight. For example, measurements east and west across a range line, or north and south across a latitudinal township line, counting from a straight-line exterior adjustment, may show distances to the nearest identified subdivisional corners to be substantially long in one direction and correspondingly short in the opposite direction. This condition, when supported by collateral evidence, would warrant an exception to the straight-line or two-way adjustment because the evidence outweighs the record. The rules for a four-way or double proportionate measurement would then apply here, provided there is conclusive proof.

5-38. *All lost quarter-section corners on the section boundaries within the township will be restored by single proportionate measurement between the adjoining section corners, after the section corners have been identified or re-located.*

In those cases where connections from the lost quarter-section corner to other regular monuments of the line nearer than the section corners have been previously noted, these will ordinarily assume control in the restoration. Such monuments may include another quarter-section corner, minor subdivision corners, a meander corner, an angle point, or a line tree, any of which may have been established when the line was previously surveyed or resurveyed. (See also under section 5-41, Closing Corners.)

5-39. *"Half-Mile Posts," Alabama and Florida*

In the early practice in parts of Alabama and Florida, so-called "half-mile posts" were established at distances of 40 chains from the starting section corner. The term was applied where the line might be more or less than an exact 80 chains in record length, and where by later methods the latitudinal lines have been run as "random and true." The practice contemplated that in some cases these subdivisional lines be run in cardinal directions to an intersection, where the next section corner would be placed, and either or both lines might be more or less than 80 chains in length. In some cases the section corners were placed across the township at intervals of 80 chains on one of the cardinal lines, and the other lines were run on random only. On the first plan the "half-mile post" would not be at midpoint unless the line turned out to be 80 chains in length. On the second plan the "half-mile post" on the lines first run would be in true position for the quarter-section corner, but on the lines last run they would usually not be on true line, nor at midpoint.

In both cases field notes were written showing a true line direction and midpoint distance for a quarter-section corner. This was done to meet the objection that the "half-mile post" did not satisfy the requirements of law, but the true line was not actually run on the ground, nor was a monument constructed at midpoint. In these cases only the true line field notes need be regarded if the evidence of the "half-mile post" has disappeared; but where the latter can be identified the point must be given proper weight for control. Each set of field notes requires its individual consideration, as the prac-

tices were not uniform even in the same surveying district.

The applicable rules for the restoration of the true line midpoint positions for the quarter-section corners in the above practices are derived from the Act of February 11, 1805 (R.S. 2396), which requires that "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."

The rules may be stated specifically as follows:

(1) In case the "half-mile post" and quarter-section corner are recorded as being at a common point, the identified "half-mile post" will be restored as the quarter-section corner.

(2) If there is evidence of the position of the section corners in both directions, and if the record *leaves doubt* as to the establishment of the "half-mile post" on the true line, the quarter-section corner will be monumented at midpoint on the true line, disregarding the record of the "half-mile post."

(3) In the absence of evidence at one or both section corners and where the record *leaves doubt* regarding the running and marking of the true line, the "half-mile post" will be employed on a north and south line for the control of the latitude of the quarter-section corner, or on an east and west line for control of its position in departure, using the record correction for distance. The alinement of the section boundary and the position of the quarter-section corner on the true line will be adjusted to the location of the two section corners *after* the double proportionate measurements have been completed.

(4) Where the field notes show proper location for alinement and record correction for distance, the "half-mile post" will be employed for the full control of the position of the quarter-section corner, and for the restoration of the lost section corners. The position of the quarter-section corner in latitude on a north and south line, or in departure on an east and west line, will be ascertained by making use of the record correction for distance from the "half-mile post." The alinement from the position of the "half-mile post" to the point for the

quarter-section corner will be determined by the position of the section corner to the south, if the record correction for distance is to be made to the north; the section corner to the north will be used if the record correction for distance is to be measured to the south; and similarly on east and west lines.

(5) The evidence of the "half-mile post" will not be destroyed.

#### 5-40. Meander Corners

*Lost meander corners, originally established on a line projected across the meanderable body of water usually will be relocated by single proportionate measurement.* However, the facts must be considered with regard to the specific problem in hand.

Under favorable conditions a lost meander corner may be restored by treating the shore line as an identified natural feature. In the event of extensive obliteration of the original corners within the locality this position may be preferable to one obtained by proportionate measurement carried from a considerable distance.

In extreme cases restoration by adjustment of the record meander courses to the bank or shore line may be indispensable to the reconstruction of the section boundaries. Granting extensive obliteration, where there has been obvious stability to the bank or shore line, or absence of appreciable changes by erosion or accretion, the record meander courses and distances may be conformed to the salients and angles of the physical bank or shore line. If found satisfactory, that restoration may be regarded as the most suitable position for the meander corner. This may give a location in both latitude and departure, in latitude only, or in departure only.

Occasionally, it can be demonstrated that the meander corners on opposite banks of a wide river were actually established as terminal meander corners even though the record indicates the line was projected across the river. If the evidence outweighs the record, a lost meander corner in such a case will be relocated by single point control. (See section 5-45, Original Control.)

#### 5-41. Closing Corners.

*A lost closing corner will be reestablished on the true line that was closed upon, and at the proper proportional interval between the nearest regular corners to the right and left.*

In order to reestablish a lost closing corner on a standard parallel or other controlling boundary, the line that was closed upon will be retraced, beginning at the corner from which the connecting measurement was originally made. A temporary stake will be set at the record connecting distance, and the total distance and falling will be noted at the next regular corner on the line on the opposite side of the missing closing corner. The temporary stake will then be adjusted as in single proportionate measurement.

*A recovered closing corner not actually located on the line that was closed upon will determine the direction of the closing line, but not its legal terminus. The correct position is at the true point of intersection of the two lines.*

The new monument in those cases where it is required will always be placed at the true point of intersection. An off-line monument in such cases will be marked AM (for amended monument) and will be connected by course and distance. The field notes of the closing line will include a full description of the old monument as recovered and a clear statement that the new monument is set at the true point of intersection.

When an original closing corner is recovered off the line closed upon and the new monument is established at the true point of intersection, the *original* position will control in the proportionate restoration of lost corners dependent upon the closing corner. In a like manner the positioning of sixteenth-section corner(s) or lot corner(s) on the closing line, between the quarter-section corner and the closing corner, will be based on the measurement to the original closing corner.

A closing corner ordinarily is not used as control corner in restoring a lost corner of the line closed upon. However, where a previous, obviously careful retracement has explicitly shown the relative positions of all the corners on the line, including the closing corners, the

latter may exercise control to the same limited extent as corners of a junior survey. Section 5-35(3).

Closing corners in some cases have been established where a line of the survey crosses previously surveyed claim lines. (See section 3-71, Closing Section Lines.) A crossing closing corner established to mark the intersection of a junior line crossing an existing senior line, if it is not at the true intersection, establishes only the direction of and a point on the junior line. In effect, such a crossing closing corner has the same standing as an angle point on the junior survey; it has no effect on the senior line.

A closing corner set to mark the intersection of a *resurvey* of a junior crossing line with a senior line has no standing if it does not, in fact, mark the true intersection. The true point remains the actual intersection of straight lines connecting the two pairs of controlling corners. Otherwise, the monument can serve only as a control point for the reestablishment of lost control corners on the junior line.

A different problem must be faced where the record tie from a closing corner to a corner of the line closed upon is fictitious, grossly in error, or in some way irreconcilable. If the closing corner in such a case is recovered, it will normally control the direction of the closing line regardless of its disagreement with the record. If there is no evidence whatever of the closing corner, and ample proof that the closing was not made as called for in the field notes, the closing corner should not be restored without verifying the nearest authentic closing on either side. The restoration will then be made by the method most nearly in harmony with the official plat. No general rule can be advanced. The procedure to be adopted should have official sanction prior to remonumentation of the lines.

5-42. The foregoing are the general rules for the restoration of lost or obliterated corners. The special cases that are hereinafter cited with respect to broken boundary lines and limited control do not have wide application and do not have similar importance excepting under those conditions, and as explained in the succeeding text.

The preceding instructions will be applicable in the large majority of cases. If there seems to

be some difficulty or inconsistent result, a careful check should be made of the record data. The special instructions for the original survey, the plat representation, or some call of the field notes may clarify the problem upon further study. This research assumes a large importance in the more difficult problems of the recovery of an old line or boundary.

It is not intended to disturb satisfactory local conditions with respect to roads and fences. The surveyor has no authority to change a property right that has been acquired legally, nor can he accept the location of roads and fences as evidence prima facie of the original survey. Something is needed in support of these locations. This will come from whatever intervening record there may be, the testimony of individuals who may be acquainted with the facts, and the coupling of these things to the original survey.

Other factors to be considered are the rules of the State law and the State court decisions, as distinguished from the rules laid down by the Bureau of Land Management (the latter applicable to the public land surveys in all cases). Under State law in matters of agreement between owners, acquiescence, or adverse possession, property boundaries may be defined by roads, fences, or survey marks, disregarding exact conformation with the original section lines. These may limit the rights as between adjoining owners.

In many cases due care has been exercised to place the property fences on the lines of legal subdivision, and it has been the general practice in the Prairie States to locate the public roads on the section lines. These are matters of particular interest to the adjoining owners, and it is a reasonable presumption that care and good faith would be exercised with regard to the evidence of the original survey in existence at the time. Obviously, the burden of proof to the contrary must be borne by the party claiming differently. In many cases there are subsurface marks in roadways, such as deposits of a marked stone or other durable material, that are important evidence of the exact position of a corner if the proof can be verified.

A property corner should exercise a regular control upon the retracement only when it was placed with due regard to the location of the

original survey, or agreement is so close as to constitute the best available evidence.

## Secondary Methods

### *Broken Boundaries*

5-43. *Angle Points of Nonriparian Meander Lines.* In some cases it is necessary to restore (or possibly to locate for the first time) the angle points, within a section, of the record meander courses for a stream, lake, or tidewater, which may be required under the special rules which are applicable to nonriparian meander lines.

In these cases the positions of the meander corners on the section boundaries are determined first. The record meander courses and distances are then run and temporary angle points are marked. The residual error is shown by the direction and length of the line from the end of the last course to the objective meander corner. The residual is distributed on the same plan as in balancing a survey for the computation of the areas of the lottings as represented on the plat.

The general rule is that the adjustment to be applied to the  $\left\{ \begin{array}{l} \text{latitude} \\ \text{departure} \end{array} \right\}$  of any course is to the resolved  $\left\{ \begin{array}{l} \text{latitude} \\ \text{departure} \end{array} \right\}$  of the closing error as the length of the course is to total length of all the courses. Each adjustment is applied in a direction to reduce the closure. If the *northings* are to be *increased*, then the *southings* will be *decreased*. A line due *east* would then be given a correction to the *north* (in effect to the *left*); a line due *west*, also to the *north* (in effect to the *right*). Each incremental correction is determined and applied in proportion to the length of the line.

The field adjustments for the positions of the several angle points are accomplished simply by moving each temporary point on the bearing of the closing error an amount that is its proportion of that line, counting from the beginning. The particular distance to be measured at any point is to the whole length of the closing error as the distance of that point from the starting corner is to the sum of the lengths of all the courses. Figure 72.

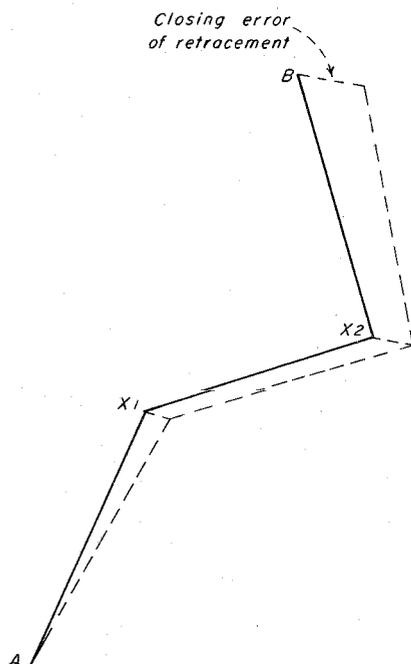


FIGURE 72.—Adjusting angle points on a nonriparian meander line.

The same principle is followed to plot lottings of dependently resurveyed sections in their true relative positions when the record meander line and the true shoreline differ greatly because of distortion.

5-44. *Grant Boundaries.* In many of the States there are irregular grant and reservation boundaries that were established prior to the public-land subdivisional surveys. In these cases the township and section lines are regarded as the closing lines. The grant boundary field notes may call for natural objects, but these are often supplemented by metes-and-bound descriptions. The natural calls are ordinarily given precedence, next the existent angle points of the metes-and-bounds survey. The missing angle points are then restored by uniformly orienting the record courses to left or right and adjusting the lengths of the lines on a constant ratio. Both angular and linear corrections are made in the direction needed to reduce the falling of the trial lines laid down according to the record.

The retracement of the grant boundary is begun at an identified corner. Calls for natural

objects are satisfied and the existent angle points are recovered. Then, between the identified or acceptable points, the position of missing angle points is determined by these steps:

(1) Reduce the *record* courses and distances to the total differences in latitude and departure. Compute the direction and length of a line connecting the identified points.

(2) Determine the *actual* differences in latitude and departure between the same identified points by retracement. Compute the direction and length of the connecting line based on these figures.

(3) The angular difference of direction between the connection lines computed in (1) and (2) gives the amount and direction of the adjustment to apply to the *record* bearing of each intermediate course.

(4) The ratio of the length of the line computed in (2) to that computed in (1) gives the coefficient to apply to the *record* length of each intermediate course.

After the adjustments are completed, additional search for evidence of the record markers should be made. The adjusted locations for the angle points are in the most probable original position, and a better check of collateral evidence is possible. If no further evidence is recovered, the adjusted points are then monumented.

In figure 73, A and B are identified points of the original boundary. It is desired to restore intermediate points T, S, R, J, I, H, and G, which have been temporarily marked at  $T_t$ ,  $S_t$ ,  $R_t$ ,  $J_t$ ,  $I_t$ ,  $H_t$ , and  $G_t$  in conformance with the original record starting from point A. The record position of point B in relation to point A is designated  $B_t$ . The adjustment has been made in the four steps already described.

The same procedure may be followed whenever it is desired to retain the *form* of the traverse being adjusted, since the interior angles are unchanged and the increase or decrease in lengths of lines is constant. The adjustment may be likened to a photographic enlargement or reduction. Mechanically, this process requires that the record distances of the traverse legs between identified points be reduced or increased simultaneously with the rotation of the record

Orientation of Record Courses to Meridian  $1^{\circ}13'30''$  to right  
 Adjustment of Record Measurements to Standard Ratio=1.09634

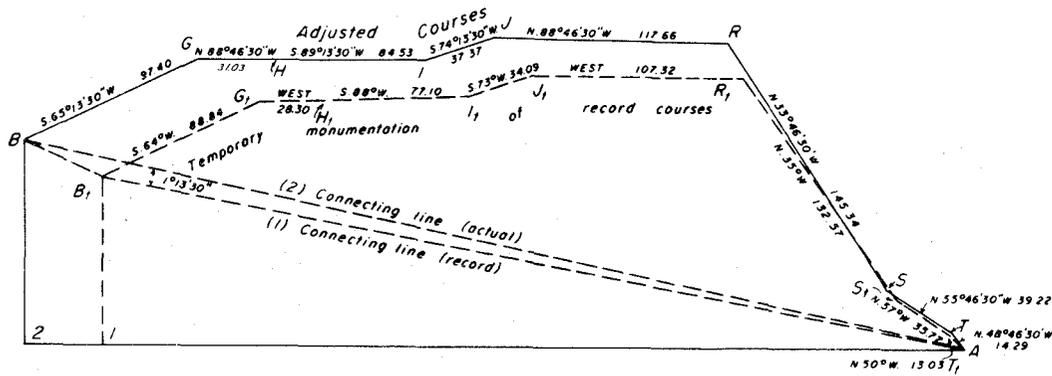


FIGURE 73.—Adjusting a grant boundary.

bearings until the two identified points coincide.

5-45. *Original Control*

Where a line has been terminated with measurement in one direction only, a lost corner will be restored by record bearing and distance, counting from the nearest regular corner, the latter having been duly identified or restored.

Examples will be found where lines have been discontinued at the intersection with large meanderable bodies of water, or at the border of what was classed as impassable ground.

An index correction for average error in the original measurement should be used, if appropriate, as discussed in section 5-29. Additionally, in cases where a retracement has been made of many miles of the original lines, between identified original corners, and there has been developed a definite angle from cardinal that characterizes the original survey, it is proper to make allowance for the average difference.

Special Cases

5-46. Experience, thoroughness, and good judgment are indispensable for the successful retracement and recovery of any survey when

it reaches a stage of extensive obliteration. It is an axiom among experienced cadastral surveyors that the true location of the original lines and corners can be restored, if the original survey was made faithfully, and was supported by a reasonably good field-note record. That is the condition for which the basic principles have been outlined, and for which the rules have been laid down. The rules cannot be elaborated to reconstruct a grossly erroneous survey or a survey having fictitious field notes.

5-47. The records of official resurveys cover many special cases. The records in Washington include the special cases from all public-land States. These plats, field notes, reports of field examinations, office opinions, Departmental decisions, opinions from the Attorney General of the United States, and frequently court opinions and decrees are drawn upon when needed to assist the surveyor in situations that are new to his own experience. When the surveyor encounters unusual situations, or finds it difficult to apply the normal rules for the restoration of lost corners, he should report the facts to the proper administrative office. If it is determined that additional retracements are necessary, these may be provided for by supplemental instructions.

## Resurveys

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**THE NATURE OF RESURVEYS**

6-1. A *resurvey* is a reconstruction of land boundaries and subdivisions accomplished by rerunning and re-marking the lines represented in the field-note record or on the plat of a previous official survey. The field-note record of the resurvey includes a description of the technical manner in which the resurvey was made, full reference to recovered evidence of the previous survey or surveys, and a complete description of the work performed and monuments established. The resurvey, like an original survey, is subject to approval of the directing authority.

6-2. Government resurveys involve considerations of a different character from those relating to original surveys. The object is twofold: First, the adequate protection of existing rights acquired under the original survey in the matter of location on the earth's surface, and second, the proper marking of the boundaries of the remaining public lands.

6-3. Although the discussion in this chapter pertains especially to the resurvey of an entire township, the same principles apply in the smaller projects necessary for proper management of the public lands. These smaller parcels must be considered in context with the township, which is the unit of resurvey because it was the unit of the original survey.

6-4. A *dependent resurvey* is a retracement and reestablishment of the lines of the original survey in their true original positions according to the best available evidence of the positions of the original corners. The section lines and lines of legal subdivision of the dependent resurvey in themselves represent the best possible identification of the true legal boundaries

of lands patented on the basis of the plat of the original survey. In legal contemplation and in fact, the lands contained in a certain section of the original survey and the lands contained in the corresponding section of the dependent resurvey are identical.

6-5. An *independent resurvey* is an establishment of new section lines, and often new township lines, independent of and without reference to the corners of the original survey. In an independent resurvey it is necessary to preserve the boundaries of those lands patented by legal subdivisions of the sections of the original survey which are not identical with the corresponding legal subdivisions of the sections of the independent resurvey. This is done by surveying out by metes and bounds and designating as tracts the lands entered or patented on the basis of the original survey. These tracts represent the position and form of the lands alienated on the basis of the original survey, located on the ground according to the best available evidence of their true original positions.

6-6. As in the case of original surveys, the records of resurveys must form an enduring basis upon which depends the security of the title to all lands acquired thereunder. The surveyor must therefore exercise the greatest care in his field work and in preparing the record so that the resurvey will relieve existing difficulties as far as possible without introducing new complications.

6-7. A *retracement* is a survey that is made to ascertain the direction and length of lines and to identify the monuments and other marks of an established prior survey. Retracements may be made for any of several reasons. In the simplest case it is often necessary to retrace

several miles of line leading from a lost corner which is to be reestablished to an existent corner which will be used as a control. If no intervening corners are reestablished, details of the retracement are not usually shown in the record, but a direct connection between the two corners is reported as a tie. On the other hand, the retracement may be an extensive one made to afford new evidence of the character and condition of the previous survey. Recovered corners are rehabilitated, but a retracement does not include the restoration of lost corners or the reblazing of lines through the timber. The retracement may sometimes be complete in itself, but usually it is made as an early part of a resurvey.

6-8. In the case of *Cragin v. Powell*, 128 U.S. 691 (1888), the Supreme Court of the United States cited with favor the following quotation from a letter of the Commissioner of the General Land Office to the surveyor general of Louisiana:

The making of resurveys or corrective surveys of townships once proclaimed for sale is always at the hazard of interfering with private rights, and thereby introducing new complications. A resurvey, properly considered, is but a retracing, with a view to determine and establish lines and boundaries of an original survey, . . . but the principle of retracing has been frequently departed from, where a resurvey (so called) has been made and new lines and boundaries have often been introduced, mischievously conflicting with the old, and thereby affecting the areas of tracts which the United States had previously sold and otherwise disposed of.

## JURISDICTION

6-9. Resurveys have been made since the early days of the public land surveys. Initially they were made as corrective surveys under the general surveying appropriations when gross errors were found. Resurveys of particular public lands in certain States were later authorized by special acts of Congress. General legislation providing for resurveys was enacted when it became apparent that many older surveys were so obliterated or distorted that the lines could not be identified with certainty.

The Act of March 3, 1909, (35 Stat. 845), as amended June 25, 1910, (36 Stat. 885; 43 U.S.C. 772) authorized the Secretary of the In-

terior to make such resurveys as, after full investigation, he may deem essential to properly mark the boundaries of the remaining public lands.

The Act of September 21, 1918, (40 Stat. 965; 43 U.S.C. 773), provided authority for resurvey of townships in which disposals exceed 50 percent of the total area. Such resurveys may be undertaken upon application of the owners of at least three-fourths of the privately owned land in the township, or upon application of a court of competent jurisdiction, and upon a deposit of the proportionate estimated cost of the resurvey.

The Act of July 14, 1960, (43 U.S.C. 1364), authorized the Secretary of the Interior to accept contributions for cadastral surveys performed on federally controlled or intermingled lands.

Conservation and intensive use of the public domain have made necessary the retracement and re-marking of lines of the older surveys in order to identify the boundaries between public and private lands. Limited resurveys for this purpose are carried out under the annual appropriations for the management of public lands and resources.

6-10. As delegated by the Secretary of the Interior, the authority for engaging in a general resurvey, where public lands are involved, can issue only through the Director, Bureau of Land Management. Other Federal agencies vested with the administration of the lands may request resurveys by addressing the Director through the usual official channels. Justification for such action must be shown.

The Bureau of Land Management has exclusive jurisdiction over all matters pertaining to surveys and resurveys affecting the public lands. As between owners of lands, the title to which has passed from United States, final determination in the matter of fixing the position of disputed land boundaries rests with the local courts of competent jurisdiction. The rules of procedure laid down in the Manual of Surveying Instructions for the re-marking of lines of previous surveys are intended to be in harmony with the leading court decisions in suits involving boundary disputes. The rules should be so applied that the courts may, with security,

accept the boundaries thus determined insofar as they represent the true location of a particular piece of land intended to be conveyed by a patent. The official resurveys are undertaken only when duly authorized, and the field work assigned to a cadastral surveyor, who in that manner is acting under the authority of the Secretary of the Interior through the Bureau of Land Management and under the immediate direction of subordinate supervising officers.

### LIMIT OF AUTHORITY OF SURVEYOR

6-11. There are certain questions of a purely judicial nature involved in resurveys of every description where the decision is to be reserved to the Director of the Bureau of Land Management, particularly those relating to compliance with the general laws in respect to the entry of the public lands. Thus it comes within the realm of the surveying process to identify and mark out on the ground the various legal subdivisions of the public domain, but it is a judicial question beyond the function of the surveyor to determine whether or not specified lands have been duly earned under a certain entry. In the resurvey process the surveyor will determine whether or not lands embraced within a claim as occupied have been correctly related in *position* to the original survey. Where the demonstration of this question may be one involving more or less uncertainty, as is often the case, the surveyor will examine and weigh the evidence relating strictly to the surveying problem involved. He will interpret the evidence with respect to its effect upon the manner in which the resurvey shall be executed to protect valid rights acquired under the original survey. The surveyor has no authority to enter into an agreement concerning the exchange of one subdivision for another or to bind the Bureau of Land Management in this particular.

### BONA FIDE RIGHTS OF CLAIMANTS

6-12. In order to carry out the provisions of the laws relating to resurveys, the surveyor

must understand the meaning of the term "bona fide rights" and under what circumstances it will be held that such rights have been impaired by a resurvey. The Act of March 3, 1909, (35 Stat. 845), as amended June 25, 1910, (36 Stat. 884; 43 U.S.C. 772) reads in part as follows:

That no such resurvey or retracement shall be so executed as to impair the bona fide rights or claims of any claimant, entryman, or owner of lands affected by such resurvey or retracement.

The rights of claimants are to be similarly protected under the provisions of the Act of September 21, 1918, (40 Stat. 965; 43 U.S.C. 773).

6-13. Bona fide rights are those acquired in good faith under the law. A resurvey can affect bona fide rights only in the matter of *position or location* on the earth's surface. The surveyor will be concerned only with the question of whether the lands covered by such rights have been actually *located* in good faith. Other questions of good faith (such as priority of occupation, possession, continuous residence, value of improvements and cultivation) do not affect the problem of resurvey except as they help to define the position of the original survey.

6-14. The basic principles of protecting bona fide rights are the same in either the dependent or the independent resurvey. Each is intended to show the original position of entered or patented lands included in the original description. The dependent resurvey shows them as legal subdivisions, the independent resurvey as segregated tracts. Each is an official demonstration by the Bureau of Land Management according to the best available evidence of the former survey. There is no legal authority for substituting the methods of an independent resurvey in disregard of identified evidence of the original survey.

6-15. The position of a tract of land, described by legal subdivisions, is absolutely fixed by the original corners and other evidences of the original survey and not by occupation or improvements, or by the lines of a resurvey which do not follow the original. A conveyance of land must describe the parcel to be conveyed so that it may be specifically and exactly identified, and for that purpose the law directs that a survey be made. Under fundamental law the

corners of the original survey are unchangeable. Even if the original survey was poorly executed, it still controls the boundaries of land patented under it.

The surveyor should neither rigidly apply the rules for restoration of lost corners without regard to effect on location of improvements nor accept the position of improvements without question regardless of their relation or irrela-tion to existing evidence of the original survey. Between these extremes will be found the basis for determining whether improved lands have been located in good faith or not. No definite set of rules can be laid down in advance. The solution to the problem must be found on the ground by the surveyor. It is his responsibility to resolve the question of good faith as to location.

6-16. It may be held generally that the entryman has located his lands in good faith if such care was used in determining his boundaries as might be expected by the exercise of ordinary intelligence under existing conditions. The relationship of the lands to the nearest corners existing at the time the lands were located is often defined by his fencing, culture, or other improvements. Lack of good faith is not necessarily chargeable if the entryman has not located himself according to a rigid application of the rules laid down for the restoration of lost corners where (1) complicated conditions involve a double set of corners, both of which may be regarded as authentic; (2) there are no existing corners in one or more directions for an excessive distance; (3) existing marks are improperly related to an extraordinary degree; or (4) all evidences of the original survey which have been adopted by the entryman as a basis for his location have been lost before the resurvey is undertaken.

6-17. In cases involving extensive obliteration at the date of entry, the entryman or his successors in interest should understand that the boundaries of the claim will probably be subject to adjustment in the event of a resurvey. A general control applied to the boundaries of groups of claims must be favored as far as possible in the interest of equal fairness to all and of simplicity of resurvey. A claim cannot generally be regarded as having been

located in good faith if no attempts have been made to relate it in some manner to the original survey.

6-18. Cases will arise where lands have been *occupied* in good faith, but whose boundaries as occupied disagree with the position of the legal subdivision called for in the description. Obviously the rule of good faith as to location cannot apply; relief must be sought through the process of amended entry under R. S. 2372, as amended (43 U.S.C. 697), to cover the legal subdivisions actually earned, rather than through an alteration of the position of established lines. This is a process of adjudication rather than one of resurvey. A case of this character should be regarded as erroneous location in precisely the same manner as if the question of resurvey were not involved.

## GENERAL FIELD METHODS

6-19. In most areas that require resurveys the survey of record can be reconstructed by the methods of the dependent resurvey. The principal resurvey problem is one of obliteration with comparative absence of large discrepancies. The special instructions provide for a retracement and dependent resurvey, and these may be carried on at the same time if no complications develop. Even where the record survey proves to be badly distorted, the extent of private ownership may dictate that the resurvey will be of the dependent type. Many areas have a checkerboard pattern of ownership as the result of railroad or military road grants, and this same condition is approximated where extensive disposals have been made. Since an independent resurvey cannot affect boundaries of lands already alienated, it serves little purpose where every section line is the boundary of private land.

6-20. Occasionally, after a dependent resurvey has been commenced, complications develop which make the methods inapplicable. Provision should always be made in the special instructions calling for the surveyor to report such facts to the supervising office. The report should embody the same information as that required in the report of a preliminary examination hereinafter outlined.

6-21. Providing a large enough area of public land remains to warrant it, the methods of the independent resurvey are employed if there are intolerable discrepancies in the original survey. This occurs where the early survey was not faithfully executed with the result that some lines usually have not been established, have no actual existence, and cannot be reconstructed to conform to a fictitious record. Action should be taken to suspend the plat of record as a basis of disposals and leases before an independent resurvey is commenced.

When it is probable that an independent resurvey will be necessary, the special instructions provide that a preliminary field examination be made. No new monuments are constructed during the examination. Interested parties are to be informed that the examination is being made strictly for the purpose of developing information. They will be given to understand that, while new lines may be run later to identify the remaining public lands, the resurvey will be planned to protect all valid existing rights.

6-22. The report of a field examination consists of a diagram to scale, a narrative, and the field notes of the retracements made. The diagram shows the correlation of existent original corners, corners established by local surveyors, and any monuments of unknown origin. Line fences, line roads, and the boundaries of claims are also shown. The narrative includes a description of the recovered evidence and statements by witnesses regarding obliterated corners. The extent of obliteration and the degree of faithfulness of the original survey is discussed when this is pertinent. Disposals made by the Federal Government are listed and, if practicable, are shown on the diagram as well. Mention is made of improvements affected by the resurvey, the basis of claim locations, conflicts between claims, and any hiatus that may be anticipated. The field notes of the retracement form an important part of the report, since they show how correctly the natural features were represented in the original record. Finally, the surveyor recommends the procedure which he believes will best meet the existing conditions.

The report of the field examination is reviewed in the supervising office. Special instruc-

tions (or supplemental special instructions) are written to show the detail of the proposed resurvey. If the independent method is selected, an important consideration is the fixing of the out-boundaries of the township or townships within the planned resurvey. These limiting boundaries must be lines which can be restored in such a manner as to protect existing rights in the adjoining outside lands. An exception is where such a large area is to be independently resurveyed that it cannot all be included in one assignment. Occasionally, one portion of a township can be dependently resurveyed, while an independent resurvey is necessary in the remaining portion. In such a case the subdivisional lines separating the two types of resurvey must be dependently resurveyed.

6-23. Even when the procedures have been based on a preliminary examination, unforeseen difficulties may crop up in the progress of the resurvey by reason of the greater detail of the work. The new factors may make the special instructions inapplicable. If this occurs the surveyor should suspend further monumentation, make any additional examination required, then report the situation to the supervising office.

6-24. During the course of a resurvey the surveyor should advise all interested parties, as occasion and opportunity allow, that the resurvey is not official or binding upon the United States until it has been duly accepted by the Director, Bureau of Land Management, as provided by law. No alteration in the position of improvements or claim boundaries should be made in advance of the official acceptance of the resurvey.

### THE DEPENDENT RESURVEY

6-25. The dependent resurvey is designed to restore the original conditions of the official survey according to the record. It is based, first, upon identified original corners and other acceptable points of control, and, second, upon the restoration of lost corners by proportionate measurement in harmony with the record of the original survey. Some flexibility is allowable in applying the rules of proportionate measure-

ment in order to protect the bona fide rights of claimants.

6-26. The dependent resurvey is begun by making a retracement of the township exteriors and subdivisional lines of the established prior survey within the assigned work. Concurrently, a study is made of the records of any known supplemental surveys, and testimony is obtained from witnesses concerning obliterated corners. The retracement leads at once to identification of known and plainer evidence of the original survey. A trial calculation is made of the proportionate positions of the missing corners, followed by a second and more exhaustive search for the more obscure evidence of the original survey. If additional evidence is found, a new trial calculation is made. Corners still not recovered are marked only as temporary points which may be influenced by acceptable locations. These steps give the basic control for the resurvey. The surveyor then weighs the less certain collateral evidence against the proportionate positions so obtained.

6-27. A comparison of the temporary points with the corners and boundaries of alienated lands often helps in determining how the original survey was made, how the claims were located, or both. In analyzing the problem of a particular corner's location, it is often helpful to determine where the theoretical corner point would fall if a three-point control were used. In extreme cases the collateral evidence may be weighed against the position obtained by use of two-point control, particularly when supported by well-identified natural features. It may then prove that the original corner, which would otherwise be lost, has been perpetuated by an acceptably located claim.

Ordinarily the one-point control is inconsistent with the general plan of a dependent resurvey. The courts have sometimes turned to this as the only apparent solution of a bad situation, and unfortunately this has been the method applied in many local surveys, thus minimizing the work to be done, and the cost. Almost without exception the method is given the support that "it follows the record." This overlooks the fact that the record is equally applicable when reversing the direction of the control from other good corners, monuments,

or marks. The use of one-point control is only applicable where the prior survey was discontinued at a recorded distance or where it can be shown conclusively that the line was never established. If the line was discontinued by record, the field notes may be followed explicitly. If it was discontinued by evident unfaithfulness in execution, its use would be limited to the making of a tract segregation where the claimant has given confidence to the so-called field notes.

6-28. Once it is accepted, a local point of control has all the authority and significance of an identified original corner. The influence of such points is combined with that of the previously identified original corners in making final adjustments of the temporary points. The surveyor must therefore use extreme caution in adopting local points of control. These may range from authentic perpetuations of original corners down to marks which were never intended to be more than approximations. When a local reestablishment of a lost corner has been made by proper methods without gross error and has been officially recorded, it will ordinarily be acceptable. Monuments of unknown origin must be judged on their own merits, but they should never be rejected out of hand without careful study. The age and the degree to which a local corner has been relied on by *all* affected landowners may lead to its adoption as the best remaining evidence of the position of the original corner. The surveyor must consider all these factors. However, he cannot abandon the record of the original survey in favor of an indiscriminate adoption of points not reconcilable with it.

The field-note record of the resurvey should clearly set forth the reasons for the acceptance of a local point where it is not identified by actual marks of the original survey. Recognized and acceptable local marks will be preserved and described. Where they are monuments of a durable nature, they are fully described in the field notes and a full complement of the required accessories recorded, but without disturbing or re-marking the existing monument. New monuments are established if required for permanence, in addition to, but without destroying the evidence of the local marks.

**6-29.** The surveyor should make certain while still in the field that he has noted complete descriptions of all identified or accepted corners for entry in the official record of the resurvey so that the record will embrace:

(1) A complete description of the remaining evidence of the original monument;

(2) A complete description of the original accessories as identified;

(3) A concise statement relating to the recovery of a corner based upon identified line trees, blazed lines, items of topography, or other calls of the field notes of the original survey, in the absence of evidence of the monument or its accessories;

(4) A statement relating to the relocation of an obliterated monument; or a statement of the determining features leading to the acceptance of a recognized local corner;

(5) A complete description of the new monument; and

(6) A complete description of the new accessories.

**6-30.** The running and measurement of the true lines of the dependent resurvey, the marking of lines between corners, the notation of objects to be recorded, and the monumentation of the survey must conform to the requirements for original surveys. The technical record of the resurvey shows the relationship between the original survey and the reestablished lines.

**6-31.** In the course of marking the true lines it is often desirable to establish sixteenth-section corners or minor subdivision corners which control the position of intermingled public land within a section. Later subdivision of the section would then not require a new resurvey of the section lines for that purpose.

**6-32.** The limit of closure already prescribed will be observed. Special stress will be given to the need for greater accuracy in the measurements, which largely govern the restoration of lost corners. (section 3-124).

### THE INDEPENDENT RESURVEY

**6-33.** An independent resurvey is designed to supersede the prior official survey only insofar as the remaining public lands are concerned. The subdivisions previously entered or patented

are in no way affected as to location. All such claims must be identified on the ground, then protected in one of two ways. Whenever possible, the sections in which claims are located are reconstructed from evidence of the record survey just as in a dependent resurvey. Where unrelated control prevents the reconstruction of the sections that would adequately protect them, the alienated lands are segregated as tracts. A particular tract is identical with the lands of a specific description based on the plat of the prior official survey. The tract segregation merely shows where the lands of this description are located with respect to the new section lines of the independent resurvey. In order to avoid confusion with section numbers the tracts are designated beginning with number 37. The plan of the independent resurvey must be such that no lines, monuments, or plat representations duplicate the description of any previous section where disposals have been made.

**6-34.** The statutory authority to review the effect of an independent resurvey upon the boundaries of privately owned land rests in the courts. A decision of the court is binding in fixing a boundary between private lands. It would be contested in fixing a boundary between public and patented lands only if monuments of the official survey have not been considered, the court having no authority to set aside the official survey.

**6-35.** The independent resurvey is accomplished in three distinct steps:

(1) The reestablishment of the outboundaries of the area to be resurveyed, following the methods of a dependent resurvey.

(2) The segregation of lands embraced in any valid claim based on the former approved plat.

(3) The survey of new exterior, subdivisional, and meander lines by a new regular plan.

### Reestablishment of Outboundaries

**6-36.** The limiting boundaries of the lands which are to be independently resurveyed must agree with the previously established and identified exterior or subdivisional lines of the approved original surveys. In order to qualify as a suitable limiting boundary, a line of the ac-

cepted established surveys must be conclusively identified in one position to the exclusion of all others. The lands on one side are to be resubdivided upon a new plan. On the opposite side the original subdivisions are to be strictly maintained, and none of the original conditions are to be disturbed. Where an outboundary has been reestablished by dependent resurvey, the subdivisions of a tract originally described as along or on opposite sides of the outboundary must agree with the line reestablished.

6-37. Although the outboundaries of the independent resurvey generally follow established township exteriors, section lines may qualify as suitable limiting boundaries in special cases. Particular attention should be given to this subject when the field examination is made, with a view to maintaining the original survey as far as it is consistent.

6-38. In some cases a proper limiting boundary cannot be secured without including a greater number of townships than it is practicable to resurvey in one assignment. One or more tracts requiring segregation may then extend across an independently resurveyed outboundary into a township not grouped for resurvey. Any such tract will be fully segregated whether or not the tract was originally described as in the township to be resurveyed. The necessary official steps will be taken to suspend disposal of lands in the adjoining township pending investigations with a view to the resurvey of that township.

Where the lines of the independent resurvey are not to be initiated or closed upon the restored original corners of the outboundaries, the new monuments will be marked only with reference to the township, range, and section to which they will thenceforth relate. New regular corners controlling the lines of the independent resurvey will be established as provided in chapter III under Defective Exteriors. During the preliminary stages of the resurvey there will often be doubt as to whether an old corner will retain its former control or not. The marking of the new monument and its accessories will be deferred until the future significance of the point is determined. Where an old point is not to be the corner of a subdivision, but is to

be perpetuated merely to control future alignment, it will be monumented as an angle point.

### Metes-and-Bounds Survey of Private Claims

6-39. The special instructions should designate the sections containing alienated lands which will be dependently resurveyed. Where there is acceptable evidence of the original survey, the identification of the areas that have been disposed of must be the same as would ordinarily be derived by the regular subdivision of the section. The tracts which are to be segregated by metes-and-bounds survey are those areas that cannot be so identified, nor conformed satisfactorily, those where amendment of description appears not to be an available remedy, and those where the disposals are found to be in conflict by overlap. Every corner of these tracts is marked by angle-point monumentation, and a tie is made from each tract to a corner of the resurvey.

6-40. An abstract of pertinent records and a status diagram should be furnished to the surveyor showing lands whose boundaries cannot legally be disturbed. These include patented lands, valid entries, school sections, land grants, disposals, reservations, or selections of lands whose position and description are based upon the original survey and plat. The resurvey will not be complete until each claim described has received full protection in the matter of location. Each must be protected either by individual metes-and-bounds survey or by the assignment of subdivisions of the resurvey whose boundaries coincide or approximately agree with the tract boundaries. In addition it is often desirable to furnish to the surveyor the status of all claims in the adjacent sections of adjoining townships ungrouped for resurvey which might affect the resurvey procedure.

6-41. The survey of private claims need not be completed before beginning the projection of the new lines of the independent resurvey. It is logical, however, to consider the subject of the tract segregations in advance of the question of the establishment of new lines. The surveyor may find it expedient to carry both branches of the survey along together.

6-42. The jurisdiction of the Bureau of Land Management, the limit of the authority of the surveyor, and the bona fide rights of claimants, where entered or patented lands are involved, remain absolutely the same whether the resurvey is to be made upon the dependent or independent plan. Thus, where the independent type of resurvey has been adopted as more feasible, identified corners of the original survey in the immediate vicinity of lands to be segregated are employed for the control of the location of such lands. The question of the good faith of the entryman is fully considered, as previously outlined in this chapter. Where the evidence of the original survey is so obliterated that lack of good faith in location cannot be charged against an entryman, the available collateral evidence is to be regarded as the best indication of the original position of the claim. It is employed as far as consistent for the control of the section boundaries within which such claim is located.

6-43. Where the surveyor cannot definitely locate a claim by identification of the original survey, he should ask the claimant to point out his boundaries. The boundaries of the private claim, so determined, are fixed as between private and public lands, subject to official acceptance of the resurvey. The surveyor should explain that an acceptably located claim must have a form agreeing with the original entry, approximately regular boundaries, an area not widely inconsistent with that shown on the plat, and a location as nearly correct as may be expected from the existing evidence of the original survey.

6-44. Dispute may arise over adjustment of the line between adjoining patented tracts, each acceptably located. If it cannot be reconciled by the surveying process, the tracts are surveyed in conflict and so shown on the resurvey plat.

6-45. The surveyor cannot change materially the configuration of a tract as shown by its original description in order to indemnify the owner against deficiencies in area, to eliminate conflicts between entries, or for any other purpose. If improvements have been located in good faith, the tract survey should be so executed, or the conformation to the

lines of the resurvey so indicated, as to cover these improvements and at the same time maintain substantially the form of the entry as originally described. No departure from this rule is allowed.

6-46. The amendment of entries is a matter for adjudication by the Bureau of Land Management after the resurvey has been accepted and the plats filed in the land office.

6-47. An attempt should be made to consult an absentee owner so that he may point out the lands subject to a metes-and-bounds survey. If the owner cannot be found and there is no indication of the boundaries of a claim, the surveyor should locate it from the nearest original point of control or from a point of a neighboring claim, or assign to the entered or patented lands the appropriate subdivisions of the resurvey. The controlling factors are individual and neighborhood improvements (such as buildings, wells, springs of water, cultivated lands, public roads, fences, corners of recognized private surveys, etc.) which indicate the evident intention of the entryman or patentee as to the position of his land.

6-48. Each nonconformable valid claim in a township is given a serial tract number, commencing with No. 37 in the smallest numbered and entered section of the original plat, progressing through the township in the order in which lot and sections are numbered. A tract number is used but once in a township, and if any tract lies partly in two or more townships subject to resurvey the number applied to the tract in the first township resurveyed is not used for other tracts in the adjoining township.

6-49. The following rules will be observed in executing the metes-and-bounds survey of designated tracts:

(1) Each acceptably located claim which is at variance with the lines of the resurvey is surveyed and monumented at each angle point.

(2) Where the limiting boundary of the independent resurvey has been reestablished in its original position by dependent resurvey, the portion of a claim lying outside the boundary is not surveyed by metes and bounds. It is located in an area where the original conditions cannot be disturbed. The portion of the claim lying

within the area of the independent resurvey has at least one identifiable original boundary. It should be defined by segregation or conformation to the lines of the resurvey in a position which is properly related to the identified or restored corners on the limiting boundary.

(3) Where the boundaries of a claim are unacceptably located as pointed out by the claimant, the claim is surveyed and monumented in a suitable relation to the original survey. If the claimant protests the location, the surveyor should request that the protest be made in writing. The written protest will be submitted with the returns of the resurvey. Accurate ties should be made to the corners of the claim as unacceptably located. The surveyor should make a complete report of the facts with reference to the question of location. Further protection to the entryman may be sought by an amendment of entry.

(4) Where the metes-and-bounds segregation of a claim (or its conformation to the lines of the resurvey) does not cover the lands occupied, improved, or claimed, the claimant may express a desire to amend his entry. The fact should be stated in the field notes. A separate full report is made by the surveyor describing the subdivisions actually occupied and those sought under the amended entry which are not within the tract as surveyed. (See current regulations relating to the amendment of entries.)

(5) Where the regular quarter-quarter sections within a claim fall in approximately the same position as the regular quarter-quarter sections of the resurvey, the entryman or patentee may desire to conform his claim to the resurvey. If no apparent objection is found by the surveyor, the facts should be stated in the field notes and the claim so indicated upon the resurvey plat. Under this circumstance the metes-and-bounds survey of the tract is omitted. However, where a tract includes a fractional lot as originally described or where any part of a tract falls upon a fractional lot of the resurvey, the tract must 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.

No claim should be conformed to the lines of an independent resurvey under an involved amended description which includes numerous subdivisions smaller than the regular quarter-quarter section, excepting as completely surveyed and monumented.

(6) Conflicting tracts, each acceptably located, are surveyed and monumented and the conflict shown upon the resurvey plat. Each intersection of conflicting boundaries is determined upon the ground and recorded in the field notes, which also show the number of acres in conflict with each other tract.

(7) The angle points of a tract are 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. The monument is marked as in the following examples:

AP 4	AP 3	T 26 N	R 17 E
TR 38	TR 37	S 14	
AP 1	AP 2	AP 1	AP 2
TR 45	TR 46	TR 38	TR 37
1971		1971	

T 26 N	R 17 E
AP 1	S 14
TR 37	
1971	

(8) No accessories are required with the monuments at the angle points of the metes-and-bounds survey.

(9) At least one angle point of each tract is connected with a regular corner of the resurvey. Where claim lines are intersected by lines of the resurvey, a connection is made to the nearest claim corner and recorded in the field notes of the section line. This is considered a satisfactory connection to all *adjoining* claims located within the interior of either section. Where an extensive system of tract segregations has been surveyed, the interior tracts of the block do not require connections. The establishment of closing corners on the regular line when entering or leaving public land will con-

form to the practice described in Closing Section Lines, sections 3-68 through 3-73.

(10) All recovered monuments of the original survey not otherwise reported upon are connected by course and distance with a corner of the resurvey. The connection and a description of the traces of the original corner as identified are recorded in the field notes of the resurvey. The old monument is destroyed unless the point may be needed to control the position of a claim. (See also Defective Exteriors, section 3-36).

### The Projection of New Lines

6-50. A plan for projecting new section lines can best be made after study of a layout showing (1) lines of the former survey which are to be restored and (2) the necessary tract segregations. If the report of the field examination is explicit, the plan may be incorporated in the special instructions. If the report does not fully identify the position of alienated lands, the plan must be delayed until these lands have been segregated.

6-51. The resubdivision of vacant public lands in a township by independent resurvey is an application of fragmentary subdivision as discussed in chapter III. However, an independent resurvey may involve the resubdivision of a group of many townships where the conditions are comparatively regular except for the tract segregations. First attention is given to completing the township exteriors which are to be independently resurveyed. These are completed as in the establishment of original surveys. The new section lines are surveyed and marked as in regular or fragmentary subdivision, whichever may be the case. New meander lines are run as required. The new exterior and subdivisional lines are usually extended across small blocks of tract segregation surveys, and connections are made as described under Metes-and-Bounds Survey of Private Claims, section 6-39. Where the new lines are so extended across tracts, the corners are fully monumented regardless of the fact that some points fall within the tract segregation surveys. They are required in order to determine the subdivision of the public lands.

6-52. After the plan of running new section boundaries has been determined, the creation of needed new lottings is considered. This must precede the marking of the corner monuments, which may be affected by the manner in which the lots are laid out and numbered.

Where any aliquot part (vacant) of a newly created section would normally have a description that duplicates the corresponding part (alienated) of an original section bearing the same section number, such part or parts of the new section are given appropriate lot numbers. The new lot numbers begin with the next number above the highest numbered lot of that section of the prior survey. Also, where there are new normal lottings in the sections along the north and west boundaries of the township, if those sections are not restorations of the corresponding sections of the prior survey (and same township and range), the lottings are given numbers beginning with the next higher number above those that were previously employed.

6-53. Some new sections may be elongated in order to absorb the discrepancy in the positions of the section-line boundaries as between the old and the new survey. This is taken care of in the lottings of the new sections. Such departure from normal procedure is made necessary by the discrepancies of the prior survey, where the location of the alienated lands cannot be changed.

6-54. Where a section of the resurvey is invaded by tract segregations, the lotting of the public lands is carried out in accordance with the usual plan of lotting within fractional sections. The numbering of the fractional lots begins 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 avoids any possible confusion which might arise from a duplication in the use of the same lot numbers.

6-55. The plan of the independent resurvey should be carefully studied for the proper placing of all needed quarter-section corners, for either one or two sections, so to provide for the position of the center lines of all sections, restored or new. Where two positions are found to come within less than half the closing limit pre-

scribed for a section, the point first derived as the appropriate position of the quarter-section corner of the restored section boundary is used for control in both sections. This rule is in the interest of simplicity of survey and monumentation.

**6-56.** The general requirements of chapters II, III, and IV must be fully observed in every

respect throughout the execution of the independent resurvey.

It is important that the surveyor make a careful study, during the period of the field work, of the construction of the resurvey plats, to make certain that every possible condition has been given consideration and that all necessary data have been obtained.

## Special Surveys and Instructions

### SPECIAL INSTRUCTIONS

7-1. The detailed specifications for each survey are set out by the officer in administrative charge of the work in a written statement entitled "Special Instructions." The special instructions are an essential part of the permanent record of the survey, both as historical information and because they show that the survey was properly authorized. The immediate purpose is to outline the extent of the field work and the method and order of procedure. Coupled with the Manual, the special instructions contain the technical direction and information necessary for executing the survey. Emphasis is given to any procedure unusual in application, but no lengthy discussion is required of procedures that are adequately covered in the Manual. The special instructions are written in the third person.

7-2. Shown below is the arrangement of subject matter in the special instructions. Italicized portions denote standard phraseology.

- (1) Title: *Special Instructions*  
*Group No. —, (State)*

(Nature of survey, and location by township, range, and meridian)

- (2) Preliminary statement:

*In the execution of the surveys included under Group No. —, (State), the chief of field party is authorized and directed to make the described examination, retracements, reestablishment of points of control, surveys, and resurveys set out in these instructions. He will be guided by the Manual of Surveying Instructions, the provisions of the following special instructions, and such supplemental instruc-*

*tions as may be issued during the progress of the work.*

- (3) *Authority*

Cite departmental or bureau instructions or authorization, the request of another Federal agency having administrative jurisdiction over the lands whose survey is being requested, or any special act of Congress relating to the survey.

- (4) *Appropriation*

*The costs of the field and office work incurred in the execution of the survey, within approved official regulation, are payable from the appropriation:* Give the title of the applicable appropriation, fund, or deposit, and cite the act of Congress under which a deposit has been received.

- (5) *Limit and Character of Work*

Describe the lines to be surveyed by township, range, and meridian, with designation by section where only parts of townships are authorized. If the work involves other than original surveys, indicate the character of the fragmentary survey, the type of resurvey, or the nature of the field examination. Legal or technical questions related to the work may be pointed out here or in the part of the instructions dealing with methods, whichever is most appropriate. Similarly treated would be known facts concerning private rights that may be affected and directions for protecting those rights.

- (6) *History of Earlier Surveys*

Each new survey, retracement, or resurvey is predicated on the surveys accepted previously. The pertinent existing surveys are reviewed in the special instructions with an explanation of known or presumed complications.

*(7) Method and Order of Procedure*

If the projected work is an extension of original surveys, it taken up in the following order in the instructions:

- (a) Standard parallels and guide meridians
- (b) Township exteriors
- (c) Subdivisions, including meander lines
- (d) Subdivision of sections if included

The instructions for each township should be completed separately. If complications are anticipated, the surveyor should be informed what to expect and what methods to apply. References to Manual rules are made by chapter and section numbers, but the surveyor is expected to understand regular practices and to be familiar with the Manual as a reference guide in unusual cases. The burden of this should not be transferred to the special instructions.

If the work involves other than original surveys, detailed specifications are stated for required examinations, fragmentary surveys, resurveys, topographic surveys, or special monumentation. There follows in this chapter a discussion of how the usual types of special surveys are treated.

Where precautions need to be taken for the preservation of esthetic values in the environment, such as the elimination of blazing on the lines or the limitation of vehicular use, the special instructions should so state. Additionally, the surveyor should be directed to exercise care in situations not covered by the instructions.

*(8) Diagrams and Supplemental Data*

In the case of original surveys a diagram constructed on a scale of 80 chains to an inch or larger should be furnished as a part of the instructions. The assigned work is usually shown by dashed lines and the adjoining previous surveys by solid lines. The diagram should indicate the directions and lengths of lines of the established surveys within two miles of the new assignment. Outlying areas protracted as though surveyed on the previous plats should always be shown.

A notation should be made in the instructions that copies of the plats and field notes of previous surveys pertinent to the assigned work will be furnished at the time of field assignment.

Known claims, improvements, or monuments

of other official surveys should be noted in the instructions.

When pertinent to the survey, the special instructions are supplemented by a status report, usually in the form of a diagram, showing disposals and withdrawals in the area to be surveyed or resurveyed. Streams upon which withdrawals for power sites or other purposes have been or may be made, and streams, ridges, or divides which constitute the boundaries of reserves, should be specified.

There should be supplied with the special instructions a list of available topographic maps, aerial photographs, and other data showing important map features. Any required additional mapping to be done in the field should be indicated.

*(9) Field Notes, Plats, and Reports*

The special instructions should include directions for the preparation of the field notes and point out the parts of the returns that will require special attention in the field. If a preliminary report or diagram is to be submitted during the progress of the field work, the instructions should so state. Special lottings or other unusual matters that are to be considered when the final returns are prepared should be specified.

Direction will be given to return for official use the special instructions and other papers that belong with the official record, data added in the field, and field computation sheets.

*(10) Modification of Instructions*

The special instructions should direct the chief of field party to report promptly conditions that call for additional or modified instructions together with a recommended procedure.

7-3. The special instructions are ordinarily prepared and signed by the technical officer in direct administrative charge of the particular surveying program. Approval of the instructions is by the office head in administrative charge of the area where the survey is made, or as delegated by current regulations. The date of the instructions and date of approval are always shown.

**SPECIAL SURVEYS**

7-4. Special surveys are surveys that involve unusual applications of or departures

from the rectangular system. They often carry out the provisions of a special legislative act. A particular category of special surveys has to do with various types of water boundaries. In some cases the special instructions merely expand the methods outlined in chapter III. In the more complicated special surveys the methods must be carefully detailed.

The following discussion of the several types of special surveys illustrates what is to be emphasized in the special instructions for each.

### Tracts and Lots

7-5. Special surveys may involve areas of land that are not aliquot parts of sections but are designated as lots or tracts. In common usage the term "tract" is applied to an expanse of land of no particular size, often irregular in form. In modern public land surveys the term is used specifically to mean a parcel of land that lies in more than one section or that cannot be identified in whole as a part of a particular section. It is properly described by tract number and township. Tracts within a township are numbered beginning with 37 or the next highest unused numerical designation to avoid confusion with section numbers.

7-6. Unless tracts have been segregated in the course of an independent resurvey, in which case they are treated as described under that subject, an irregular parcel lying entirely within a surveyed section should be designated as a lot of that section. "Small tracts," when not aliquot parts of sections, are designated as lots wherever they can be identified as parts of a section. The description is by lot, section, and township.

7-7. Except in independent resurveys, or if the proper name is "Tract \_\_\_\_\_," an area of non-public land should be designated as a parcel, not as a lot or tract, when a special designation is necessary for identification. To distinguish among several parcels, they may be called "Parcel A," "Parcel B," and so on.

### Subdivision of Sections-Special Cases

7-8. The need for subdivision of sections and any usual methods required are brought out in the special instructions. Examples are

Indian allotment surveys, subdivisions within reclamation projects, the determination of boundaries between intermingled public and patented lands within a section, the subdivision of sections into "small tracts," and various fragmentary surveys needed to mark the boundaries of the remaining public lands. In complicated cases the subdivision of sections may be advisable to avoid the possibility of an incorrect local survey.

7-9. Nearly always the subdivision-of-section lines are run out in accordance with the showing of the official plat. An uncommon exception is when a disposal has been made of a parcel whose description clearly differs from the lottings or aliquot parts represented on the plat.

7-10. The customary lottings are often not shown on plats of very old surveys. A determination of what the disposals were intended to convey can then be made only by reference to the record of the disposals themselves. Furthermore, in some of the old surveys quarter-section corners were not established on all true lines of the survey. Instead, the record shows that "half-mile" points were marked on the random line and not corrected to the true line midpoints. All such unusual problems should be brought out in the special instructions, as the diversity of the questions arising and the limited applicability of the answers precludes extended Manual treatment. (See Half-Mile Posts, Alabama and Florida, section 5-39.)

7-11. Where special methods are unavoidable, they should be made to conform as nearly as possible with the rules for the subdivision of sections discussed in chapter III. The special instructions should specify the procedure when the areas do not conform to the rectangular system of surveys.

7-12. If a section is subdivided, the center quarter-section corner is established and monumented. If a quarter section is subdivided, all sixteenth-section corners are established and monumented. Monuments of lower order are established where necessary to mark the actual boundaries of the minor subdivisions involved. Only the required boundaries need be surveyed within the sixteenth section, but, if this method is used, such lines must be connected to and



established in addition to the angle points and witness points. The plan of monumentation should be designated in the special instructions for the survey.

Metes-and-bounds surveys located upon surveyed land are connected to a regular corner of the subdivisional survey. If the area surveyed lies entirely within a surveyed section, it should be designated as a lot of that section and be numbered accordingly. If the location is within an unsurveyed township, the special instructions should call for the running of a connecting line to an established corner, the establishment of a location monument, or the determination of the geographic position of the initial point.

Nonriparian boundaries of these irregular areas, as called for by the law or executive order creating them, have sometimes been partly or entirely located along a natural boundary such as a watershed. Boundaries of this sort are normally winding, and it should be understood that they are technically defined by the natural feature and not by the straight lines between angle points monumented in a survey. *Northern Pacific Railway Co. v. United States*, 227 U.S. 355 (1913).

### Townsite Surveys

7-17. R.S. 2380 and 2381 (43 U.S.C. 711, 712) and numerous special acts make provision for the executive withdrawal of public lands for townsite purposes. A townsite survey, in public-land surveying practice, is a survey made within one or more regular units of the township subdivision by which the land is divided into blocks, streets, and alleys as a basis for the disposal of title in village or town lots.

Ordinarily special instructions are prepared for a preliminary reconnaissance of the townsite and for the resurvey and subdivision of sections which may be necessary. These are followed by supplemental instructions based on the findings of the examination and providing for the townsite survey proper.

### Planning the Survey

7-18. Townsite surveys fall into two general classes, those with few or no prior im-

provements and those where villages or towns already exist. Occasionally a townsite may be planned in connection with some Federal project where the survey must fit special requirements already set up. Whatever class the townsite falls in, a study of approved townsite plats with similar elements is helpful in planning. A visit to some of these developed areas may be worth-while to show good and bad planning clearly.

7-19. Consideration of every facet of townsite planning is beyond the scope of this Manual. There may be need for consultation with specialists in architectural and industrial planning, landscaping, and various branches of city engineering such as water supply, sewerage, street, highway, and railroad location. Provision is needed for public school grounds, other public buildings, and park areas. All these things are interdependent, and, wherever possible, local planning bodies should be asked to present plans which meet with zoning requirements. The planner should also refer to some of the many books on the subject of town planning.

### Surveying the Townsite

7-20. The rules that follow set out the minimum specifications for the running and measuring of the lines, the monumentation, and the elements of plat construction by which the blocks and lottings may be identified. The detail of the plan should be set out in the special instructions.

The character of the area—the topography, its location, and whether it is a new townsite or an addition to an old one—to a large extent determines the detail of the street and block system. A topographic survey is of value in ascertaining the layout best suited; the special instructions should call for the appropriate contour interval. Wherever practicable, especially where there are existing improvements, photogrammetry should be employed in the preliminary examination with panelled boundary monuments incorporated in the aerial control.

7-21. In the typical townsite the block dimensions are usually between 300 and 400 feet. The principal streets are usually made 80 feet in width, though frequently as much as 100 feet where greater width is called for. The

less important intersecting streets, though narrower, are seldom given a width of less than 60 feet.

The normal frontage of the lots is 50 feet. Unless conditions require a special plan, the whole system is laid out on cardinal. The blocks are given serial numbers, usually beginning with the northeast block and proceeding with the numbers alternately to the west and to the east. The lots are given serial numbers within the block.

7-22. The foot unit is employed in townsite surveys, and long steel tapes graduated in that unit are furnished for the purpose. Lengths of lines are reduced to the horizontal. In most cases the necessary accuracy can be secured only with the use of a spring balance for the maintenance of the proper tension, and with allowance for temperature corrections to the degree at which the tape is standard.

7-23. The field traverse of the townsites will ordinarily be made to close within an error not to exceed 1/5000, and never to exceed 1/2000. The determined lengths of lines and their bearings are balanced to secure a perfect closure for the data which are to be carried to the plat. Instrumental accuracy is obtained by the method of repetitions in turning the angles. These data should leave no discrepancy whatever in any calculated position, whether working from one monument to another, or between any two points.

7-24. If the proposed townsite is in an area already surveyed, great care should be exercised to identify the original section lines and to subdivide the section or sections in the proper legal manner to ascertain the assigned townsite boundaries. Permanent monuments are placed at each angle of the townsite boundary. These may be the regulation 2½-inch iron post or a tablet seated in a concrete post, 3 feet long and at least 8 inches square in cross section. Markings consist of the usual subdivisional identification marks, the capital-letter initials of the townsite name, and the letters "TS" in the appropriate quadrant.

7-25. The boundary streets are laid out first, then the other streets, blocks, and lots. Permanent control monuments are established

and connecting line measurements made as necessary to afford an exact relocation of any point. All data, including true bearings and deflection angles, connecting lines, and dimensions of streets, blocks, and lots are carried to the townsite plat. Their sufficiency may be tested by the ease with which the position of any given point can be ascertained and the area of any lot can be calculated. If there are curved lines, the curve elements are shown on the plat.

7-26. Permanent monuments are placed at the intersections of the street center lines and connections made to the block corners to insure a ready restoration of any block corner which might be obliterated. The 2½-inch iron post or a tablet seated in a concrete post, 24 inches long and at least 6 inches square in cross section may be used. These should be sub-surface monuments, placed as much as a foot below the probable grade line of the street and marked only for the point of intersection.

Where the street center-line intersections are intervisible, the markers may be placed at alternate intersections. Otherwise, a marker is placed at each intersection.

7-27. Where the street center-line intersection is not marked, the adjacent block corners are monumented with the regulation post set with the top flush with the ground and with a guard stake. If the intersection is monumented, durable markers such as galvanized iron pipes are set at the block corners and the front corners of the lots. These points are always monumented. The lot corners are set only on the block lines. Only the monuments at block corners are marked with the appropriate numbering. A permanent monument is placed at each angle point within the block boundary, when irregular, and at each point of curvature and point of tangency if the line of the block has been placed on a curve.

7-28. Lengths of lines and all angles or bearings are determined in the field for all irregular blocks and lots. In such cases both the side lines and back lines are always measured in the field. The dimensions are carried to the plat wherever needed, as when the lines cannot be readily located by the method of intersections.

### *Use of Photogrammetry*

7-29. Photogrammetry is especially useful in showing the irregular layout of an existing town or village. With the extent of the improvements known, the streets, blocks, and lots can be laid out on a trial basis on the photographs in order to determine the best plan. If the coordinates of lot corners, street center lines, monuments, and other points of significance are to be determined, the work should be done with a first order plotting instrument or by analytical methods. A sufficient number of positions are marked in advance of photography to reduce the work of transit and tape to a minimum.

### *Field Notes and Plats*

7-30. The field notes of the townsite survey describe the resurvey of the old section lines, the restoration of any needed corners, the subdivision of sections, and the controlling monuments. All important connecting lines and measurements between the boundary monuments and the corners of the block lines, or to the permanent monuments marking the street center lines adjacent to the boundaries, are included. The plan followed in the townsite survey is explained and a general statement made as to the monumentation. Beyond this, the further detail of all directions and lengths of lines is carried to the plat but omitted in the field note record. If any improvements are unavoidably left in conflict with the townsite layout, the information is brought out in the field notes but omitted from the plat.

7-31. Townsite plats are usually published at a scale of 200 feet to an inch, but they are frequently drawn at a somewhat larger scale, subject to reduction when published. A marginal diagram is usually supplied in order to show the relation of the townsite boundaries to the section lines, with lengths of lines here given in the chain unit. Tenths and hundredths of links are used where appropriate for making reduction to the lengths of lines shown on the main drawing.

On the main drawings all lengths of lines are shown in the foot unit, with tenths where needed. All directions and lengths of lines, intersection angles, and connecting lines to monu-

ments are given on the plat with a view to the location of any point by calculation from the points of permanent control. This facilitates ready calculation from the plat of the area of any individual lot.

The drawing shows the block and lot numbers, areas of lots to the nearest square foot, and the designation of streets by letters, numbers or names. In drafting the data for the regular blocks some of the figures which would be applied in each lot of the block may be omitted if it is left clear within the block that the lottings are regular for dimension and area.

All permanent monuments are shown on the main drawing and connecting data supplied. The widths of the streets should be plainly shown, but not repeated needlessly. Where all of the lots in a block are of the same dimensions, it is sufficient to show the measurements only along the block lines. A memorandum is supplied to note the general plan of monumentation, with an outline description of the monuments.

If there are reservations for public-school grounds, or of grounds for other public buildings or parks, the provision should be stated in the special instructions. The designated blocks are shown upon the plat, numbered regularly and titled, but not subdivided.

Reference should be made to chapter IX for the usual requirements regarding the title and the certificates which are to appear on the townsite drawing.

### *Small Tract Surveys*

7-32. The Act of June 1, 1938, (52 Stat. 609), as amended by the Act of June 8, 1954 (68 Stat. 239; 43 U.S.C. 682a), provides for the sale or lease of small tracts not exceeding five acres. The survey made to delineate the tracts differs from a townsite survey in that it normally follows a pattern of progressional subdivision down to the desired lot sizes without block designations or the segregation of streets and alleys. Regulations provide for reserving rights-of-way in the patents or leases.

7-33. The first requirement of the survey is the establishment or reestablishment of the section boundaries. The ensuing subdivision into small tracts should not be made without a

study of the terrain. Under favorable circumstances the section may be subdivided into legal subdivisions and thereafter into lesser aliquot parts. However, it is sometimes necessary to depart from normal subdivision lines in order to make the tract layout compatible with drainage features, existent roads, and improvements on adjoining lands.

7-34. Aerial photographs and topographic maps are helpful in devising a suitable plan of subdivision. A preliminary survey and development of a topographic map may be necessary. The small tracts might then take an irregular form so to fit the topography. While the individual parcels are called "small tracts," they are designated on the official plat as lots when not describable as aliquot parts of the section. If the survey is in the vicinity of urban or suburban development, the plan should be discussed with local officials as to suitability.

7-35. Small-tract surveys should always be executed within a closure limit of 1:2560 in either latitude or departure. If stricter limits are desirable in an urban or suburban area, provision will be made in the special instructions.

7-36. All corners of each lot should be monumented. Regulation monuments are used on section boundaries and on subdivisional lines down to 1/64 section lines. Further monumentation may be with approved materials called for in the special instructions such as iron pipes, rods, or angles. On an irregular lotting scheme regulation monuments should be used at approximate intervals of ten chains, preferably at intervisible points. Where all corners of an individual lot can be established on the lines of larger subdivisions, the minor subdivisional lines need not be surveyed.

7-37. The final field notes contain the regular record of the survey or resurvey of the section lines and subdivisional lines to the extent of all actual field surveys. The plat shows all data relating to established lines and measurements. Lot lines and measurements developed by protraction should be appropriately dashed and shown parenthetically. Bearings should be shown to 15" of angular value and distances to tenths of links. Each "tract" is assigned an appropriate lot number, and the area is shown to hundredths of an acre.

7-38. Topographic detail on the plat should be kept to a necessary minimum and subordinated to the base data. *Anticipated* new rights-of-way for road and public utility purposes, to be reserved in the lease or conveyance of the lots, need not be shown. It may be desirable to show the scheme of corner monumentation on the plat by appropriate symbols.

### Mineral Segregation Surveys

7-39. A mineral segregation survey is a metes-and-bounds survey made to define the limits of non-mineral public land adjoining one or more mining claims and to supply data for lotting the non-mineral land against the claims. Although a necessary part of the survey is to ascertain the boundaries and position of the mining claims, it is not a mineral survey and confers no permanent rights upon the mineral claimant. If the subsisting records furnish the information necessary for a proposed segregation of mineral claims from the non-mineral public lands, no mineral segregation survey is required.

7-40. Mineral segregation surveys fall into two classes:

(1) Where the record of official mineral surveys is faulty or fails to locate the claims accurately with respect to the rectangular net. Proper segregation usually requires the resurvey of section boundaries with connections to the mineral surveys.

(2) Where unsurveyed mining claims require segregation from land embraced in a pending administrative action. The field work consists of metes-and-bounds surveys of the mining claims, with connections to corners of the public land net, and the resurvey of section boundaries.

7-41. Where regular conditions are found, the mineral segregation survey consists only in running not less than two connecting lines from identified corners of the rectangular survey to a corner or corners of the mineral location, followed by a survey of the outboundaries of the mining claim or group of claims.

Monuments are placed at the angle points along the boundary of the mining claim or outboundaries of a group of claims as needed to mark the limits of the non-mineral land. The

angle points of the claim are numbered in accordance with the practice in mineral surveys. Each monument is marked with the initials of the name of the claim or claims and the angle point number. If the monument at the corner of the mineral location is in proper position, constructed of durable material, and suitably marked, the monument may be adopted without any alterations, and its description entered in the field notes.

7-42. In townships where there appears to be an extensive obliteration of monuments, or where the condition of the lines does not conform to the original plat and field notes, the survey will consist of such retracements and restoration of the corners of the section lines as may be necessary to define the non-mineral land or pending entry. If the distortion of the section lines is so great as to warrant the subdivision of one or more sections, the work authorized should be described in the special instructions or supplemental instructions.

7-43. The retracement of the lines of the mineral location should be made with the same degree of accuracy as a mineral survey, but all measurements are returned in the chain unit. It is essential that the requirements regarding the legal length and width of the mineral claims be observed, including parallelism of end lines. That is, the claim should be confined to the legal length along the mineral lode, the side lines should be placed within the legal width as determined from the center of the vein at the surface, and the end lines of each claim should be parallel. The segregated claim is to be made identical with, or be embraced within, the boundaries of its location, as provided in the mining regulations. A corner of the survey not identical with the corresponding corner of the location is tied to that corner.

7-44. Rules for the plat construction are found in chapter IX.

### Mine Surveys

7-45. This class of survey is important in connection with the leasing of mineral lands, particularly coal lands. The field work usually consists of a dependent resurvey and partial

subdivision of the section or sections involved, a traverse of the main entries of the mine, with ties to the portals and improvements, and the marking of the section and subdivision-of-section lines within the mine which divide private and public ownership.

A plat showing the subdivisions of the section or sections is prepared with an additional diagram added to show the underground workings of the mine or mines. This diagram should generally be drawn to the same scale as that used on the plat of the mine operations, which is usually 1 inch to 50 or 100 feet, thus permitting a direct comparison. The traverses of the underground workings should be shown by broken lines and the section and surveyed subdivision-of-section boundaries indicated by solid lines.

## SPECIAL SURVEYS—WATER BOUNDARIES

7-46. The subject of water boundaries has been divided into a number of parts—navigability, beds of nonnavigable streams and lakes, apportionment of accretion and reliction, accretion after survey but prior to entry, avulsion, and erroneously omitted areas—in order that the elements of each type of problem can be brought out clearly. As a practical matter, two or more of the conditions discussed are nearly always present along water boundaries where the surveyor will be working. An overall analysis is necessary to find out which problems are involved. A study of the available historic maps and aerial photographs should be made in all but the simplest cases.

### Navigability

7-47. Upon the admission of a State into the Union title to the beds of navigable bodies of water inures to the State as an incident of sovereignty. In *Pollard's Lessee v. Hagan*, 44 U.S. 212 (1844), the Supreme Court held that:

First. The shores of navigable waters, and the soils under them, were not granted by the constitution to the United States, but were reserved to the States respectively. Secondly. The new States have the same rights, sovereignty, and jurisdiction over this subject as the original States.

7-48. The question of navigability in law, where there may be controversy, is a matter to be decided by the courts, based upon the facts and conditions in each case as these prevailed at the date of Statehood. A frequently cited definition of navigability appears in *The Daniel Ball*, 77 U.S. 557 (1870) :

Those rivers must be regarded as public navigable rivers in law which are navigable in fact. And they are navigable in fact when they are used, or are susceptible of being used, in their ordinary condition, as highways for commerce, over which trade and travel are or may be conducted in the customary modes of trade and travel on water.

The same definition is applied to lakes. In *United States v. Holt State Bank*, 270 U.S. 49 (1926), the Supreme Court stated :

The rule long since approved by this court in applying the Constitution and laws of the United States is that streams or lakes which are navigable in fact must be regarded as navigable in law; that they are navigable in fact when they are used, or are susceptible of being used, in their natural and ordinary condition, as highways for commerce, over which trade and travel are or may be conducted in the customary modes of trade and travel on water; and further that navigability does not depend on the particular mode in which such use is or may be had—whether by steamboats, sailing vessels or flatboats—nor on an absence of occasional difficulties in navigation, but on the fact, if it be a fact, that the stream in its natural and ordinary condition affords a channel for useful commerce.

Artificial or natural changes *subsequent* to the date of Statehood do not bear on the subject of navigability. However in *United States v. Appalachian Electric Power Co.*, 311 U.S. 377 (1940), the Supreme Court made the following clarification :

“Natural and ordinary condition” refers to volume of water, the gradients and the regularity of the flow. A waterway, otherwise suitable for navigation, is not barred from that classification merely because artificial aids must make the highway suitable for use before commercial navigation may be undertaken.

7-49. The legal question of navigability is determined by the facts in any particular case and not from any action on the part of the surveyor. In *Oklahoma v. Texas*, 258 U.S. 574 (1922), the Supreme Court stated :

A legal inference of navigability does not arise from the action of surveyors in running meander lines along the banks of the river. Those officers are not clothed with the power to settle the questions of navigability.

7-50. The navigability or nonnavigability of a body of water may have been resolved by a jury upon consideration of the evidence and the opinion of competent witnesses. Courts have often taken judicial notice of the navigability or nonnavigability of streams and lakes. Where such determinations have not been made, studies by the Corps of Engineers in connection with the improvement of rivers and harbors are helpful in showing whether a river is navigable in fact. In questionable cases the necessary research as to navigability should be made and the facts noted in the special instructions.

### Beds of Nonnavigable Streams and Lakes

7-51. Nonnavigable streams and lakes are meandered under certain conditions which were described in chapter III. Title to the beds remains in the United States until the shore lands have passed into private ownership. *United States v. Oregon*, 295 U.S. 1 (1935). The Government's conveyance of title to a fractional subdivision fronting upon a nonnavigable body of water, unless specific reservations are indicated in the patent, carries ownership to the middle of the bed *in front of* the basic holding. *Oklahoma v. Texas*, 261 U.S. 345 (1923). See also 43 U.S.C. 931, quoted in chapter I.

7-52. It is necessary at times to survey the beds of nonnavigable streams and lakes, or the portions of the beds owned by the Government, in connection with the administration of the public lands. Where all the shore remains in public ownership, the survey is simply an extension of the regular system. More commonly, it is desired to establish partition lines between private and public lands. In either case, if the area is covered by water, the survey cannot be monumented in the regular manner, and many of the lines cannot be surveyed on the ground. The plat then represents a survey made largely by protraction. The procedure should be outlined in detail in the special instructions.

7-53. The field work usually consists of: (1) a dependent resurvey of the lands bordering on the area to be surveyed; (2) the subdivision of the upland sections when necessary to determine the boundaries of publicly owned riparian subdivisions; (3) the monumentation of as many corners as practicable; (4) the exten-

sion of section lines across the bed to the extent needed for making computations; and (5) the establishment of median and partition lines if this is to be done on the ground.

### Median Lines

7-54. It is sometimes necessary to define a line representing the limits of ownership between opposite banks. In navigable waters such a line might be either the deepest navigable channel (thalweg) or a median line. This is occasionally important in cases of reliction to public land fronting a navigable body of water. In nonnavigable waters the common property line is usually the median line.

The median line is a continuous line, formed by a series of intersecting straight line segments or a combination of straight line and curved line segments, every point of which is equidistant from the nearest point on the opposite shores. The method by which the median line is to be determined should be specified in the special instructions.

7-55. *Definition by Salient Points.*<sup>1</sup> The simplest method of determining the median line is by use of salient points. This method is of limited application in public land surveys, where the median line is nearly always determined from the meander lines. In certain surveys in Alaska no ground survey is required along meanderable water boundaries, and the salient point method may be used. It may also be applicable in special circumstances elsewhere if the meander lines are not defined. A salient point is any point on the shore that has an effect on the location of the median line. Along smooth shore lines the number of salient points becomes infinite, and a mathematical definition by this method is impracticable.

The angle points of the median line are first approximated graphically on suitably controlled

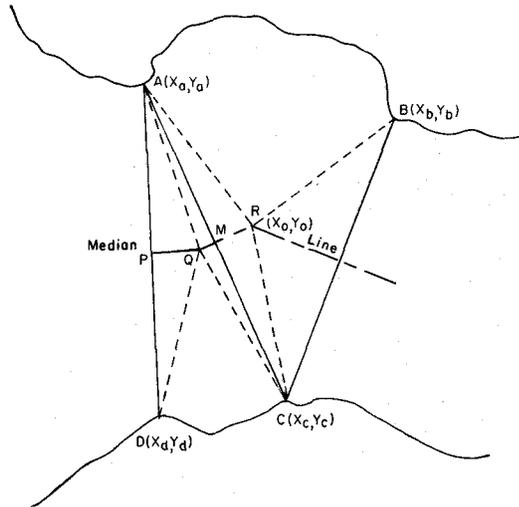


Figure 75.—Definition of a median line by salient points.

aerial photographs or reliable maps. The coordinates of the points are then determined analytically with values placing them truly equidistant from the nearest salient points. The analysis treats the salient points as lying on the circumference of a circle with radii extending from an angle point of the median line.

In figure 75 the median line has been initiated at point P midway between salient points A and D. The median line must pass through point P and be perpendicular to the line connecting A and D.

The coordinates of a point on the median line exactly midway between two salient points, such as point P, are

$$x_p = \frac{x_a + x_d}{2},$$

and

$$y_p = \frac{y_a + y_d}{2}$$

Line segment QR represents a portion of the line every point of which is equidistant from salient points A and C, one on each opposite shore. The median line passes through point M midway between salient points A and C, and is perpendicular to line AC.

Angle points on the median line occur at the intersection of adjacent straight line segments. At an angle point such as point R, the median line is equidistant from three salient points, one

<sup>1</sup> The salient point method is that used generally in connection with sea boundaries. As defined in the United Nations' "Convention on the Territorial Sea and the Contiguous Zone," held in Geneva in 1958, a median line is a "line every point of which is equidistant from the nearest points on the baseline." In that case, the "baseline" is the line of mean low water. The definition may be made applicable to inland submerged land boundaries by substituting "line of ordinary high water" for "baseline."

of which must be located on the shore opposite the other two.

The coordinates  $((x_o, y_o)$  of point R are determined from the equations

$$y_o = \frac{H_b^2 (x_b - x_a) - H_a^2 (x_c - x_a)}{2 G}$$

and

$$x_o = \frac{H_a^2 - 2y_o - (y_b - y_a)}{2(x_b - x_a)}$$

in which:

$$G = (y_c - y_a)(x_b - x_a) - (y_d - y_a)(x_c - x_a)$$

$$H_a^2 = x_b^2 + y_b^2 - x_a^2 - y_a^2$$

$$H_b^2 = x_c^2 + y_c^2 - x_a^2 - y_a^2$$

$x_a$  = the x coordinate of point A, and

$y_b$  = the y coordinate of point B, etc.

If the angle point is equidistant from more than three salient points, any three points can be used in determining the coordinates of the angle point. The three points selected should form the strongest possible geometric figure, that is, most nearly form the vertices of an equilateral triangle.

#### 7-56. Definition Between Meander Lines

When the original meander line defines the true shore, or where new meanders have been run preliminary to the determination of the median line, the points on the median line may be considered as the centers of circles tangent to the meander course on either shore or coincident with one or more angle points of the meander line. The resulting median line is made up of intersecting straight line segments and curved line segments.

Straight line segments represent those portions of the median line every point of which is equidistant from straight line segments of the two meander lines, one on each opposite shore and more or less parallel to one another. Straight line segments also occur under certain conditions when the median line passes between two meander line angle points on opposite shores.

Angle points occur at points of intersection between adjacent straight line segments of the median line. At angle points the median line is equidistant from three or more straight line segments of the two meander lines, one of which segments must be located on the shore opposite the others. Median line angle points usually occur in the vicinity of a meander line angle

point when one shore line is concave toward the median line and the opposite shore line is straight.

Curved line segments of the median line occur whenever the median line is equidistant from an angle point on the meander line on one shore and a straight meander course on the opposite shore. The meander line at the angle point is convex toward the median line.

The approximate positions of the angle points on the median line can be determined most easily by graphical means based on aerial photography or maps. A detailed analysis is too lengthy to include here. The surveyor should present the survey data for office computation.

### Partition Lines

7-57. The partition lines are established in accordance with the same principles for both rivers and lakes. Some variation is necessary in adapting the methods to particular cases. Care must be taken to award each basic holding on the shore the part of the bed *in front of it*. If one method fails to do this, another method, or a combination of methods, must be used.

### RIVERS

7-58. Instructions for surveying the partition lines are found in 50 L.D. 216 (1923), in the syllabus:

In establishing the side boundaries of claims of riparian proprietors to the area between the original meander line on the north and the medial line of Red River in Oklahoma in accordance with the decisions of the Supreme Court in the case of *Oklahoma v. Texas*, lines should be run from points representing the limits of frontage of the original claims on the meander line to points on the medial line at distances thereon proportionate to the lengths of frontage of the respective abutting owners.

This is an adaptation of the rule outlined in the case of *Johnston v. Jones*, 66 U.S. 117 (1861). By that rule the new frontage along the water boundary of an accreted area was apportioned in the same ratio as the frontage along the ancient bank. In applying the rule, if the shore has deep indentations or sharp projections, the general shoreline, not the actual length, should be taken in setting the ratio. Normal lines are extended to the median line, above and below the area to be apportioned, at

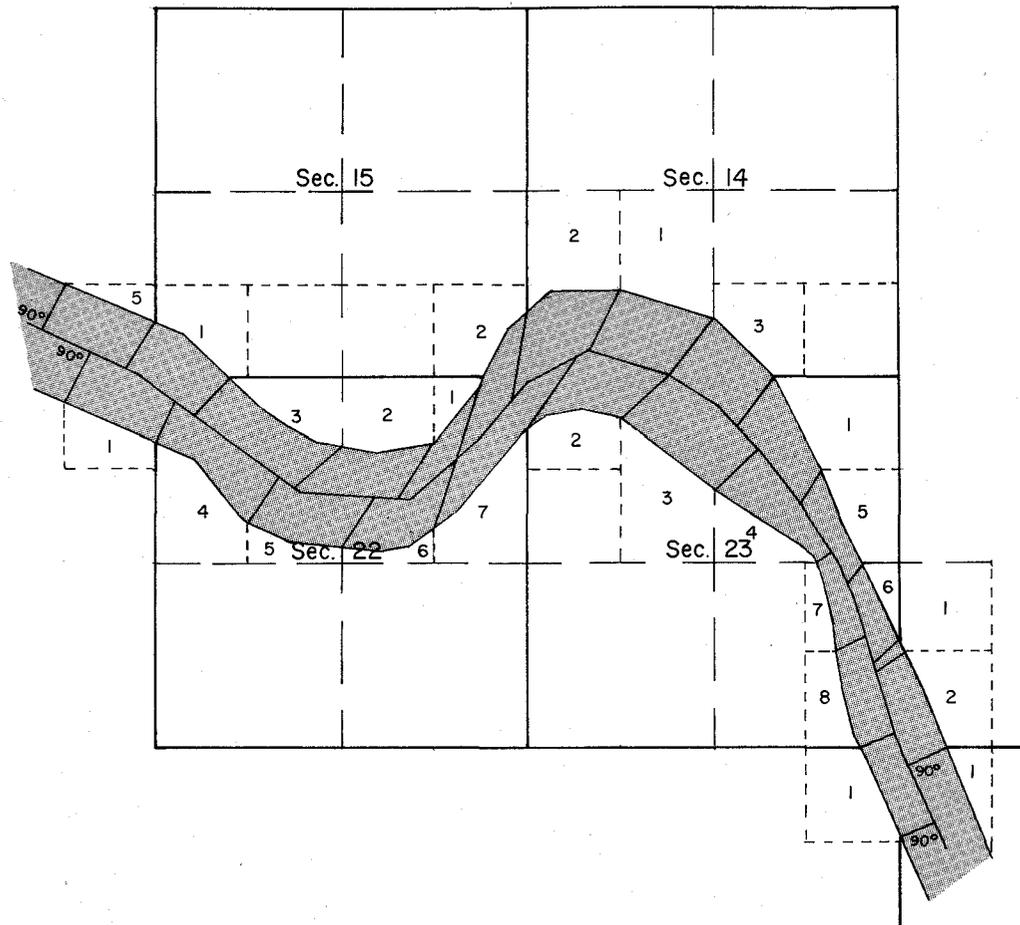


FIGURE 76(a).—Method of apportioning the bed of a nonnavigable river. Points were selected above and below the bend from which normals were extended to the median line. The intervals along the median line were determined by proportionate measurement. In this case the results are not as satisfactory as those obtained by the method shown in figure 76 (b).

points where the river's course is straight, or nearly so. The intermediate distance along the median line is then prorated according to the frontage. See figure 76 (a).

7-59. An alternate method is to run each partition line normal to the median line. This method awards to each riparian lot the area immediately in front of it. Where a winding stream course causes the normals to deflect rapidly, more than one normal can sometimes be extended from a single point on the shore, or perhaps no suitable normal can be drawn. A combination of methods may then have to be used to obtain equitable results. For instance, normals might be drawn to the median line at straight parts of the river, and the intermediate

parts apportioned along the median line. See figure 76 (b).

#### LAKES

7-60. The method of procedure depends on the shape of the shore line. The courts have generally held that the bed of a round lake should be divided among the riparian owners by ascertaining the center point and connecting that point by straight lines to the boundary corners on the shore. When a lake is long in comparison with the width, the methods applied to streams, with converging lines only at the ends, make the best division.

7-61. In figure 77 the ends of the lake have

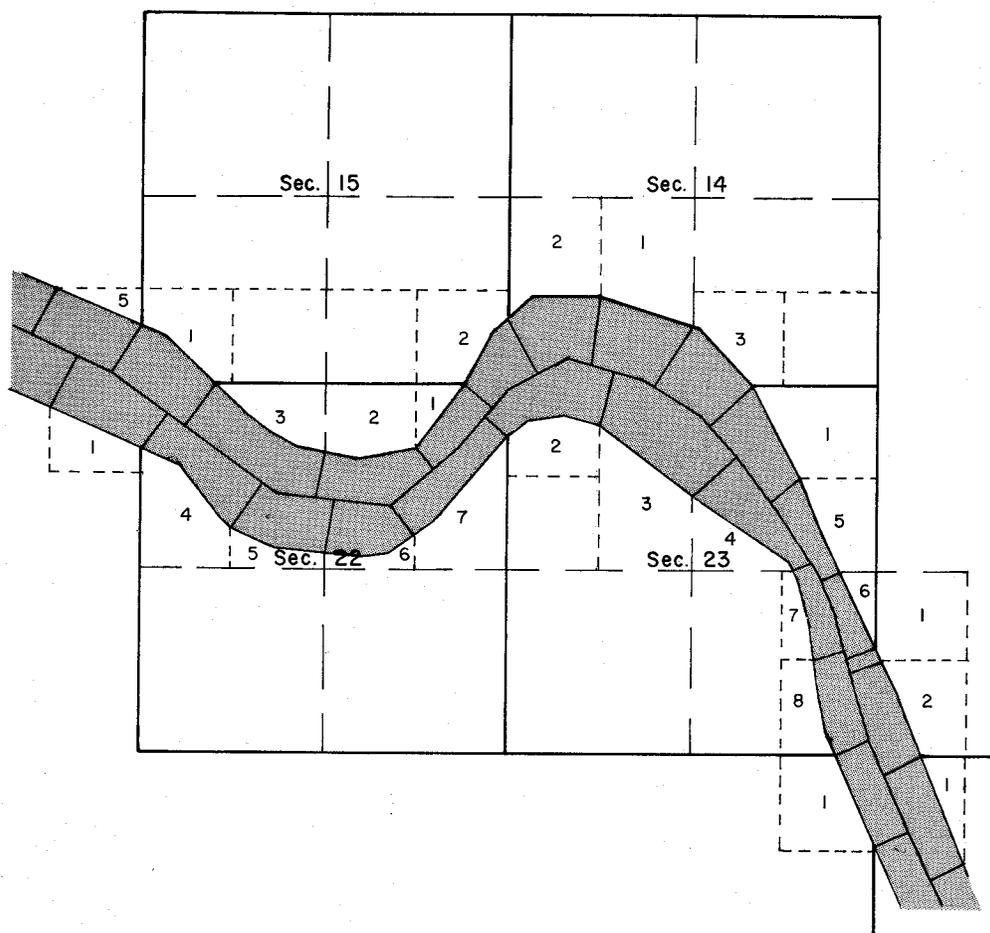


FIGURE 76(b).—Alternate method of apportioning the bed of a non-navigable river by extending normals to the median line.

been treated as arcs of a circle; the remainder of the bed has been divided by use of proportionate measurement along the median line. In this case normals to the median line would have resulted in the encroachment of some lots in front of others, and two normals could have been projected from several points as indicated by the dashed lines.

#### Apportionment of Accretion and Reliction

7-62. The term "accretion" is applied both to the gradual and imperceptible deposition of material along the bank of a body of water and the lands formed by this process.

7-63. "Reliction" is the gradual uncovering of land caused by the recession of a body of

water. Relicted land is treated in the same manner as accreted land insofar as its survey is concerned.

7-64. A meander line is not surveyed as a boundary. When the Government conveys title to a fractional lot fronting on a navigable body of water, the intention, in all ordinary cases, is that the lot extends to the water's edge.

7-65. The title and rights of riparian owners in areas *below* the line of mean high water of navigable bodies of water are governed by State law rather than Federal law. Whether Federal or State law controls the ownership of land accreted to a riparian holding has been answered in a series of cases:

In *Borax Consolidated, Ltd. v. Los Angeles*, 296 U. S. 10 (1935), the Supreme Court held that "The question as to the extent of this

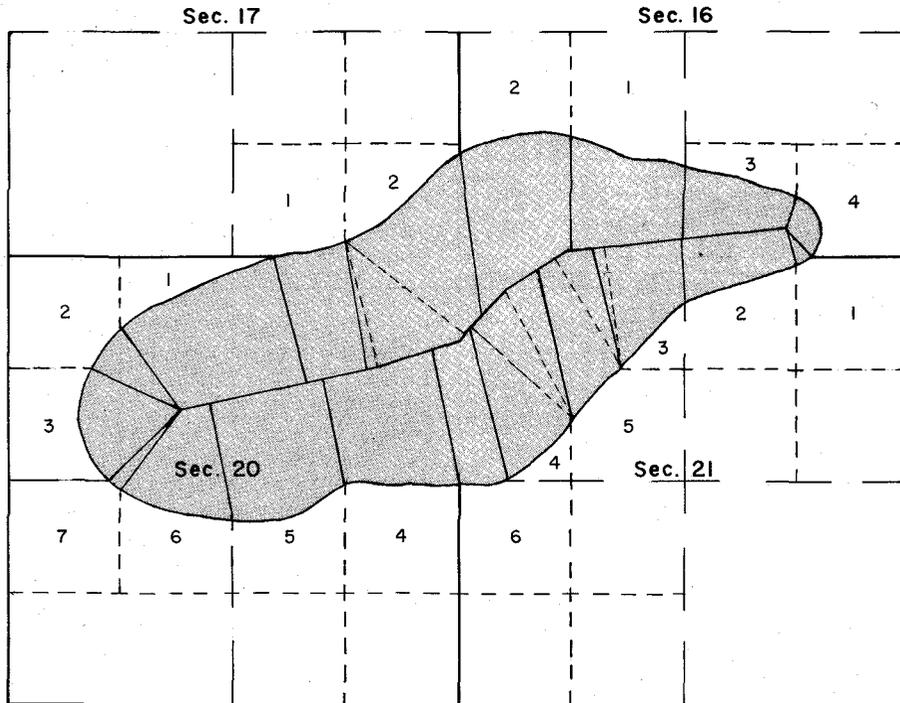


FIGURE 77.—Apportionment of the bed of a nonnavigable lake.

federal grant, that is, as to the limit of the land conveyed, or the boundary between the upland and the tideland, is necessarily a federal question.”

The ownership of accretion to land covered by an Indian trust patent was considered in *United States v. Washington*, 294 F. 2d 830 (1961), *cert. den.*, 367 U. S. 817 (1962). The Ninth Circuit Court of Appeals held that Federal law applied because of the underlying Federal title.

The general question of whether Federal or State law controls as to ownership of accretion was considered in *Hughes v. State of Washington*, 389 U. S. 290 (1967). The Supreme Court ruled:

The question for decision is whether federal or state law controls the ownership of land, called accretion, gradually deposited by the ocean on adjoining upland property conveyed by the United States prior to statehood. . . .

We hold that this question is governed by federal, not state, law and that under federal law Mrs. Hughes, who traces her title to a federal grant prior to statehood, is the owner of these accretions. . . .

This brings us to the question of what the federal rule is. The State has not attempted to argue that

federal law gives it title to these accretions, and it seems clear to us that it could not. A long and unbroken line of decisions of this Court establishes that the grantee of land bounded by a body of navigable water acquires a right to any natural and gradual accretion formed along the shore. . . .

We therefore hold that petitioner is entitled to the accretion that has been gradually formed along her property by the ocean.

It is therefore settled that wherever it retains title to the original subdivisions along a body of water, either navigable or nonnavigable, the Government may subdivide the lands formed by accretion or by recession of the water, since these, too, are public lands.

7-66. A survey of accreted or relicited land is usually made when one or more of the riparian subdivisions has been disposed of, and it is desired to mark the boundaries of the remaining public land. As in the apportionment of the beds of nonnavigable bodies of water, the riparian owner is entitled to the area lying *in front of* his basic holdings. In the case of navigable waters the extent of survey is the water's edge. Accrued lands granted by State law to riparian proprietors within the bed of a navigable body of water are not considered here, since their

definition would be in accordance with State law.

Apportionment of the accreted lands is usually made by proportioning the new frontage in the same ratio as the frontage along the old shore as outlined in the case of *Johnson v. Jones*, 66 U.S. 117 (1861), discussed in sections 7-58 and 7-61.

7-67. If there should be substantial areas of accretion to be dealt with that fact will be brought out in the special instructions, with outline of the governing procedure, and the surveying work in reference to all accretion areas will be distinctly mentioned in the field notes and so shown upon the plat.

### Accretion Prior to Entry

7-68. Occasionally, subsequent to survey, but before entry, a *large* body of land has formed by accretion between the meander line and the high water line. If such land had formed *after entry*, it would merely attach to the riparian holdings. If the land had been in place before the survey and at all subsequent times, it would fall in the class of omitted land, to be treated as hereafter described under that subject. But, in this special case, the meander line is treated as the boundary line of the grants, and patent is construed to convey only the lands within the meander line. *Madison v. Basart*, 59 I.D. 415 (1947).

7-69. The lands accreted after survey but before entry are not usually surveyed as would be ordinary accreted lands. Instead, the regular rectangular survey is extended to the body of water. The same procedure would be followed in surveying regular accreted lands only if none of the riparian lots had been patented and it was desired to extend the survey.

7-70. In determining what constitutes a "substantial" accretion, to which the rule in *Madison v. Basart* is applicable, the area of accretion should be compared quantitatively with the riparian lots to which it attached. Some consideration should also be given to the total area accreted. Accretion to a small lot might be large in proportion but negligible in absolute size. From the standpoint of *size* and *relative size*, the area in question can be weighed as in the case of omitted lands.

### Avulsion

7-71. "Avulsion" is the sudden and rapid change of channel of a boundary stream, or a comparable change in some other body of water forming a boundary, by which an area of land is cut off. An island may result or the avulsed land may become attached to the opposite shore.

7-72. In the case of *Nebraska v. Iowa*, 143 U.S. 359 (1892), the Supreme Court held:

When grants of land border on running water, and the banks are changed by the gradual process known as accretion, the riparian owner's boundary line still remains the stream; but when the boundary stream suddenly abandons its old bed and seeks a new course by the process known as avulsion, the boundary remains as it was, in the centre of the old channel: and this rule applies to a State when a river forms one of its boundary lines.

7-73. An avulsive change cannot be assumed to have occurred without positive evidence. When no such showing can be made, it must be presumed that the changes have been caused by gradual erosion and accretion.

7-74. The change in course of a stream is clearly avulsive when the land between the old and new channels remains substantially as it was. The unaltered condition of the land may be indisputably shown by the continued existence of improvements in place or of timber, undergrowth, and other vegetation. A study of historic documents, especially maps and aerial photographs, will often help in determining what process has taken place. As a general rule the abandoned channel is easily identifiable where an avulsive action has occurred.

7-75. The bed of a new channel resulting from avulsion continues to belong to the owner of the land encroached upon. The bed of the former channel continues to belong to the riparian owners if the stream is nonnavigable. Ownership of the abandoned bed of a navigable stream is governed by State law.

7-76. When the change in a water course is avulsive, and the boundaries remain unchanged, any subsequent movement of the avulsive channel, whether caused by accretion or by another avulsive action, does not change property lines.

### Erroneously Omitted Areas

7-77. Lands exposed by changes in water level or accreted subsequent to survey are not

erroneously omitted lands. This title is applied to lands, not shown on the plat of the original survey, which were excluded from the survey by some gross discrepancy in the location of a meander line. The unsurveyed land typically lies between the actual bank of a lake, stream, or tidewater and the record meander line.

7-78. In some older surveys temporarily flooded lands, or swamp and overflowed lands, were meandered as if they were permanent bodies of water. In a few cases, meander lines were reported where no body of water ever existed in fact. In still other instances, several lakes have been surveyed as one lake. All are treated in the same manner as those where the discrepancy is a grossly erroneous position of the record meander line. The converse is sometimes found where the record meander line leaves the bank and extends into the body of water. A water area may thus be shown as land.

7-79. Marginal discrepancies between the meander lines and the water at the time of survey fall into two classes, those that are merely technical differences and those that constitute erroneous omission. The guide lines for determining the class of a particular case are laid down in court and departmental decisions.

7-80. If land is to be regarded as erroneously omitted from survey, it must first be shown affirmatively that the area was *land in place* at the date of the original subdivision of the township. Then, if the land is similar to the surveyed lands, the usual inference that the official survey was correct may be set aside, and the conclusion may be substituted that the land should have been covered by that survey. However, a convincing showing is needed that the representations of the original plat and field notes are *grossly* in error.

7-81. Applications for the extension of the subdivisional lines to include the areas erroneously omitted from the original survey may be initiated either by settlers on the omitted land or by the owners of the adjoining land. The owner of the surveyed land, or a claimant who has purchased from him, may apply for the survey as a preliminary to quieting the title. There may or may not be adverse claims. The immediate question is the merit of the application

under the acts of Congress which grant relief in these cases. A field examination is nearly always required to verify the conditions alleged in the applications. It is objectionable in principle to amend a plat unless large and unwarranted discrepancies can be shown.

7-82. The survey of erroneously omitted lands may also be undertaken as an administrative responsibility for identifying public lands. Such cases may be brought to the attention of the Bureau by a Federal agency having administrative authority over the general area.

7-83. No proof is required to show the whys and wherefores of an erroneous meander line, but only that the line as run and as represented on the plat and in the field notes is in effect grossly in error. The rule is concisely stated in *John McClennen*, 29 L.D. 514 (1900):

It is not necessary to search for the source of the error. The result is the same whether such error arose from mistake, inadvertence, incompetency or fraud on the part of the men who made the former survey.

7-84. Where lands have been determined to be erroneously omitted from the original survey, the original meander line is made a fixed and limiting boundary segregating the previously surveyed areas from the unsurveyed public lands. The line is reestablished and marked with permanent monuments at the old angle points. Retracement between successive meander corners nearly always will show differences from the record in latitude and departure. The positions of the angle points are adjusted by the broken boundary method described in section 5-43 under "Angle Points of Nonriparian Meander Lines." The angle points are given serial numbers which do not duplicate numbers that may have been previously assigned in that section. The monuments are marked as shown in section 4-45.

The position of the original meander line having been determined, the survey is extended across the unsurveyed areas. Finally, a new meander line is surveyed in the correct position.

7-85. The requirements for making the plats to represent omitted land surveys are outlined in sections 9-78 through 9-83. The plat should carry a memorandum precisely stating the situation with reference to the survey represented, as in the following cases:

The position of the original record-meander courses of the so-called Moon Lake is shown by an irregular line with numbered angle points. This line as thus originally reported was grossly in error, and has therefore been marked as a fixed boundary, with the directions and lengths of the several courses adjusted to the record of the original survey.

The position of the original record-meander courses of Ferry Lake fronting along lot 4, section 9, and lots 2, 3, and 4, section 10, is shown by an irregular line with numbered angle points. This line as thus originally reported was grossly in error, and has therefore been marked as a fixed boundary, with the directions and lengths of the several courses adjusted to the record of the original survey.

The position of the original record-meander courses of a lake reported as having been located in section 36 is shown by an irregular line with numbered angle points. This line as thus originally reported was grossly in error, and, with the exception of certain courses fronting along lots 1, 2, and 9, has therefore been marked as a fixed boundary, with the directions and lengths of the several courses adjusted to the record of the original survey.

This memorandum is in addition to the memorandum referring to the dependent resurvey of the original section lines.

7-86. The three examples represented by the memoranda in section 7-85 are situations where the survey of erroneously omitted areas has been necessary. An examination of the manner in which each type was treated will help in determining how to approach similar cases.

7-87. *Nonexistent Moon Lake*: The plat of T. 12 N., R. 9 E., Fifth Principal Meridian, Arkansas, approved October 27, 1845, shows a meandered lake occupying the greater part of sections 22 and 27, and extending a short distance into section 26. The field notes of the line between sections 26 and 27 call for an intersection with the southeast side of "Sunk Lake," here classed as impassable and navigable. The surrounding fractional subdivisions as surveyed were all patented to the State under the provisions of the swamp land grant.

The case originated on the report of the removal of timber from portions of the area under the color of title arising through the ownership of the adjoining land. The report indicated that practically all of the area was high, dry land, covered with a growth of large timber, with no difference in the character of the land from that which had been included in the original subdivision. The topography, elevation, and timber

all revealed little if any change since the date of the subdivision of the township.

The greater part of the excluded area was found to be covered with various species of oak, maple, cottonwood, hickory, sycamore, hackberry, cypress, and willow. Many of the trees were of great age, 300 years or more, and many of them indicated strictly upland site conditions. The area was found to be level land, at about the same elevation and in some places higher than the surrounding lands, though there was evidence of what had been a slough along parts of the edge of the so-called lake.

7-88. By decision dated November 30, 1909, bearing departmental approval, the Commissioner of the General Land Office held that the area, 853.25 acres, was not a navigable lake on June 15, 1836, the date when Arkansas was ad-

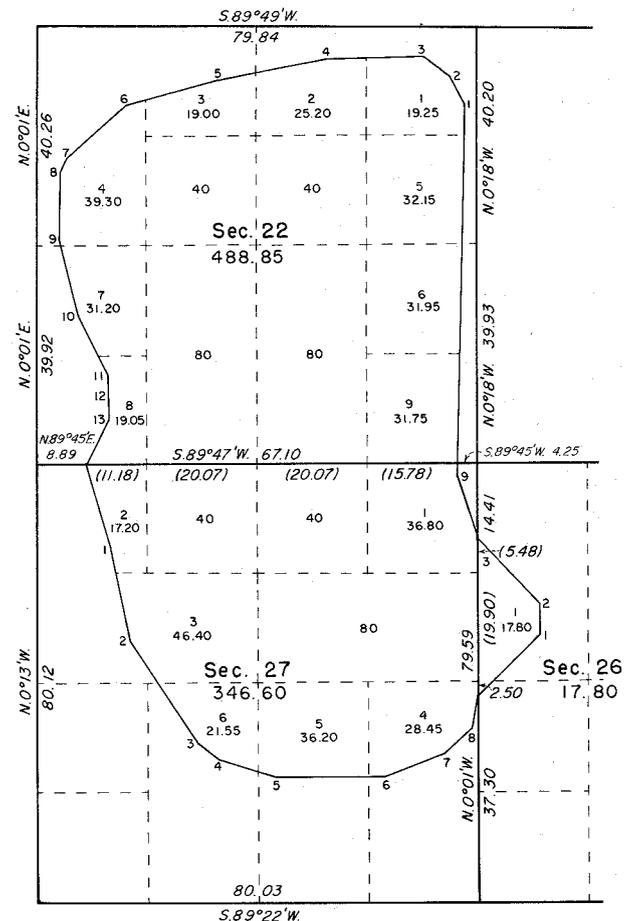


FIGURE 78.—The nonexistent "Moon Lake."

mitted into the Union, nor in 1841 at the date of the subdivision of the township. As the land was in place at that period and was not permanently covered by water, it was part of the public domain, and title had not passed from the Government.

On November 5, 1917, the Supreme Court announced an opinion (*Lee Wilson & Company v. United States*, 245 U.S. 24) denying the merits of the riparian claims to the area within the meander line of the so-called lake, restating two legal propositions held indisputable because settled by previous decisions:

*First.* Where, in a survey of the public domain a body of water or lake is found to exist and is meandered, the result of such meander is to exclude the area from the survey and to cause it as thus separated to become subject to the riparian rights of the respective owners abutting on the meander line in accordance with the laws of the several States. *Hardin v. Jordan*, 140 U.S. 371 (1891); *Kean v. Calumet Canal Co.*, 190 U.S. 452 (1903); *Hardin v. Shedd*, 190 U.S. 508 (1903).

*Second.* But where upon the assumption of the existence of a body of water or lake a meander line is through fraud or error mistakenly run because there is no such body of water, riparian rights do not attach because in the nature of things the condition upon which they depend does not exist and upon the discovery of the mistake it is within the power of the Land Department of the United States to deal with the area which was excluded from the survey, to cause it to be surveyed and to lawfully dispose of it. *Niles v. Cedar Point Club*, 175 U.S. 300 (1899); *French-Glenn Live Stock Co. v. Springer*, 185 U.S. 47 (1902); *Security Land & Exploration Co. v. Burns*, 193 U.S. 167 (1904); *Chapman & Dewey Lumber Co. v. St. Francis Levee District*, 232 U.S. 186 (1914).

Other important points in this and similar cases are found summarized in the syllabus:

If, in the making of a survey of public lands, an area is through fraud or mistake meandered as a body of water or lake where no such body of water exists, riparian rights do not accrue to the surrounding lands, and the Land Department, upon discovering the error, has power to deal with the meandered area, to cause it to be surveyed, and lawfully to dispose of it.

The fact that its administrative officers, before discovery of the error, have treated such a meandered tract as subjected to the riparian rights of abutting owners, under the State laws, and consequently as not subject to disposal under the laws of the United States, cannot stop the United States from asserting its title in a controversy with an abutting owner; and even as against such an owner, who acquired his property before the mistake was discovered and in

reliance upon such actions and representations of Federal officers carrying assurance that such riparian rights existed, the United States may equitably correct the mistake and protect its title to the meandered land. The equities of the abutting owner, if any, in such circumstances are not cognizable judicially, but should be addressed to the legislative department of the Government.

The swamp land act of September 28, 1850 (ch. 84, 9 Stat. 519), did not convey land of its own force, without survey, selection, or patent.

7-89. The surveying in the Moon Lake case consisted of a retracement of the boundaries of the several sections, a restoration of the obliterated corners, a remonumentation of all of the corners, a retracement of the record meander line with monumentation of the angle points, and a completion of the fractional section lines.

7-90. *Erroneously meandered Ferry Lake:* Ferry Lake is one of the lakes formed by the "Great Raft" of the Red River. The "Great Raft" was a complex series of logjams which probably began to form in the fifteenth century. Over a long period of time the raft moved upstream as the lower end decayed and additional material lodged against the upper end. As the raft moved, it blocked off tributaries and forced the main river into new channels. Numerous lakes and bayous were formed which extended almost to the Arkansas-Louisiana State line. Ferry Lake was formed near the close of the eighteenth century. It was a permanent navigable body of water in 1812 when Louisiana was admitted into the Union. Because the "Great Raft" was a hindrance to navigation and transportation, Congress provided funds by the Act of May 23, 1828, to remove it. Clearing the river was a slow process, and the removal of the "Great Raft" was not completed until 1873. Most of the lakes were thereby artificially lowered or drained, and the State retained the uncovered portions of the beds. Only lands above the line of mean high water *before the artificial reliction* could be considered in determining if there had been an erroneous omission from the original survey. Location of the mean high water line was one of the complications of the case.

The plat of T. 20 N., R. 16 W., Louisiana Meridian, Louisiana, approved August 31, 1839, shows the north boundary of the township discontinued on the bank of Ferry Lake (now Cad-



The plat of fractional sections 4, 9, and 10 of the same township, approved August 18, 1871, represents an extension of the lines between sections 3 and 10, and between sections 4 and 9, to the main lake front. The corner of sections 3, 4, 9, and 10 was established in this survey, also a meander corner on the west side of a narrow bayou which drains out of the north part of section 9; but again, for no apparent reason, in running south on the line between sections 9 and 10 the survey was terminated at a point more than 3,400 feet north of the bank of Ferry Lake. A part of the meander courses in sections 4 and 9 were accurately run, but the remaining courses, particularly those which connected with the terminal point on the line between sections 9 and 10, were merely a traverse line through the woods, though represented in the field notes and shown on the plat to be the bank of the lake.

Following the discovery of oil and gas, mineral applications were filed with the Department in 1909 and 1910. The locations covered not only the omitted area but the bed of the lake. It was alleged that large errors had been made in running the meander lines, that the lake was merely a temporary body of water, and that it had not been navigable in 1812 when Louisiana was admitted to the Union. By 1910 all of the fractional lots adjoining the omitted area had been disposed of by the United States.

The report of the field investigation covered the historical data, the geology of the lake basin, an examination of the forest trees, and the surveying situation. It was concluded that Ferry Lake existed as a navigable body of water in 1812, though there had been a marked recession of the lake by 1910; and that in neither of the surveys of 1839 and 1871 had the lake been correctly meandered in sections 9 and 10, either as it was at the dates of the surveys or as it was in 1812.

The soil, topography, and timber on the omitted area were the same as found on the surveyed land. Along most of the meander line there was no indication of there ever having been a lake bank or water-washed escarpment of any kind.

The forest growth on the omitted land included overcup oak, sweet gum, and red gum on the lower levels, and on the higher levels post

oak, blackjack oak, Spanish oak, hickory, pine, and other varieties, many of them of great age, and clearly the descendants of a mixed forest that had existed for many centuries. The overcup oak was found in a belt immediately above a belt covered predominately by cypress, which occupied the plain terraces above and below an easily traceable escarpment. This bank, which had been made by the waters of Ferry Lake, continued without interruption around the entire basin. A contour survey showed the elevations in the omitted area in sections 9 and 10 to range up to 17 feet above the former lake level. The area omitted in these sections amounted to 229.67 acres.

7-91. Upon a review of the record, the Attorney General of the United States, in a letter to the Secretary of the Interior, dated September 11, 1916, concluded:

That no action should be taken to enforce or assert any claim by the Government to that portion of the area involved which is covered by the waters of the lake because if the State's title by virtue of its sovereignty should fail for any reason, I see no way of successfully resisting her claim under the swamp land grant.

However, in so far as concerns the land lying between the old meander line and the waters of the lake, I entirely agree with you that it constitutes unsurveyed public land of the United States, and . . .

On January 2, 1923, the Supreme Court of the United States announced an opinion (*Jeems Bayou Fishing & Hunting Club v. United States*, 260 U.S. 561), denying the claims to the land in sections 9, 10, 15 and 16, adverse to those of the Government, and commented:

The inaccuracy of the plat is plainly apparent upon a like inspection. Why ——— made the survey and returned the plat as he did is a matter of speculation, but the facts demonstrate that no survey of the large, compact body of land, which includes the tract in controversy, was ever made. The circumstances, as well as the extent and character of the lands, necessitate the conclusion that the omission was of deliberate purpose or the result of such gross and palpable error as to constitute in effect a fraud upon the Government.

7-92. Surveying the Ferry Lake case consisted of the steps mentioned in the Moon Lake case, also a monumentation of the contour which agreed with the evident mean high-water elevation of the lake as it was in the year 1812.

7-93. *Crooked Lake and Bear Lake*: The plat of T.43 N., R. 6 E., Fourth Principal Meri-

dian, Wisconsin, approved April 6, 1863, shows a meandered lake in section 36. Meander corners were established regularly on the south and east boundaries of the section. The field notes show the running of meander courses through the section on opposite sides of the lake, and call for high banks, along timbered land. No mention is made of an arm of a lake extending northwesterly into section 25. The fractional lottings were disposed of according to the representations of the plat.

By letter dated April 16, 1923, the Commissioner of the General Land Office advised the Secretary of the Interior of an application to make a forest lieu selection for the NE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 36 (lot 15, figure 80), which according to the representations of the township plat would be located entirely within the bed of the meandered lake as above described. This letter contains a review of the facts as developed by a field examination, and concludes with a recommendation that the land theretofore shown as a meandered lake be surveyed and a proper plat constructed. The proposed action bears departmental approval.

The report of the field examination showed the following facts:

The south and east boundaries of the section

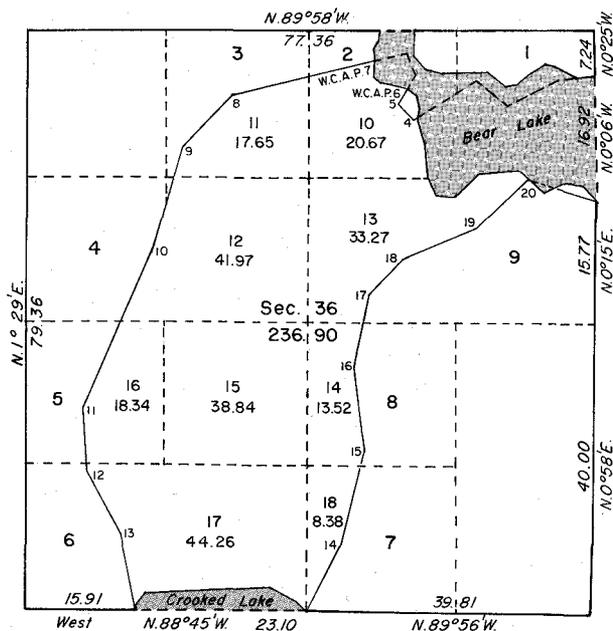


FIGURE 80.—The Crooked Lake and Bear Lake case.

cross two lakes instead of one, the lakes being separated by a body of land amounting to 236.90 acres contained within the lines represented on the original plat as the banks of the one meandered lake. This area is rolling upland ranging up to 50 feet above the level of either lake, and forested with pine, hemlock, birch, maple and spruce timber. There was no evidence of any changes in the water level of the lakes, nor of any escarpment along the fictitious meander courses connecting them, these lines having been found to traverse rolling land instead of following a contour, with not the slightest difference between the character of the land, soil or timber on the area theretofore surveyed and that which had been omitted. The shores of the two lakes were well defined, with banks from 3 to 8 feet high, bordered by a strip of level land from 10 to 30 feet in width, surrounded by rolling hills. The geologic formation, as well as the forest trees, indicated great age.

The surveying work to be done consisted of the steps previously outlined in the Moon Lake case.

#### Survey of Land Outside Meander Line Where No Gross Error Is Involved

7-94. Lands omitted from the original survey lying between the position for the record meander line and the actual bank of a lake, stream, or tidewater, situated in front of Government-owned subdivisions, are subject to survey as public land although they may not be of sufficient size and extent to constitute gross error or fraud in the original surveys.

If title to all the subdivisions in a section, shown to be riparian by the plat of the original survey, is still in the Government, and there is no reason for retaining the original lottings, new areas and designations may be returned for the public land. This procedure ordinarily is not involved unless warranted by the values involved, or justified by the difference in area of the subdivisions. However, when title to some of the record riparian subdivisions has passed into private ownership and no claim can be maintained by the United States to the omitted land in front of these subdivisions, partition lines are run and monumented segregating the public land from the area belonging to the pri-

vate owners. Generally it is necessary to subdivide the sections in the regular manner, reestablish the original meander line, and remeander the body of water. Lot numbers and areas are shown on the official plat for the public land being surveyed for the first time.

Where title to all the land in a section based upon the plat of the original survey has passed from the Government, it is not necessary to reestablish the original meander line. This line is protracted upon the survey plat, which should be prepared in the manner similar to the method adopted for showing an area formed by accretion in front of patented lands (figure 88, chapter IX). The division lines between patented holdings are not surveyed in the field or shown by protraction upon the plat.

The partition lines between the Government land and privately owned land are run in the same manner as partition lines dividing areas formed by accretion. The general rule is to follow the method described in *Johnston v. Jones*, 66 U.S. 117 (1861), that is, to apportion the new frontage along the water boundary in the same ratio as that along the line of the record meander course. There are acceptable variations to this rule where local conditions prevail and the added lands are not of great width or extent. In such cases the extension of normal lines to the water boundary is an equitable division to the avoidance of unrealistic or oblique lines which are not commensurate with the considered manner of the land's formation.

## SWAMP AND OVERFLOWED LANDS

7-95. The acts of Congress which granted to certain States the swamp and overflowed lands within their respective boundaries were listed in chapter I. These lands are not conveyed without survey, selection, or patent. *Lee Wilson & Company v. United States*, 245 U.S. 24 (1923). They are surveyed as public lands and subject to classification at that time.

In *San Francisco Savings Union, et al v. Irwin*, 28 Fed. 708 (1886), aff. *Irwin v. San Francisco Savings Union, et al.*, 136 U.S. 578 (1890), the court stated:

The act of 1850 grants swamp and overflowed lands. Swamp lands, as distinguished from overflowed lands,

may be considered such as require drainage to fit them for cultivation. Overflowed lands are those which are subject to such periodical or frequent overflows as to require levees or embankments to keep out the water, and render them suitable for cultivation.

Swamp lands include marshes and intermittent ponds which do not have effective natural drainage, particularly where such conditions are long continued.

Overflowed lands include essentially the lower levels within a stream flood plain as distinguished from the higher levels, according to the characteristic effect of submergence where long continued.

7-96. Tidelands are coastal areas situated above mean low tide and below mean high tide, particularly as they are alternately uncovered and covered by the ebb and flow of the daily tides. As a part of the bed of navigable waters, such lands belong to the States. *Pollard's Lessee v. Hagan*, 44 U.S. 212 (1844). Tidelands are mentioned here to stress their distinction from swamp and overflowed lands. Coastal "salt marshes" that are covered by the daily tide are tidelands and not subject to survey. On the other hand, coastal marshes that are not covered by the daily tide are swamp and overflowed lands within the meaning of the grants and are subject to survey.

7-97. It has already been emphasized in section 3-115 that meander lines will not be established between the upland and the swamp and overflowed lands. Riparian rights, which are applicable within the beds of lakes, streams, and tidal waters, are not enforceable over the swamp and overflowed lands granted to the States. The survey of meander lines at the margin of swamps in the past has been an important cause of the erroneous omission of lands from survey.

7-98. The following rules should be followed in making surveys or field examinations of swamp and overflowed lands:

(1) According to R.S. 2481 (43 U.S.C. 984), any legal subdivision the greater part of which is "wet and unfit for cultivation," shall be included in the category of swamp and overflowed lands. When the greater part of a subdivision is not of that character, the whole of it shall be excluded. The legal subdivision referred to is the quarter-quarter section or comparable lot.

(2) "Wet and unfit for cultivation" is interpreted to mean that the land must have been so swampy or subject to overflow during the planting, growing, or harvesting season, in the majority of years at or near the date of the grant, as to be unfit for cultivation in any staple crop of the region in which it is located, without the use of some artificial means of reclamation such as levee protection or drainage ditches.

(3) A subdivision which becomes swampy or overflowed at a season of the year when this condition does not interfere with the planting, cultivating, or harvesting of a crop at the proper time and by the ordinary methods is not "made unfit for cultivation" and does not qualify under the swamp land grant.

(4) Tame grass or hay, when produced by the ordinary methods of preparing the ground, is considered a staple crop, as well as the cereals, or cotton, or tobacco.

(5) In the administration of the swamp acts the States have been allowed optional methods of preparing the lists of subdivisions that are to be identified as swamp and overflowed within the meaning of the acts. But the surveyor must determine with accuracy the position and extent of the swamp and overflowed land within the area under survey regardless of the methods employed by the States in asserting claims.

(6) Alabama, Indiana, Louisiana, Michigan, Minnesota (excepting as to lands within the Indian reservations), Mississippi, Ohio, and Wisconsin have elected to base their swamp-land lists on the field note record. In these States it is imperative that the field notes include a specific list of the subdivisions each of which is more than 50 per cent wet and unfit for cultivation, regarding such character as at the date of the passage of the granting act.

Arkansas, by the Act of April 29, 1898 (30 Stat. 367; 43 U.S.C. 991), relinquished all right, title, and interest to the remaining unappropriated swamp and overflowed lands within its boundaries.

(7) In California, under R.S. 2488 (43 U.S.C. 987), the swampland lists are based upon the representations of the plat of survey, and in this State it is imperative that the plats correctly show the conditions in this respect.

(8) The selection of swamp lands in Florida,

Illinois, Iowa, Missouri, and Oregon, and in Indian reservations within Minnesota, is based upon investigations and reports by representatives of the State and of the Bureau of Land Management, but this does not set aside the Manual requirements for the usual complete showing of the character of the land.

7-99. It is always important to note any marked changes in the water level and drainage conditions of the region, and to ascertain the situation as of the date of the granting act. It is desirable to secure the testimony of persons who have known the lands for long periods. The most convincing evidence of the land's character at the date of the granting act is the older native timber, as the varieties reflect their site conditions with great certainty.

This line of investigation requires an inquiry into the habitat of the forest species which are found, particularly as to whether the usual range of the tree is within low wet ground, as for example the cypress, tupelo, sweet gum, water ash, water locust, and red bay of the southern latitudes, and the tamarack, white cedar, black spruce, swamp spruce, and black ash of the northern latitudes of the United States. The presence of any of the species named indicates the possibility of swamp land, and, while conclusive with some of them, others of the species named have a wider range and may be found associated with upland varieties. If upland varieties are present the plain inference will be that the site conditions are that of upland, even though a forest species may favor moist rich soil.

## SOIL CLASSIFICATION

7-100. Earlier manuals have stressed the appraisal of soil characteristics as an essential part of the survey returns. This classification has been an invaluable aid in the development of the public domain, both to the prospective settler and in the administration of natural resources. Such information is now generally available from other sources, and its provision by the field notes is not as important as it once was. Yet, in the making of original surveys, it is necessary to tie the available information to specifically described lands. Further, the gen-

eral law (R.S. 2395; 43 U.S.C. 751) requires the surveyor to note and report upon the soil types. These requirements will hereafter be limited to lands being surveyed for the first time and need not be routinely applied to resurveys unless provided for by the special instructions.

7-101. The soil types, when considered in relation to precipitation and other climatic factors, the drainage, the adaptability of the terrain to irrigation, the elevation, and the latitude, will indicate whether the highest and best use of the land is for farming, grazing, forestry, or other purposes.

7-102. An outline of the matters to be considered in soil studies is presented below as a guide to the surveyor in making his report.

(1) Texture: Gravel, coarse and fine; sand, coarse and fine; sandy loam; silt loam; loam; clay, heavy and light; and muck.

(2) Structure: Single grained, pulverulent, and lumpy.

(3) Color: Surface soil and subsoil, both when dry and when wet.

(4) Chemical properties: Acidity, alkalinity, and humus content.

(5) Depth: Surface soil and subsoil.

(6) Location: River bottom or flood plain, bench, slope, plateau, prairie, and mountain.

(7) Topography: Level, rolling, broken, hilly and mountainous; and elevation above sea level.

(8) Drainage: Direction, depth to water table, and quality, as poor, good, or erosive.

(9) Mode of formation: Water laid, glacier laid, wind laid, and residual.

(10) Geological derivation:

(a) Sedimentary rocks are either formed of fragments of other rock transported from their sources and deposited as conglomerate, sandstone, and shale; or formed by simple precipitation from solution, as limestone, or of secretions of organisms, as some coastal rocks.

(b) Metamorphic rocks: Formed through change in constitution, especially those due to great pressure, heat, and water, and resulting in a more compact or more highly crystalline condition, including, for example, quartzite, marble, slate, and schist.

(c) Igneous rocks: Formed through the action of intense heat, including, for example (first, eruptive rocks) basalt, lava, and volcanic ash; (second, trap rock) felsite and quartz-porphry; and (third, granular rock) granite, diorite, and porphyry.

7-103. Soil has its origin in the material which comes from the disintegration of the rocks. Roots and other vegetable matter in the soil are by decay gradually converted into humus, which is found only in the surface soil, and in quantities which vary with the activity and profusion of plant life. Plant food comes from the chemical elements contained in the rock and the humus; one is the product of inorganic matter, the other a product of the decomposition of organic matter. Plants draw four elements from the soil that are essential to their development: phosphorus, potassium, nitrogen, and calcium. Other elements are usually present in plentiful supply and so are of less importance. The amount of humus is important to the fertility of the soil, and it absorbs and retains moisture.

Soil bacteria thrive best in soil that is rich in decaying vegetation, with favorable proportions of lime, air, light, warmth, and moisture, and through their presence much nitrogen is taken from the air for storage in the ground. The relation of these things leads to the notable observation that soils seem to select their plants, or vice versa. There is found in a certain soil type one class of grasses or forest cover, in another soil very different plant life. These are the keys to a study of the soil, and when all are considered in connection with the moisture, climatic, and other conditions of the environment, will very largely determine its value for agriculture, stock grazing, or forestry.

7-104. The following is an illustration of a general description of the land and soil types found within a selected township, designed to bring out rather minute references to the soil structure:

Land, level, and gently rolling plateau, with elevation from 500 to 700 feet above sea level. Soil, fine sandy loam; surface soil dark gray to black, rich in humus, from 10 to 15 inches deep; subsoil, light brown loam, 36 inches deep, rest-

ing on gravel bed; sedimentary origin, lake laid. Drainage good, the stream system being the \_\_\_\_\_ River and its tributaries. The normal precipitation of the region is ordinarily deficient for general farming, but

the soil is well adapted to any of the cereals usually grown in this latitude by dry-farming methods, and it produces excellent grasses, both native and tame. \_\_\_\_\_

## Field Notes

## PURPOSE AND STYLE

8-1. The field notes are the written record of the survey. This record identifies and describes the lines and corners of the survey and the procedures by which they were established or reestablished. The new subdivisions to be platted (or replatted in the case of some resurveys) and the quantity of land in each unit are derived from the field notes. The laws governing surveys of the public lands have required the return of field notes from the beginning.

8-2. The initial notes are kept in pocket field tablets. The final field notes for filing are transcribed from the field tablets and are typewritten upon regulation field-note paper. It is desirable that the final field notes conform to the general arrangement and phraseology set out in the Manual. A large part of the final field notes must be extended from an abbreviated field record. At the same time, much of the minute detail of the initial notes may be summarized into a form of record which refers directly to the completed survey. This distinction in the two stages of the record is carried through the text. The subject in hand is the transcribed field notes, the record that is extended from the field tablets; this record is termed the "field notes."

8-3. All appropriate notes of the method and order of the survey procedures are entered in the field tablets. The tablets should show the dates on which each part of the field work was done. The field tablet record should supply the information needed for a complete preparation of the final record.

8-4. Because of the great variety of survey types, the surveyor must plan carefully how the notes in the field tablet are to be arranged. The

chief of field party is responsible for the accuracy and sufficiency of this record.

The work of transcribing the record usually receives the personal attention of the surveyor, but it is important that the arrangement of the notes in the tablets and the use of abbreviations be such as to be readily understood by others who are familiar with the technical processes. Due regard should be given to the Manual requirements and form, though it is intended that set forms of expression be used flexibly and modified when necessary to conform to the survey procedure. The work of the reviewing officers is directed to the fundamental requirements of the Manual and the written special instructions. Comments *as to the form* of the transcribed field notes are based upon broad grounds, but it is necessary that the notes follow a standard form.

Random lines with fallings are shown in the field tablets but are omitted from the transcribed field note record except where some special purpose is served by showing the detail of a triangulation, offset, or traverse.

8-5. The township is considered as the unit in compiling the field notes. Normally the field notes of all classes of lines pertaining to a township when concurrently surveyed and not previously compiled are included in a single book. In the survey of a block of exterior lines only, all of the field notes may be placed in one book.

8-6. The field notes and plat are considered the primary record of any survey and, upon their approval and acceptance, the responsibility for the survey vests in the accepting authority. After the final record has been prepared, accepted, and officially filed, the *field tablets* and related field data are disposed of.

## TITLES

8-7. Each book of field notes is included in a regulation cover, with appropriate title setting out general information as follows:

(1) The description of the lines recorded in that book;

(2) The principal meridian to which the survey refers;

(3) The State in which the survey is located;

(4) The name or names of the surveyors by whom the work was executed;

(5) The date of the special instructions, with survey number or serial group number, and date of approval;

(6) The date of the assignment instructions; and,

(7) The dates of the beginning and completion of the work included in that book.

## EXAMPLES OF TITLES

Field Notes

Of the Survey of the  
Tenth Standard Parallel North,  
Along the South Boundary of Township 41 North,  
Through Ranges 13, 14, 15, and 16 West;

and the  
Fourth Guide Meridian West,  
Through Townships 41, 42, 43, and 44 North,  
Between Ranges 16 and 17 West

(or)

East and North Boundaries of  
Townships 41 and 42 North,  
Ranges 15 and 16 West

(or)

Subdivisional and Meander Lines of  
Township 41 North, Range 15 West

(or)

West and North Boundaries  
and  
Subdivisional and Meander Lines of  
Township 41 North, Range 13 West  
(All)

Of the Sixth Principal Meridian  
In the State of Wyoming,  
Executed by  
Wm. C. Jones, Cadastral Surveyor

(or)

John B. Smith and Fred A. Brown,  
Cadastral Surveyors  
(All)

Under special instructions dated June 30, 1971, which provided for the surveys included under Group No. 205, approved July 9, 1971; and assignment instructions dated July 15, 1971.

Survey commenced July 26, 1971.

Survey completed October 8, 1971.

8-8. The descriptive portion of the title is appropriately modified if there is a fractional portion of a township included in a survey, and for resurveys and fragmentary surveys, as for example:

Field Notes

Of the Survey of  
A portion of Subdivisional Lines  
Completing (or continuing) the  
Subdivision of  
Township 39 South, Range 18 East

(or)

Field Notes

Of a Limited Dependent Resurvey  
Of Sections 26 and 27,  
Township 63 North, Range 12 West

(or)

Field Notes

Of the Survey of  
Fiddlers Island in Venice Bay,  
In Section 1,  
Township 39 South, Range 18 East

(or)

Field Notes

Of the Dependent Resurvey of the  
Exterior and Subdivisional Lines of  
Township 18 South, Range 59 West

(or)

Field Notes

Of the Dependent Resurvey of the  
Eleventh Standard Parallel North,  
Along the South Boundary of Township 45 North,  
Through Range 79 West;  
The East Boundary of  
Township 45 North, Range 80 West;  
and the  
South Boundary of  
Township 46 North, Range 79 West

(or)

Field Notes

Of the Independent Resurvey of the  
East Boundary and Subdivisional Lines of  
Township 45 North, Range 79 West,  
and

Metes-and-Bounds Survey of Private Claims

(or)

Field Notes

Of the Dependent Resurvey of the Boundaries of the  
Anastasia Island Lighthouse and Military Reservations  
In Sections 21, 22, 27, and 28,  
Township 7 South, Range 30 East

(or)

Field Notes

of U.S. Survey No. 9901  
at Mile 320, Alaska Highway  
and

Establishment of Location Monument No. 9901  
at Geodetic Position:  
Latitude 53°22'17.63" N., Longitude 146°58'43.00" W.  
(or)

## Field Notes

Of the Dependent Resurvey and Extension Survey,  
Subdividing Land Bordering Ferry Lake and James  
Bayou,

In Sections 9, 10, 15, and 16,  
Township 20 North, Range 16 West

(or)

## Field Notes

Of the Retracement and Extension Survey  
Subdividing Accretion Area Bordering Red River,  
Including Riverbed Tracts,

In Sections 4, 5, and 8,  
Township 5 South, Range 14 West

(or)

## Field Notes

Of the Dependent Resurvey of the Section Boundaries,  
The Subdivision of the Sections,  
and

The Establishment of Corners of Indian Allotments,  
Sections 9, 10, and 15,

Township 143 North, Range 30 West

(or)

## Field Notes

Of the Dependent Resurvey of the Section Boundaries,  
The Subdivision of the Sections,  
and

The Establishment of the Boundary, Block and Lot  
Corners, and Street Center Lines of the  
Townsite of Lac du Flambeau,

In Sections 5 and 8,  
Township 40 North, Range 5 East

(or)

## Field Notes

Of the Dependent Resurvey of the Section Boundaries  
And the Metes-and-Bounds Survey of a body of land  
classified as mineral bearing, included within the  
Whitmore Quartz and the Monday Quartz Mining  
Claims, in Section 22,

Township 7 North, Range 12 East

(or)

## Field Notes

Of a Traverse of the Workings in the  
Badger Coal Mine  
and

A Dependent Resurvey and Subdivision  
of Section 15,

Township 36 North, Range 75 West

## INDEX

8-9. Each book of field notes has a small-scale index diagram of the lines included, for which there is a form on back of the cover. It

is often necessary, however, to construct an additional special diagram to suit the work. For this a sheet of regulation field-note paper, or a sheet of the same size, is employed, and a scale adopted that is suited to the available space. It is usually preferable to orient the diagram with north to the top of the page, though sometimes the outline of the work is such that it is better to orient the diagram with north to the left-hand or binding edge. The diagram should show all of the lines surveyed with the page number on which the record of each begins. Meanders and other irregular lines should be drawn and indexed. The added index sheet is inserted in the book on the inside of the front cover, to appear on the right-hand side, without page number. Field notes will not be written on the index sheet.

## HEADINGS

8-10. Each page of the field notes is given a heading. The heading is a short summary of the title of the field notes to be continued on that page. New headings are employed within the body of the field notes where changes are made to a new division of the survey; this will become the heading of the pages that follow. The heading should include the principal meridian and State. Examples may be found in the specimen field notes in the appendix.

New headings inserted in the body of the field notes of a resurvey are accompanied by subheadings which relate the resurvey to the earlier work. For example:

- (1) Dependent Resurvey of the W. Bdy.  
of T. 2 N., R. 18 W., Prin. Mer., Montana  
(Restoring the 1882 survey by  
James M. Harvey)

(or)

DEPENDENT RESURVEY OF THE  
ELEVENTH STANDARD PARALLEL  
NORTH, SOUTH BOUNDARY  
OF T. 45 N., R. 79 W., SIXTH PRIN-  
CIPAL MERIDIAN, WYOMING

Reestablishment of the survey executed by John B. Smith, Deputy Surveyor, in 1872

(2) METES-AND-BOUNDS SURVEY OF PRIVATE CLAIMS IN T. 45 N., R., 79 W., SIXTH PRINCIPAL MERIDIAN, WYOMING

As originally located in accordance with the survey executed by John B. Smith, Deputy Surveyor, in 1872

(3) Independent Resurvey of the Subd. Lines of T. 45 N., R. 79 W., 6th Prin. Mer., Wyoming  
(Superseding the 1872 survey by John B. Smith)

### ABBREVIATIONS

8-11. The following abbreviations, especially suited to field notes of surveys, are permitted in the final transcript record, and are used where repetitions in the form of the record and the expressions used are such as to make the abbreviations readily understood. These abbreviations are in addition to those shown in chapter II for analytical notation of observations, and those shown in chapter IV for marks upon monuments. Some of these abbreviations, as appropriate, are employed upon the township plat. All abbreviations will be given capital or lower-case letters the same as would be proper if the spelling were to be completed.

### TABLE OF ABBREVIATIONS

A.....	acres
alt.....	altitude
a.m.....	forenoon
Am.....	amended
app. noon.....	apparent noon
app. t.....	apparent time
asc.....	ascend
BM.....	bench mark
bet.....	between
bdy., bdrs.....	boundary, boundaries
ch., chs.....	chain, chains
cor., cors.....	corner, corners
corr.....	correction
decl.....	declination
dep.....	departure
desc.....	descend
diam.....	diameter
dir.....	direct

dist.....	distance, or distant
E.....	east <sup>2</sup>
e. e.....	eastern elongation
elev.....	elevation
ft.....	foot, feet
frac.....	fractional
Gr.....	Greenwich
GM.....	guide meridian
hor.....	horizontal
h.....	hour, hours
h. a.....	hour angle
in., ins.....	inch, inches
lat.....	latitude
lk., lks.....	link, links
l. m. noon.....	local mean noon
l. m. t.....	local mean time
log.....	logarithmic function
long.....	longitude
l. c.....	lower culmination
m.....	minute, minutes, (time)
meas.....	measurement
mer.....	meridian
Mi. Cor.....	mile corner
mkd.....	marked
MS.....	mineral survey
N.....	north <sup>2</sup>
NE.....	northeast
NW.....	northwest
No.....	number
obs.....	observe
obsn.....	observation
orig.....	original
p.m.....	afternoon
pt.....	point
Prin. Mer.....	principal meridian
R., Rs.....	range, ranges
red.....	reduction
rev.....	reverse
s.....	second, seconds, (time)
sec., secs.....	section, sections
S.....	south <sup>2</sup>
SE.....	southeast
SW.....	southwest
sq.....	square
Stan. Par.....	standard parallel
sta.....	station
temp.....	temporary
t.....	time
T., Tp., Tps.....	township, townships
u. c.....	upper culmination
USLM.....	United States Location Monument
USMM.....	United States Mineral Monument <sup>1</sup>
vert.....	vertical
W.....	west <sup>2</sup>
w. e.....	western elongation
x.....	separating dimension values

<sup>1</sup> Discontinued in favor of the preferred term "United States Location Monument (USLM)".

<sup>2</sup> Optional use of period (.)

## THE DETAILED FIELD-NOTE RECORD

8-12. The introductory statement includes:

(1) History of prior pertinent surveys.  
(2) The surveys encompassed in that book of field notes.

(3) Description of unusual survey situations and special methods used.

(4) A statement that the survey was executed in accordance with specifications set forth in the Manual of Surveying Instructions and the special instructions.

(5) How the directions of lines were determined and that they refer to the true meridian.

(6) In the case of a dependent resurvey, a statement to the effect that "Preliminary to the resurvey the lines of the original survey were retraced and search was made for all corners and other calls of the record. Identified corners were remonumented in their original positions; lost corners were restored and monumented at proportionate positions based on the original record. The retracement data were thoroughly verified and only the true line field notes are given herein."

(7) The geographic position of a corner of the survey—the southeast township corner if practicable—and how it was determined.

(8) The observed magnetic declination.

8-13. The items of information to be included in the field notes are described in section 3-126. The description required for particular subjects is covered by the following list.

Amended monuments, section 3-36.

Base line, method of alining, section 3-11.

Corner descriptions in general, sections 4-3, 4-6, and 8-14.

Corner descriptions, markings—form to follow

Iron posts and brass tablets, sections 4-24—4-46.

Stone monuments, sections 4-48—4-62.

Tree monuments, sections 4-64, 4-67—4-81.

Corner descriptions, other references

Closing corners, sections 5-41, 8-16 (4)(5)(6).

Location monuments, sections 10-32, 10-33, and 10-34.

Quarter-section corners, sections 8-16 (7)(8)(10).

Sixteenth-section corners, section 8-16 (8)(10).

Use of non-standard monuments, section 4-7.

Witness corners, sections 4-15 and 4-82.

Witness points, sections 4-17 and 4-82.

Corner accessories

Bearing trees, sections 4-85, 4-86, 4-87, 4-96—4-114.

Bearing objects, sections 4-85, 4-89, and 4-90.

Memorials, section 4-91.

Mound of stone, section 4-92.

Pits, section 4-95.

Reference monuments, section 4-82.

Dependent resurvey, sections 6-28, 6-29, and 6-30.

Field examination, sections 6-22 and 6-50.

Independent resurvey, sections 6-49 (5)(6)(9) and 8-15.

Magnetic declination, section 2-18 and 3-126 (19).

Meander lines, sections 3-119, 3-121, 3-122, and 3-123.

Measurement of standard line, section 3-9.

Metes-and-bounds surveys, sections 7-16 and 9-82.

Mineral segregation surveys, sections 7-41 and 7-42.

Parts of sections, section 3-94.

Recovered monument, sections 3-32, 4-3, and 6-28.

Report on swamp and overflowed land, section 7-98.

Resurveys, section 6-1.

Resurveys prior to extension, section 3-102.

Resurveys prior to subdivision of township, section 3-32.

"Small tract" surveys, section 7-37.

Soil classification, section 7-100—7-103.

Subdivision of sections, section 3-75.

Subdivision of township, sections 3-53 and 3-67.

Testimony about corner point, section 5-11.

Township exteriors, section 3-23.

Townsite surveys, section 7-30.

Triangulation, section 2-6.

Unofficial marks at corner, section 5-12.

Examples of application are found in the sample field notes in the appendix.

8-14. A full description of all monuments of the established survey, upon which the new lines are to be initiated or closed, or all monuments of the established survey which is to be resurveyed, is furnished to the surveyor when a field assignment is made. It has been required in previous manuals that such monuments be completely described in the new record only if changes are made in the new survey or if the monument or its accessories do not agree with the record. Since one of these conditions is nearly always the case, *the new requirement is that a redescription be made in every case.* However, it is not required that the markings on the brass cap of a properly marked regulation monument be repeated. If the year date is added, that information may be placed in the field notes without showing a complete corner diagram. The description of an identified corner should follow the order given in section 6-29. Examples of descriptions are shown in the sample field notes in the appendix.

When it is necessary to refer to a reconstructed corner monument described in another book of field notes of concurrent resurveys, a reference is given to the particular field notes in which the description of that monument will be found. For example: "the cor. of secs, 3, 4, 33, and 34, on the N. bdy. of the Tp., previously described in the field notes of the dependent resurvey of the S. bdy. of T. 24 S., R. 3 W., of this assignment."

The complete description of a monument is entered once only. In subsequent notes the expression "heretofore described" may be employed when referring to a point already occupied in the new survey. All corners recorded in the same book of field notes are referred to by name only, without repeating the description of the monument, as for example: "the cor. of secs. 2, 3, 10, and 11" or "the standard cor. of secs. 33 and 34" or "the cor. of secs. 5, 6, 31, and 32, on the S. bdy. of the Tp."

8-15. In the record of an independent resurvey the field notes of the metes-and-bounds survey of each valid claim are preceded by a copy of the abstract of entry. A brief statement then follows concerning the principal factors controlling the location of the particular tract, and whether or not the claimant was consulted or communicated with, in the matter of the identification of the boundaries of his claim. The statement should be clear as to whether the location of a claim, shown either as a tract segregation or as conforming to the lines of the resurvey, was controlled by collateral evidence, or by one or more identified corners of the original survey, nearby or remotely located, or by its relation to adjoining tracts. In case all of the tract segregations within a township can be covered by one general statement, the same should appear at the beginning of the field notes of the metes-and-bounds surveys. The field notes should be made to account for each tract shown upon the status diagram.

Historical references to the field notes and plats of the earlier surveys, to the lines more recently resurveyed that form a portion or portions of the plat outline, to lines run and marked by the county surveyor and similar surveys found acceptable for the identification of tract boundaries, etc., should be incorporated in the

introductory part of the field notes of the independent resurvey.

8-16. It is important to standardize the writing of the field notes of retracements and the subdivision of sections, and to simplify the record so far as possible. In the majority of the work this can be done by adherence to the following rules:

(1) Complete descriptions are given in those cases where the retracement is not followed by resurvey procedure or the subdivision of a section.

(2) No detailed description of the retracement is required in the field notes when the retracement is followed by a resurvey. In that case the procedure is described in the introductory statement, and the corner monumentation and lines (corrected to true lines) are described in the field notes of the dependent resurvey. When the section lines are retraced as a preliminary to subdivision of a section, it is usually necessary to resurvey them in order to establish sixteenth-section corners on the section lines.

(3) The directions and lengths of the true lines; the descriptions of natural objects, stream crossings, principal slopes, and other topographic calls; the descriptions of the physical, collateral, and record evidence or testimony concerning the old monuments and their accessories; and all new monumentation are given in the true-line field notes.

(4) The descriptions of closing corners of the exterior and subdivisional surveys originally placed on the standard parallels or township exteriors where the record calls for two sets of corners, and similarly within partially subdivided townships where there are offsets to be dealt with, will be given in the field notes of closing lines of the exterior or subdivisional survey that is being retraced or resurveyed.

(5) When a closing corner monument is found which marks a line that is not being concurrently resurveyed, a connecting course and distance and a complete description of the monument will be given in the field notes of the retracement or resurvey of the line closed upon.

(6) The new monument for a closing corner, in those cases where required, will always be placed at the true point of intersection, and so stated clearly. An off-line monument will be

marked AM, connected by course and distance, and fully described in the field notes of the closing line.

(7) Intermediate quarter-section corners between closing corners will be recorded in the field notes of the closing section immediately following the description of the closing line which completes the survey of the section. A cross reference will be entered in the field notes of the retracement or resurvey of the line closed upon.

(8) The descriptions of the section, quarter-section, and sixteenth-section corners on the section boundary lines, as required for the subdivision of a section, will be given in the field notes of the retracement or resurvey of the section boundaries.

(9) Random or trial lines that are required for the subdivision of a section are treated in a prefacing statement concerning the type of work to be performed in one or more sections, but no field-note statement of the detail is necessary.

(10) The descriptions of the center quarter-section corner, and of the sixteenth-section corners within the section will be carried in the true-line field notes of the subdivision-of-section lines.

8-17. The character of the land, soil, and forest cover upon the lines surveyed will be summarized at the conclusion of the field notes of each mile. The record of the mile will be closed by a line drawn across the page. A general description of a township as a whole, with regard to topography, soil, forest cover, merchantable timber, native grasses, water supply and drainage, minerals, settlement, and improvements, will be supplied at the conclusion

of the subdivisional notes. This general description for resurveys need not be as expansive as that for original surveys.

8-18. Signed statements relating to the positions of lines or corners are placed in the field notes following the general description. The record of the names of the assistants and the certificates of the surveyor and of approval will take the forms given in the specimen field notes in the appendix.

### SPECIMEN FIELD NOTES

8-19. In the specimen field notes in the appendix there are shown the several forms of description of the approved types of corner monuments. The types that are employed ordinarily are given prominence, but those that are used in exceptional circumstances are included in order to supply a form of description. The indicated departures from the usual type of monumentation (iron posts) are not to be construed as an authorization to disregard the standard practice.

8-20. Other specimen field notes as needed to show the miscellaneous forms of record relating to a variety of surveys found in the usual work are available in the survey office. A liberal assortment of such field notes and their accompanying plats should be on hand for reference purposes.

8-21. In the case of fragmentary surveys, such as the limited resurvey of a section line, the survey of a connecting line, the survey of an island, or other surveys that require only a brief note record, the field notes may be placed directly upon the plat.

## Plats

## THE IMPORTANCE OF THE PLAT

9-1. The plat is the drawing which represents the lines surveyed, established, retraced, or resurveyed, showing the direction and length of each line; the relation to the adjoining official surveys; the boundaries, description, and area of each parcel of the land; and, as far as practicable, the topography, culture, and improvements within the limits of the survey. Occasionally the plat may constitute the entire record of the survey.

9-2. Ordinarily an original survey of public lands does not ascertain boundaries; it creates them. The running of lines in the field and the platting of townships, sections, and legal subdivisions are not alone sufficient to constitute a survey. Although a survey may have been physically made, if it is disapproved by the authorized administrative officers, the public lands which were the subject of the survey are still classed as unsurveyed.

The returns of a survey are prepared in the state survey office or service center and transmitted to the Director, Bureau of Land Management, by the state or service center director for consideration as to acceptability. The survey only becomes official when it is accepted on behalf of the Director by the officer to whom he has delegated this responsibility. Any necessary suspension or cancellation of a plat or survey must be made by the same approving authority.

9-3. The legal significance of plat and field notes is set out in *Alaska United Gold Mining Co. v. Cincinnatti-Alaska Mining Co.*, 45 L.D. 330 (1916).

It has been repeatedly held by both State and Federal courts that plats and field notes referred to in patents may be resorted to for the purpose of determining the limits of the area that passed under such

patents. In the case of *Cragin v. Powell* (128 U.S. 691, 696), the Supreme Court said:

"It is a well settled principle that when lands are granted according to an official plat of the survey of such lands, the plat itself, with all its notes, lines, descriptions and landmarks, becomes as much a part of the grant or deed by which they are conveyed, and controls so far as limits are concerned, as if such descriptive features were written out upon the face of the deed or the grant itself."

These legal principles apply to subsequent deeds of transfer related to the official plat.

The public lands are not considered surveyed or identified until approval of the survey and filing of the plat in the administering land office by direction of the Bureau of Land Management. *United States v. Cowlinshaw*, 202 Fed. 317 (1913). No subdivisions are to be "disposed of" until so identified. *United States v. Hurlburt*, 72 F. 2d 427 (1934).

9-4. The subdivisions are based upon and are defined by the monuments and other evidences of the controlling official survey. As long as these evidences are in existence, the record of the survey is an official exhibit and, presumably, correctly represents the actual field conditions. If there are discrepancies, the record must give way to the evidence of the corners in place.

9-5. In the absence of evidence, the field notes and plat are the best means of identification of the survey and they will retain this purpose. In the event of a resurvey they provide the basis for the dependent method and the control for the fixation of the boundaries of alienated lands by the independent method.

## PLAT REQUIREMENTS

9-6. Plat requirements have been given in numerous sections of the preceding chapters in

connection with technical field procedure. The following list will serve as a reference:

- Latitude and longitude, section 2-21.
- Retracements that require platting, section 3-32.
- Amended monuments to be platted, section 3-36.
- Direct tie, computed from traverse, to be platted, section 3-71.
- Subdivision of sections to be protracted on plat, section 3-74.
- Lots and some 40-acre subdivisions to be shown, sections 3-77 and 3-78.
- Protractions against segregated areas, sections 3-79 and 3-80.
- Size and shape of lots, section 3-81.
- Numbering of lots, section 3-82.
- Lotting of elongated sections, section 3-83.
- Lots adjoining defective south and east boundaries, section 3-84.
- Subdivision of sections, sections 3-87, 3-88, 3-90, and 3-92.
- Lots adjoining irregular boundaries, sections 3-97 and 3-98.
- Protraction of outlying areas, section 3-100.
- Retracements in connection with extension surveys, section 3-102.
- Completion of partially surveyed sections, sections 3-103 through 3-107.
- Lots resulting from fragmentary surveys, sections 3-111.
- Platting meanders, section 3-118.
- Showing the tie to A.M.C. and outline of artificial bodies of water, section 3-121.
- Platting of islands, section 3-122.
- Summary of items to be shown, section 3-126.
- Witness corner to be shown on plat, section 4-15.
- Adjustment of broken boundaries, sections 5-43 and 5-44.
- Conformed entries and conflicts to be shown on plat, section 6-49 (5) (6); see figure 90.
- Resurvey lottings, no duplication, sections 6-52 through 6-54.
- New lots adjacent to meanders, section 7-15.
- Townsite plats, sections 7-25, 7-28, 7-30, and 7-31.
- Beds of nonnavigable lakes and streams, sections 7-52 through 7-61.
- Plats of accretion, sections 7-66 and 7-67.
- Plats of omitted lands, sections 7-85 and 7-94.
- Showing of swampland on plats, section 7-98 (7).
- Abbreviations on plats, section 8-11.
- Field notes on plat, section 8-21.

### SPECIMEN TOWNSHIP PLAT

9-7. The specimen township plat (insert 1) is a revision of the one which accompanied the Manual of 1947. All-mechanical lettering has been used, and an enlarged diagram has been added to show the required data relating to the segregation of mineral surveys. In practice,

where the detail is often more complicated, the segregations may be shown on a separate sheet at an even larger scale.

The green overlay is discontinued. The brown overlay is seldom needed but is shown for contrast where numerous examples are placed in a single township. The hachure has been retained only to show rimrocks or mesas.

9-8. The specimen plat shows the basis of the computation of all areas. The distances noted in parentheses are the regular and fractional portions of lines which constitute the boundaries of the quarter-quarter sections and fractional subdivisions. Parenthetical distances are employed where the field notes do not indicate what was used in the calculation of areas. The same lengths are adopted proportionately in establishing sixteenth-section corners on the section boundaries and for control in the subdivision of sections.

9-9. Most township plats are maps in that they show topographic and other mapping features. Strictly speaking a plat is a base drawing stripped of every detail nonessential to the identification of the subdivisions shown. The base drawing is always in black. It shows the lines of section boundaries, subdivision of sections, and lines of segregation such as mineral or other claim boundaries, meander lines (unless to be shown in blue), together with all lettering referring to title, names, memorandum, certificates, section numbers, lot numbers, areas, and lengths and directions of lines, as well as important improvements, works, or structures where required. The arrangement of data on all base drawings is made as nearly uniform as possible and in harmony with the specimen drawing, subject to modification where irregular lottings are made. Sections 3-69 and 3-71 explain the plan for relating patented irregular tracts to the rectangular system as a basis for their segregation. Conditions vary where the tracts are numerous, particularly where there is a network of patented mineral surveys to be segregated. The important plat feature is the resulting fractional lottings. It is generally unnecessary to show the courses and distances of the boundaries of the mineral surveys or their connections unless they affect the lotting, a mere outline being sufficient. Fre-

quently this permits their complete showing on the base drawing.

Occasionally it is feasible to letter the number and name of each claim on the base drawing. More often this is impracticable, and serial numbers for the purpose of indexing only should be assigned to all segregated locations throughout the township and carried to a marginal table followed by the survey number and name of each location. When this is done only the serial numbers are shown on the face of the drawing. Where a number of mineral surveys are segregated, large scale drawings on additional sheets may be required for each of the sections invaded. An outline of the mineral surveys is shown on the base plat for the sections involved, and a marginal reference is made on the base drawing calling attention to the sheets upon which the segregations in the various sections may be found. In many instances an enlarged diagram on the base plat will obviate the necessity for an additional sheet. Figure 84 (discussed in section 9-74) is an example of a drawing which should be shown as an enlarged diagram on the base plat.

9-10. Transparent color overprints are employed for those plats where topographic features tend to obscure the essential data on the base drawing. Overprints are not required where these features may readily be shown in black on the base drawing.

### DRAFTING THE BASE DRAWING

9-11. Township plats are generally drawn on the scale of 1 inch equals 40 chains, on sheets 19 x 24 inches when trimmed. The scale is often enlarged to 1 inch equals 20 chains for showing portions of townships in detail; the scale of 1 inch equals 10 chains or larger is employed where necessary. A bar or graphic scale stating only the unit of measurement is shown on all plats. The size of the sheets is always made 19 x 24 inches, regardless of the scale or area to be show; this is important on account of the need for uniformity in the dimensions of filing devices. A borderline rectangle  $16\frac{1}{2}$  x 20 inches is right for the normal township plat; the size of the rectangle may be varied slightly when necessary. Generally the drawing is placed to

the left of the center of the sheet, thus allowing space for the memorandum and other data in the margin to the right and resulting in a better balanced plat.

9-12. The plat subject should be compiled or laid out with a good grade, medium hard drawing pencil, one which will make a clean mark, but not so hard that it will engrave the lines.

9-13. The township is drafted as a plane, without allowance for reduction from the spheroid, as is required in the making of small-scale topographic maps showing large areas. All *regular* townships are laid out as a rectangular grid, with allowance for fractional measurements along the north tier and west range of sections.

9-14. In the case of *irregular* townships, or those containing meanderable bodies of water, or irregular tracts, the drawing should be laid out from the field closing sheets, duly balanced. The point of origin is selected on the drawing, from which point the exteriors are carefully laid out, each salient being accurately located by scaling, from the point of origin, the balanced values of the total latitude and departure of that salient. The section boundaries are then laid out similarly from suitable points of origin on the exteriors. Finally the subdivisions of each section, including the necessary lines of segregation and meander lines, are accurately scaled by the method of total latitudes and departures from an origin on the section boundary. On this plan the work may be laid out without introducing accumulative errors of scaling.

9-15. Elements of triangulation figures and offset lines are not shown on the plat when the field procedure results in ascertaining the course and length of the line established. Such diagrams are shown in the field notes if needed for a clear understanding of the procedure but are not required on the plat.

9-16. Plats of entire townships show the complete condition of all exteriors, including closing and standard township and section corners, with connecting courses and distances (figure 81). The connecting courses and distances are omitted where the scope of the work is not sufficient to determine the relationship accurately. A line common to two townships is

drawn with equal completeness for both, as far as approved surveys permit. The relative position of and the data for nearby corners of one or two townships and closing township corners, if established, are shown. Corners of maximum control are shown only as referring to the subdivisional survey on that plat. Separate diagrams of township exteriors are not required when the townships are subdivided.

9-17. The boundary of a State, surveyed reservation, or private land grant is lettered on

the plat, and connecting distances are shown from line intersections to the mile posts.

9-18. Where only a portion of a township is being surveyed, the condition of the adjacent areas is shown clearly by words lettered thereon, such as "Unsurveyed," "Rancho San Luis," "Surveyed by John Smith, 1877," or "Waste Lava Bed."

9-19. On plats of fragmentary surveys, areas previously surveyed do not have the sections and lots drawn in unless needed to show the relation of the old and new work along the common boundary.

9-20. The line of demarcation between areas previously counted in the total acreage surveyed and the new surveys is distinctly shown. A light diagonal shading with black ink on the side previously surveyed is recommended to distinguish such a line.

9-21. Each regular section shows the center lines only and the area as 640 acres. In other sections where lottings are required, each subdivision must be distinctly shown. Where a section contains one or more fractional lots, its regular parts show the usual areas as 40, 80, or 160 acres; the fractional lots each show the assigned lot number and are computed to the nearest 1/100 of an acre. The total area of public land within each irregular section is shown as equal to the sum of the several parts, as identified by the plat, disregarding parts omitted.

9-22. The complete technique of laying out the regular and fractional subdivisions of sections and the designations of the same by reference to aliquot parts and serial lot numbers is covered by sections 3-74 through 3-123.

9-23. On plats which show the completion of sections, particularly where parts have been shown as outlying areas protracted as surveyed (sections 3-100 through 3-111), it is the practice, where irregular conditions are found on the ground and no entries have been made, to annul the showing on the former plat. See section 9-2. The special instructions should provide that such unentered, protracted subdivisions need not be protected, thus simplifying the execution and platting of the new surveys.

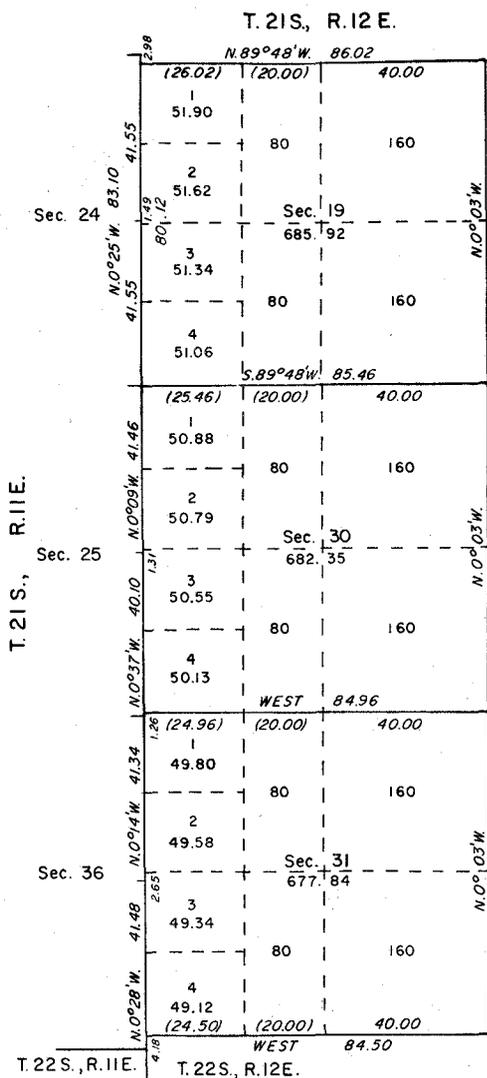


FIGURE 81.—Plat showing two sets of corners on an irregular township boundary.

COMPUTATION OF AREAS

9-24. The deficiency in area which results from the convergency of meridians is placed normally in the fractional lots adjoining the west boundary of the township. Sections 7, 18, 19, 30, and 31 each usually contains lots 1 to 4, inclusive, whose meridional dimensions are all an even 20.00 chains; the dimensions of the latitudinal boundaries of these lots are computed proportionately from the fractional measurements ascertained on the section lines. The area, in acres of each lot, is then found simply by adding the lengths, in chains, of its north and south boundaries.

9-25. For example, taking section 30, shown on the specimen plat, the dimensions of the latitudinal boundaries and the areas are found as follows:

	(1)	(2)	(3)	(4)
N.....	18.21	18.245	18.28	18.315 chs.
S.....	18.245	18.28	18.315	18.35 chs.
	<u>36.455</u>	<u>36.525</u>	<u>36.595</u>	<u>36.665</u> acres
	36.45(+)	36.53(-)	36.59(+)	36.67(-) acres

9-26. The areas of lots 5, 6, and 7, section 6, are ascertained similarly, making due allowance, when calculating the length of the north boundary of lot 5, for any material variation from 20.00 chains in the meridional dimension of lot 4.

9-27. The surplus or deficiency in area which results from the discrepancy in the meridional measurements between the exterior boundaries and the subdivisional lines is placed normally in the fractional lots adjoining the north boundary of the township. Sections 1 through 5 each usually contains lots 1 through 4, whose dimensions on their latitudinal boundaries are all treated as an even 20.00 chains; the meridional dimensions of these lots and their areas are computed on the plan heretofore described for the fractional lots adjoining the west boundary of the township.

9-28. The areas of lots 1, 2, and 3, section 6, are ascertained similarly, making due allowance when calculating the length of the west boundary of lot 3, for the departure across lot 4, where more or less than 20.00 chains. The area of lot 4, section 6, in acres, equals the prod-

uct of its mean dimensions in chains, divided by 10.

9-29. The following is an example of ascertaining the areas of the fractional lots in section 6, shown on the specimen township plat:

	(1)	(2)	(3)	(4)
E.....	20.05	20.037	20.024	20.011 chs.
W.....	20.037	20.024	20.011	20.000 chs.
	<u>40.087</u>	<u>40.061</u>	<u>40.035</u>	acres
	40.09	40.06	40.03(+)	acres
				<u>20.005</u> mean
	(5)	(6)	(7)	
N.....	17.78	17.81	17.84	17.75 chs.
S.....	17.81	17.84	17.87	17.78 chs.
	<u>35.59</u>	<u>35.65</u>	<u>35.71</u>	acres
				<u>17.765</u> mean
				2.0005 × 17.765 =
				<u>35.539</u> acres
				35.54 acres

9-30. In irregular sections and in sections which are invaded by meanderable bodies of water, or by lines of segregation, the center lines of the section and the center lines of each quarter section in turn are given calculated values based upon the balanced field closing sheets. Points of intersection of the center lines with the meander lines or other lines of segregation are then computed in order to complete the boundaries of each fractional lot. With the results of these computations at hand the area of each fractional lot may be most readily computed by the method of "double meridian distances."

9-31. In order to compute an area by double meridian distances, the closing error of the figure is eliminated, or the traverse of its boundary is balanced, by the most applicable rule. The general rule is that the correction to be applied to the { latitude } of any course is to the total error in { latitude } as the length of the course is to the perimeter of the figure. Another method of balancing the closing error is applicable if the purpose is to apply a uniform correction to the directions and lengths of lines. Section 5-44.

The double meridian distances (D.M.D.'s) of the several courses are then computed by the following rules:

- (1) The D.M.D. of the first course equals

the departure, or the increment in easting or westing, of the course itself;

(2) The D.M.D. of the second course, and each of the succeeding courses in turn, is ascertained by taking the D.M.D. of the preceding course, plus the departure of the preceding course, plus the departure of the course itself; and,

(3) The D.M.D. of the last course is numerically equal to its departure, but with opposite sign, thus verifying the value of each preceding D.M.D.

For convenience in making the computations, the differences in  $\left\{ \begin{matrix} \text{latitude} \\ \text{departure} \end{matrix} \right\}$  to the  $\left\{ \begin{matrix} \text{north} \\ \text{east} \end{matrix} \right\}$  are treated as of positive sign, to the  $\left\{ \begin{matrix} \text{south} \\ \text{west} \end{matrix} \right\}$  as of negative sign. The point of beginning is taken at the westernmost salient of the figure, and the direction of the traverse is run counterclockwise. On this plan each D.M.D. and the

algebraic sign of the final result are of positive sign.

The next step is to multiply the latitude of each course by the double meridian distance of the course; the positive products are arranged in a column for "north areas," and the negative products in a column for "south areas." The sum of the negative products is subtracted from the sum of the positive products. The area, corresponding to the unit of measurement that is employed, is ascertained by taking one-half of the last result. Where the unit of measurement is the chain, the area in square chains is divided by 10 to give the area in acres.

The field closing sheets may be readily adapted to the calculation of areas by the method of double meridian distances; two examples follow:

9-32. Tabling and calculations of T. 15 N., R. 20 E., Diamond Rock, in Lins Lake, in section 18:

No.	Course	Distance	Latitudes		Departures		D.M.D.'s	Totals			
			North	South	East	West		N. areas	S. areas	Lat. N	Dep. E
Tie	N. 71° 30' E.....	21.44	6.80	.....	20.33	.....	.....	.....	.....	6.80	20.33
5	S. 86° 46' E.....	3.19	.....	0.18	3.185	.....	4.73	.....	0.85	6.62	23.52
4	N. 33° 00' E.....	2.20	1.845	.....	1.20	.....	9.12	16.83	.....	8.465	24.72
3	N. 48° 30' W.....	3.50	2.32	.....	.....	.....	7.70	17.86	.....	10.785	22.10
2	S. 61° 15' W.....	2.90	.....	1.395	.....	.....	2.54	.....	3.54	9.39	19.56
1	S. 16° 30' E.....	2.70	.....	2.59	.77	.....	.77	.....	1.99	6.80	20.33
			4.165	4.165	5.155	5.16	.....	34.69	6.38	.....	.....
					.005			6.38			
		14.49	4.165	4.165	5.16	5.16	.....	28.31	Double area.		

Begin total lats. and depts. at M. C. on W. bdy. sec. 19, for purposes of platting.

D. M. D.'s	
(1)	0.77 9.12 (4)
	+ .77 +1.20
	+3.19 -2.62
(5)	4.73 7.70 (3)
	+3.19 -2.62
	+1.20 -2.54
(4)	9.12 2.54 (2)

14.15 Square chains.  
1.41 Acres.

Numbering of courses as taken from field notes, order reversed to counterclockwise.

Begin D. M. D.'s at angle point of meanders farthest west, end of course No. 2 running SW., or end of course No. 1 running NW.

9-33. Tabling and calculations of T. 15 N., R. 20 E., right bank of Yellowstone River, in section 25:

No.	Course	Distance	Latitudes		Departures		D. M. D.'s	N. areas	S. areas	Totals	
			North	South	East	West				Lat. N.	Dep. E.
	S. 0°01' E	5.36		5.36	0.00		0.00			0.00	0.00
					+ .04						
	S. 89° 56' E	79.96		.09	79.96		80.00		7.20	-.09	80.00
	North	23.20	23.20				160.00	3,712.00		23.11	80.00
				-.01		+0.01					
1	S. 85°00' W	13.00		1.13		12.95	147.04		164.68	21.99	67.04
2	S. 72° 00' W	7.10		2.19		6.75	127.33		278.85	19.80	60.29
				-.01		+ .01					
3	S. 64°30' W	13.00		5.60		11.73	108.84		608.42	14.21	48.55
4	S. 40° 30' W	5.40		4.11		3.51	93.59		384.65	10.10	45.04
				-.01							
5	S. 77° 45' W	7.00		1.49		6.84	83.24		123.20	8.62	38.20
				+ .01							
6	N. 76° 00' W	7.40	1.79			7.18	69.22	124.60		10.42	31.02
				-.01							
7	S. 80° 00' W	12.00		2.08		11.82	50.22		103.96	8.35	19.20
				-.01		+ .01					
8	S. 81° 08' W	19.43		3.00		19.19	19.20		57.41	5.36	0.00
			24.99	25.05	79.96	79.97		3,836.60	1,728.37		
			+ .01	-.05	+ .04	+ .03		1,728.37			
		84.33	25.00	25.00	80.00	80.00		2,108.23	Double area.		

Begin traverse and D.M.D.'s at M. C. on W. bdy. of sec. 25. 1,054.11 Square chains.  
 Begin total lats. and deps. at point for S. 1/8 sec. cor. on W. bdy. of sec. 25, 105.41 Acres, sum of lots 5 to 8, incl.  
 for purposes of platting.  
 Numbering of courses as taken from field notes.

Tabling and calculations of T. 15 N., R. 20 E., section 25, lots 5 and 6:

No.	Course	Distance	Latitudes		Departures		D.M.D.'s	N. areas	S. areas
			North	South	East	West			
	South	19.73		19.73					
	S. 89° 56' E	20.00		.02	20.00		20.00		0.40
	North	23.20	23.20				40.00	928.00	
1	S. 85°00' W	13.00		1.12		12.96	27.04		30.28
2	S. 72°00' W	7.10		2.19		6.75	7.33		16.05
3	S. 64°30' W	.33		.14		.29	.29		.04
			23.20	23.20	20.00	20.00		928.00	46.77
								46.77	
								881.23	
								44.06	Lot 5
	South	9.06		9.06					
	S. 89° 56' E	20.00		.02	20.00		20.00		0.40
	North	19.73	19.73				40.00	789.20	
3	S. 64° 30' W	12.67		5.45		11.45	28.55		155.60
4	S. 40° 30' W	5.40		4.11		3.51	13.59		55.85
5	S. 77° 45' W	5.16		1.09		5.04	5.04		5.49
			19.73	19.73	20.00	20.00		789.20	217.34
								217.34	
								571.86	
								28.59	Lot 6

## Tabling and calculations of T. 15 N., R. 20 E., section 25, lots 7 and 8:

No.	Course	Distance	Latitudes		Departures		D.M.D.'s	N. areas	S. areas
			North	South	East	West			
	S. 0° 01' E	8.51		8.51					
	S. 89° 56' E	20.00		.03	20.00	20.00		0.60	
	North	9.06	9.06			40.00	362.40		
5	S. 77° 45' W	1.84		.39		1.80	38.20		14.90
6	N. 76° 00' W	7.40	1.80			7.18	29.22	52.60	
7	S. 80° 00' W	11.19		1.93		11.02	11.02		21.27
			10.86	10.86	20.00	20.00		415.00	36.77
								36.77	
								378.23	
								18.91	Lot 7
	S. 0° 01' E	5.36		5.36					
	S. 89° 56' E	20.00		.02	20.00	20.00		.40	
	N. 0° 01' W	8.51	8.51			40.00	340.40		
7	S. 80° 00' W	.81		.14		.80	39.20		5.49
8	S. 81° 08' W	19.43		2.99		19.20	19.20		57.41
			8.51	8.51	20.00	20.00		340.40	63.30
								63.30	
								277.10	
								13.85	Lot 8

9-34. The use of electronic data processing equipment affords a fast and accurate means of calculating the area of irregular land and water forms. Where practical, with resultant savings in time and funds, this equipment may be used to make lengthy and complicated calculations. No specific instructions can be given for establishing a computer program or presenting the data for calculation purposes as there are several makes and sizes of this equipment available, each with the capacity to make area determinations. The computer program should be based upon the procedures of the double meridian distances method (section 9-31).

### INKING THE DRAWING

9-35. The best *black* drawing ink should always be employed, and the ink should never be diluted. The drafting work should be sharp and clear, uniform in density of color, and the lettering standardized as to gage and style. It is important to bear in mind that if the drafting is done with a diluted ink or otherwise left gray in appearance, it will be lost in varying degrees during the process of reproduction.

9-36. The drafting work should be *open*, making reasonable allowance for needed separation of detail. This will help to avoid a tendency for work to close across narrow spaces during reproduction. The detail of improvements, works, or structures should be omitted when necessary to avoid overlapping or obscuring the more essential features of the plat. The arrangement of some of the more minute data on the specimen township plat illustrates the minimum to which the work may be condensed safely. Attention is directed to the space allowed between the lettering and the adjacent lines; this is never less than the space between the upper two points of the gage for the lettering; this is the rule where the drawing is to be reproduced at the same scale; proportionately more space should be allowed on special drawings where a reduction of scale is to be made on reproduction. The same safeguards should be applied in spacing the adjoining letters, and it will be noted that the spacing between letters bears a definite relation to the gage employed.

9-37. An experienced draftsman keeps the drawing as clean as possible to avoid needless

erasing. A cover sheet, with an opening, is recommended. The sharp, black lines must be preserved in their original clear-cut effect, or else, unless carefully retouched, there will follow a certain loss in the process of reproduction. If uniformity is lacking, such as a mixture of heavy and pale letters and figures of a varying degree of density, the photographing has a tendency to exaggerate the differences and the reproduction will be unsatisfactory.

## LETTERING

9-38. Generally all letters and figures are drafted in pure Gothic style. The improvement in recent times of mechanical lettering templates and pens permits the almost exclusive use of such equipment in lettering the plat. If the lettering is accomplished by free hand methods, direct type impression or by the stick-up process with type printing on adhesive backing, corresponding sizes should be used.

9-39. The following list on pages 200 and 201 shows the usual styles and sizes to be followed in preparing a plat on the scale of 1 inch equals 40 chains; the number of the guide refers to thousandths of an inch.

9-40. At this stage of the drafting work attention should be given to the showing of the directions and lengths of all necessary connecting lines, in addition to the data which ordinarily appears on the section boundaries. The requirements are set out in sections 3-36, 3-71, 3-121, 3-122, and 4-15. Additional sheets, drawn to a larger scale, are used to show the detail of complicated situations. Section 9-9.

## TOPOGRAPHY

9-41. Generally only the most essential topographic data need be shown upon the plat. Some plats may not require the showing of any topography, others may require the showing of many different features, where the drawing in addition to being a plat may be a complete topographic map. The map features are delineated by the standard symbols adopted by the Board of Surveys and Maps of the Federal

Government.<sup>1</sup> A summary of what is required is contained in section 3-126.

9-42. In the preparation of the drawing the first question to be considered, after the completion of the base and before adding the topography, is how the important map features are to be shown without obscuring the base data. In simple cases all work may be done readily in black ink on the base drawing. In the difficult cases overprints in transparent colors are occasionally required. Good judgment should be exercised regarding what is essential, and how the essential things may be shown without unwarranted cost.

9-43. If a transparent overprint of a particular conventional color is required, all of the map features usually shown in that color are included. The specimen plat is intended as an example where all map features, with the exception of certain improvements, works, or structures are shown in conventional transparent overprints.

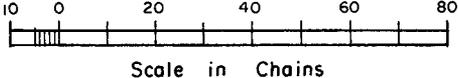
9-44. Where colors are not required, all map features or groups of features are delineated upon the base drawing in black ink, following the conventional symbols, and with the exercise of the greatest care that the map features do not interfere with or overlap, or too closely approach the base data. In all such simple cases the topography is shown as in the following outline:

### *Simple Drawings, All Black*

Low relief .....	Black hachure.
Roads and highways .....	Black lines, parallel
Trail .....	Black line, broken.
Culture .....	Black pattern.
Alkali flats .....	Black depression-contour and pattern.
Sand dunes .....	Black pattern.
Water surface, large rivers and lakes .....	Black meander line, with- out water lines.
Minor drainage .....	Black line, or broken line and dots.
Wide sandy bottomed draws	Black pattern.
Ponds .....	Black pattern.
Marsh .....	Black pattern.
Timber .....	Marginal note.

<sup>1</sup> Standard symbol sheet may be obtained from the Director, U.S. Geological Survey, Washington, D.C., 20242.

<u>Description</u>	<u>Lettering Style</u>	<u>Guide - Pen Size</u>
Plat Heading	TOWNSHIP I NORTH	240 - 3
Subtitle	DEPENDENT RESURVEY SUPPLEMENTAL PLAT	175 - 2
North Arrow		80 - 000
Section Number	Sec. 16	120 - 0
Area (section)	160, 639.54	100 - 00
Lot Numbers & Area	10 39.95	60 - 0000
Bearing	<i>N. 89° 58' W.</i>	80 - 000
Distance	79.95	80 - 000

<u>Description</u>	<u>Lettering Style</u>	<u>Guide - Pen, Size</u>
Witness Corner	<i>w.c., N.0°05'W, 0.50</i>	60-0000
Proper Names	LAKE CITY TOWNSITE	100-00
Descriptive Names	Ivy Island, Alkali Flat	80-000
Hydrographic Names	<i>YELLOW RIVER</i>	100-00
	<i>Clear Lake</i>	100-00
	<i>Canal, Spring, Aqueduct, Clear Cr.</i>	80-000
Mineral Survey	M.S. 2053	80-000
Lode or Placer Name	NUGGET	80-000
Scale	 <p>Scale in Chains</p>	60-0000 80-000
Extra Sheets	<i>SHEET 1 OF 3</i>	140-1
Control Station	ROUNDUP 1942 U.S.C. & G.S. NORTH PEAK 1957 U.S.G.S.	60-000
Guide Meridian	<i>FIRST GUIDE MERIDIAN EAST</i>	120-0
Standard Parallel	<i>SECOND STANDARD PARALLEL SOUTH</i>	
Sectional Correction Line	<i>CORRECTION LINE</i>	80-000
Geographic Position	Latitude 48°17'46.75"N. Longitude 121°35'15.58"W.	80-000

9-45. Where groups of important map features are extensive or complicated, or are of such a character that it is impracticable to execute the drawing in black without detriment to the base, transparent overprints are employed as shown in the following outlines:

*Brown Overprint*

Low relief, where important, and heavy relief ..... Brown hachure.  
 Roads and highways ..... Brown lines, parallel.  
 Trails ..... Brown line, broken.  
 Culture ..... Brown pattern.

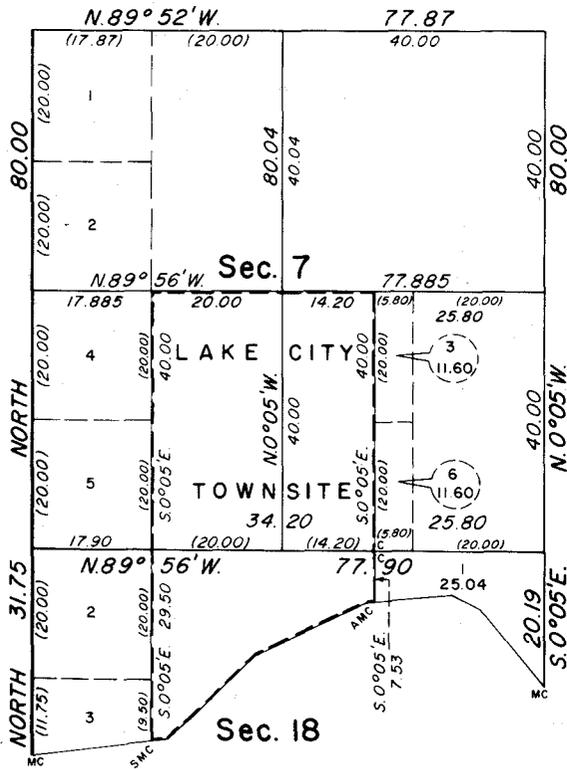


FIGURE 82.—Enlarged diagram. Boundaries of Lake City townsite.

- Alkali flats ..... Brown depression-contour and pattern.
- Wide sandy bottomed draws ..... Brown pattern.
- Sand dunes ..... Brown pattern.
- Blue Overprint*
- Water surface, large rivers and lakes ..... Blue meander line and blue water lines, or black meander line with flat blue tint.
- Minor drainage ..... Blue line, or broken line and dots.
- Ponds ..... Blue pattern.
- Marsh ..... Blue pattern.

9-46. In making the drawing, where overprints are required, separate transparent sheets are employed, known as overlays, upon each of which is drawn in *black ink* all natural features which are to be shown by overprint in the same color. The transparencies must have a low coefficient of expansion so there will be an exact register with the base.

9-47. Usually it is best to transfer the section boundaries accurately from the base drawing to the overlay by carefully pricking through, then showing the lines in pencil only. For purposes of assembling, the positions of a few section corners should be indicated by very short intersecting fine black lines. The township corners and the center point of the township generally serve best for purposes of registration. Additional points may be employed if the work is complicated. The map features are then drawn on the overlay in black ink.

Each color employed requires a separate overlay.

9-48. The description of the timber throughout the township is covered by a marginal note. The use of the green overprint to show timber has been discontinued.

9-49. The hachure is seldom used on modern plats. It may be used to show abrupt changes in elevation within level and gently rolling regions, such differences as the eye would quickly note on the ground and readily follow. The hachure is also used to show important mesas, peaks, ridges, spurs, and heavy slopes, in such a manner as to portray the bold relief without attempting to show unimportant and minor detail. Only the most important slopes are shown in a gently rolling country. If the hachure is used, care should be taken in drafting to avoid giving a rolling mountainous region the appearance of abrupt or high mountainous slopes.

9-50. The blue overprint is used where there are streams and lakes of importance, or where the drainage features, if shown in black, would obscure the base, as where there are numerous lakes and streams, or extensive ponds or marshes to be shown in areas of swamp and overflowed lands.

9-51. The availability of well-prepared topographic maps of much of the public land area makes it less important to show upon the plat all of the detail relating to topography, culture, and improvements. However, it is still necessary to show the major items of topography and improvements in their correct relationship to the survey. It may be advantageous to use these maps to complete detail within the sections.

## FIELD SKETCH

9-52. Where the area to be surveyed is not covered by reliable topographic maps or aerial photography, the surveyor must prepare an accurate field sketch for reference in the drafting of the final plat. The sketch should show the crest or divide forms, slope forms, and stream or drainage lines correctly related to the lines of the survey.

9-53. If hachure is to be used on the final plat, the relief is shown on the sketch plat by form lines that approximate contours, sketched without an exact interval or precise elevation above sea level. The available data for elevation above sea level and extent of ascents and descents along the surveyed lines may be incorporated in the form-line method for field sketching. The draftsman transfers the form lines to the overlay in pencil and then supplies the hachuring for the final plat.

9-54. In the areas where aerial photographs are available, copies should be supplied with the field data. While the survey is in progress, connecting lines may then be run to points selected on the photographs. A half dozen such points fairly evenly spaced along each flight afford ample control for laying out the section or other lines of the survey on the photographs.

The following statement, when applicable, is placed on the final plat above the border line in the lower left corner:

Aerial photographs, coordinated with ground control obtained during survey have been used in compiling the topography shown on this plat.

9-55. The special instructions for each survey should outline any exceptional methods to be employed in the field in obtaining topographic data, particularly where overprints will be required on the completed plat. The field sketch should represent the situation on the ground with an accuracy in details which reflects the practical relative importance.

Occasionally, in connection with resurveys, for example, the development of map data may even precede other parts of the survey work, for its value in making restorations of lost or obliterated corners, and for locating roads, improvements, and cultivated tracts upon patented and entered lands. The map features of the plat

are also important in certain classes of surveys within Indian and forest reservations, coal fields, mineral areas, waterpower sites, reservoir sites, irrigation projects, and other regions of relatively large prospective value. In these cases, which frequently embrace regions of extremely bold relief, coordinated cadastral and topographic surveys are made if advisable for administrative purposes.

9-56. The names of natural features must be given according to accepted usage. Surveyors are not authorized to report names of their own selection, but in case of doubt may submit the question through official channels to the United States Board on Geographical Names.

## TITLES AND SUBTITLES

9-57. Every plat is given a title similar to that on the specimen plat. This shows the township, the principal meridian, and the State. Plats showing the original subdivision of only a portion of a township are usually given a similar title for the sake of simplicity. Supplemental plats, plats of fragmentary subdivisional surveys, and resurvey plats are given an appropriate subtitle to qualify the nature of the survey. The title and date of acceptance usually suffice to identify the plat. The subtitle, if employed, explains the special purpose of the plat.

9-58. A subtitle is modeled after one of the following forms:

- (1) Supplemental plat
- (2) Four Islands in Burntside Lake
- (3) Extension Survey
- (4) Dependent Resurvey
- (5) Independent Resurvey
- (6) Survey of Omitted Lands
- (7) Survey of Accretion Lands
- (8) Survey of Tracts 37 and 38
- (9) Subdivision of Sections
- (10) Survey of Hiatus
- (11) Survey of the Moore Coal Mine
- (12) Poplar Townsite
- (13) Segregation Survey

Only the main purpose of the plat is included in the subtitle. The detail is carried in the memorandum.

## MEMORANDUM

9-59. A memorandum is required on each plat to correlate and consolidate the record of the subsisting surveys so far as shown on that plat. This memorandum will have a wide variety of references. The simple form shown on the specimen township plat is extended as required.

Where the plat represents the entire record of the survey, a statement to that effect should be placed on the plat.

A conventional symbol is shown to indicate the line of the true meridian. The mean magnetic declination over the area surveyed is shown at the base of the north arrow. Sections 2-18 and 3-126 (19).

The latitude and longitude are shown for the southeast corner of the township, lettered on the plat at that point, or for the southeast point of the survey when less than the normal township. The values are given according to the best available data, such as to the nearest even single minute when depending upon a calculation from some remote known station. The value may be extended to tenths of minutes based on an accurate map reference or to seconds if the field notes give a tie to a geodetic station of known accuracy. Section 2-21.

Each plat of an original survey carries a note of the total area surveyed, derived by taking the sum of all sectional-total areas which are identified by that plat. If resurveys are involved the rule is stated in sections 9-86 and 9-106.

The scale of the plat is shown by a bar scale.

9-60. The following list covers other marginal or tabular data that facilitate the drafting and increase the usefulness of the plat:

- Retracement of prior surveys, section 3-102.
- Witness corners, section 4-15.
- Townsites, monumentation, section 7-31.
- Townsites, titles and certificates, section 7-31.
- Erroneously omitted areas, memorandum, section 7-85.
- Plat requirements, general, section 9-6.
- Base drawing, memoranda and data on, section 9-9.
- Use of aerial photographs, section 9-54.
- Supplemental plats reference to former plats, section 9-67.
- Supplemental plats, memorandum and certificates, sections 9-72 through 9-75.
- Erosion, memorandum on plat, section 9-81.

Fragmentary surveys, reference to former plat, section 9-82.

Dependent resurvey, memorandum, section 9-85.

Independent resurvey, conformation of claims, section 9-87.

Independent resurvey, memorandum, sections 9-88, 9-89, and 9-90.

Independent resurvey, index of segregated tracts, sections 9-94, 9-95, 9-97, 9-98, and 9-110.

Independent resurvey, overlapping claims, section 9-102.

Independent resurvey, memorandum, section 9-103.

Independent resurvey, numbering of sheets, section 9-104.

Resurveys, citation of authority, section 9-107.

Resurveys, descriptions and areas, section 9-108.

Subtitles, section 9-58.

## CERTIFICATES

9-61. The approval of surveys of the public lands is a part of the authority vested in the Director, Bureau of Land Management, under the direction of the Secretary of the Interior (R.S. 453; 43 U.S.C. 2). The certificate shows official acceptance of the survey as represented on the plat. The form and arrangement of the certificate of acceptance are shown on the specimen township plat and should be followed so far as practicable on all plats.

## REPRODUCTION AND DISTRIBUTION OF PLATS

9-62. Two photolithographic copies of the original plat are printed on hard paper which are designated as the official duplicate original plat and triplicate original plat. The original plat is transmitted to the proper state survey office, the duplicate original is retained in the Washington office, and the triplicate original is transmitted to the proper land office. Other copies printed on map paper are transmitted to the state public survey office or retained in the Washington office for official use and to supply the public.

9-63. The original returns of current surveys within those States where the public survey offices have been discontinued are filed in the Bureau of Land Management at Washington, D.C. The duplicate original plat and field notes of such surveys are furnished to the

proper State office, noted in section 1-23. The triplicate original plat is furnished to the proper land office.

9-64. The state public survey offices should furnish to the appropriate regional office of the Geological Survey, from their supply of map paper prints, a copy of each accepted survey, resurvey, or supplemental plat. Courtesy copies of the plats are also furnished to other federal or state agencies as appropriate.

### SUPPLEMENTAL PLATS

9-65. A supplemental plat is prepared entirely from office records and is designed to show a revised subdivision of one or more sections without change in the section boundaries and without other modification of the subsisting record. Supplemental plats are prepared for acceptance by the Director.

9-66. Supplemental plats are required where the subsisting plat fails to provide units suitable for administration or disposal, or where a modification of its showing is necessary. They are also required to show the segregation of alienated lands from public lands where the former are included in irregular surveys of patented mineral or other private claims made subsequent to the plat of the subsisting survey or where the segregation of the claims was overlooked at the time of its approval.

9-67. All supplemental plats should show a proper reference to the former plat, the purpose of and the authority for the preparation, and all essential data, without unnecessary duplication of that carried by the former plat. The scale of the supplemental plat may be enlarged to 1 inch equals 10 or 20 chains, as appropriate.

9-68. The new lots are numbered as required in sections 3-82 and 3-111, and proper areas returned. The areas of the lots are computed from the subsisting record. No revision of the total area within the section is required and generally there is no occasion for showing topography.

9-69. The revised lottings on supplemental plats resulting from the segregation of mineral surveys are not confined to the subdivisions embraced within the pending entry. It is desirable to lot all public land within the scope of the

plat to avoid later piecemeal preparation of additional supplemental plats.

The plat should show an appropriate direct tie between a claim and a section corner or distances along claim and section lines to points of intersection. Complete courses and distances are shown for the claim lines which bound the public lands.

9-70. The lengths of lines are expressed in feet in the record of a mineral survey and in chains in the record of the rectangular net. Whenever the segregation of mineral claims is involved, the values on the face of the drawing are given in the chain unit only.

9-71. The administrative determination of the need for a supplemental plat ordinarily rests with the State Director, subject to the plat's acceptance by the Director, Bureau of Land Management.

9-72. The certificate of acceptance follows the arrangement shown on the specimen township plat; the memoranda include the pertinent data involved in the preparation of the plat.

Following are examples for supplemental plats:

9-73. Illustration, figure 83.

A modified form of lotting to provide new descriptions, based entirely upon the public land survey record on file in the public survey office, and without additional field work.

Title: Township 8 North, Range 20 West, of the San Bernardino Meridian, California. Subtitle: Supplemental Plat.

Scale: Bar scale in chains.

Memorandum:

This plat showing a subdivision of original lots 3 and 4, sec. 19, T. 8 N., R. 20 W., S.B.M., California, is based upon the plat approved October 8, 1880.

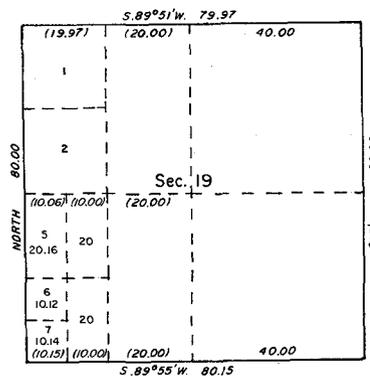


FIGURE 83.—Explanation in section 9-73.





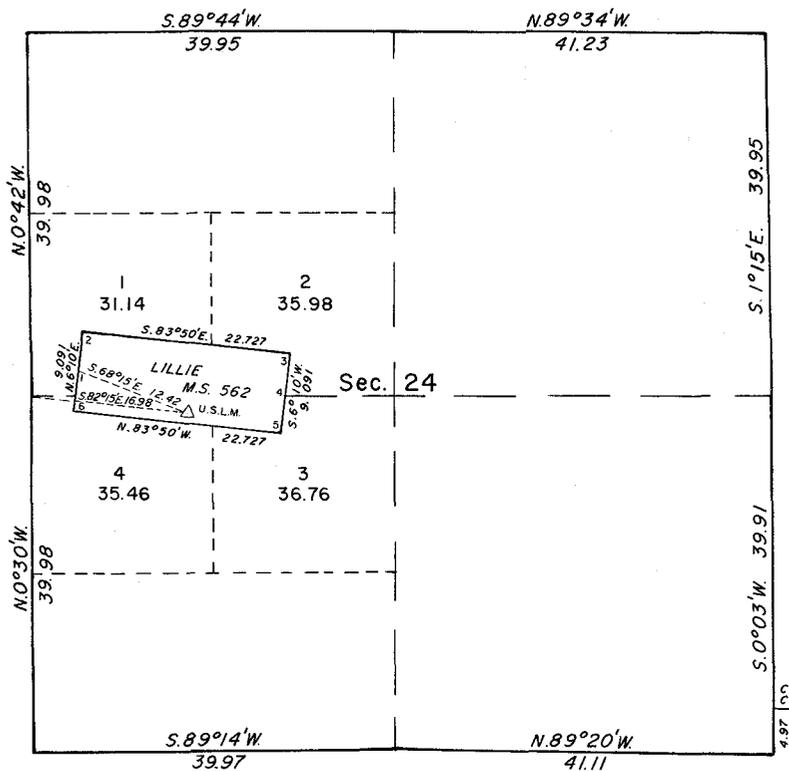


FIGURE 86.—Explanation in section 9-76.

This plat is strictly conformable to the approved field notes, and the survey, having been correctly executed in accordance with the requirements of law and the regulations of this Bureau, is hereby accepted.

For the Director

9-77. Illustration, figure 87.

Metes-and-bounds survey of an unsurveyed mineral claim, including a resurvey of the section boundaries and the survey of connections to the mineral claim.

Title: Township 21 South, Range 70 West, of the \_\_\_\_\_ Meridian, (State). Subtitle: Mineral Segregation.

Scale: Bar scale in chains, and bar scale in feet.

Memorandum:

Metes-and-bounds survey of an unsurveyed mineral claim with connecting lines and the incidental dependent resurvey of section 20, providing the basis for the segregation of the mineral claim, executed by John Smith, Cadastral Surveyor, October 7 to 12, 1972, inclusive, under Special Instructions dated September 14, 1972, for Group \_\_\_\_\_, (State).

Boundaries of sec. 20 surveyed by Albert W. Brewster, D.S., in 1879, as shown on the plat approved October 23, 1879.

Certificate: Heading similar to that shown on the specimen township plat.

This plat is strictly conformable to the approved

field notes, and the survey, having been correctly executed in accordance with the requirements of law and the regulations of this Bureau, is hereby accepted.

For the Director

PLATS OF FRAGMENTARY SURVEYS

9-78. The term "fragmentary survey" is applied to surveys made to identify parts of townships and sections that were not completed in the first instance. In this class are included partially surveyed sections; omitted islands, if title is in the United States; such areas as lands in place at date of original subdivision situated between a grossly erroneous or fictitious meander line and the actual bank of a stream or lake, where riparian rights do not obtain as under the usual doctrine; and other lands of substantial extent that for various reasons were not included in the original surveys. Section 3-100 to 3-114, 3-122, 7-65, 7-68, 7-77, and 7-94.

9-79. These types of surveys frequently require consideration of the question of title in-

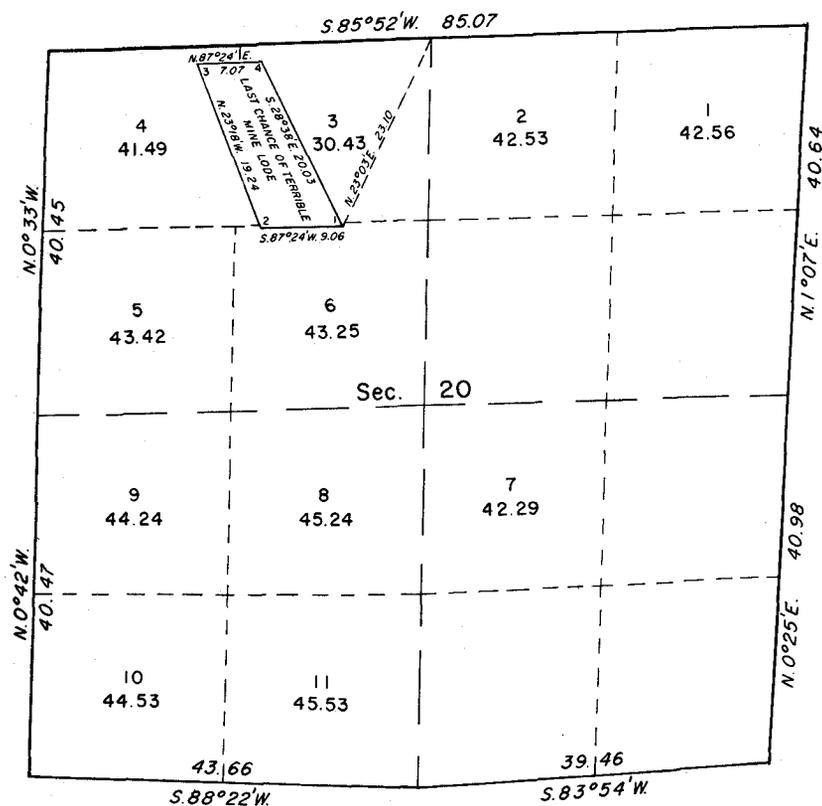


FIGURE 87.—Explanation in section 9-77.

involved preliminary to the extension of the former surveys.

9-80. In all such fragmentary surveys the new lottings are in addition to but without changing the former subdivisions if alienated. The scale of the plats may be enlarged as appropriate.

9-81. A notable exception to the principle that no changes should be made in the former lottings is found in those cases which involve retracements or resurveys where erosion has occurred along the bank of a stream or lake or other body of water which substantially changes the configuration of the former lots, and where it may be desirable to show the quantity of land remaining and that destroyed. Similar problems in platting are found in those cases of erroneous meandering where the record position of the original meander line is found to fall within the body of water. In these cases the former lot boundaries where situated within the water area are indicated in light broken

lines, and the quantities of each subdivision affected are shown in two parts; part "a" denoting land area and part "b" denoting water area. These areas are computed proportionately according to the amount shown for the original subdivision, the sum of "a" and "b" being made equal to the original total. A memorandum to this effect should appear upon the plat. This procedure is applicable in showing the effect of the flooding of public lands by artificial impoundment.

9-82. All technical data in reference to the retracement, reestablishment and extension of the section boundaries and connecting lines, and the complete topographical representation over the additional areas, are shown upon the plats of fragmentary surveys. If the retracements and remonumentation assume the character of a dependent resurvey of the boundaries of one or more sections, that fact is indicated on the plat together with a proper showing of the important map data throughout the entire area

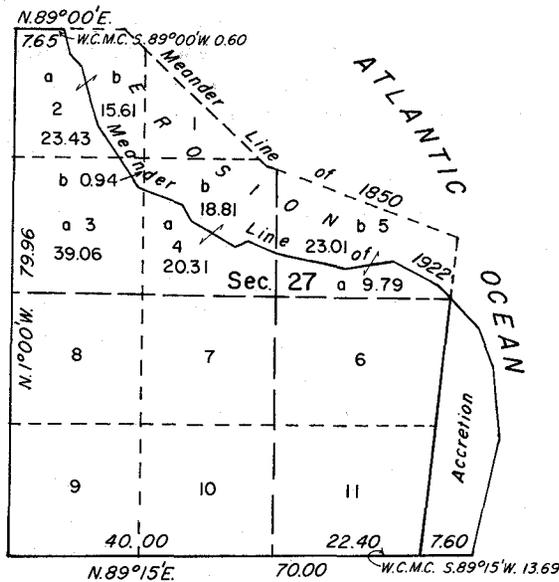


FIGURE 88.—Representing fractional subdivisions as affected by erosion and accretion after survey, without introducing questions of riparian rights. The subdivisions affected are shown in two parts: "a" denoting land area and "b" water area. A proportional adjustment is made in the computation of the quantities, if necessary, to make the sum of "a" and "b" equal to the original total.

surveyed and resurveyed. There is also shown an appropriate reference to the former approved plat or plats, and a citation of the authorization for the extension survey. The area statement includes separately the total areas surveyed and resurveyed.

In some fragmentary surveys the main purpose is to ascertain by retracement the true location of previously established monuments, and to account for discrepancies in the directions and lengths of lines, for correct plat representation and as a proper basis for the calculation of exact areas within the lottings, where the methods customarily followed in the construction of a supplemental plat are inadequate (section 9-65). Where such field work is required, the data derived by the retracement is used for all purposes as in a dependent resurvey. Thus where there are segregations to be made, the areas of the new lottings are derived by exact calculation.

In some metes-and-bounds surveys (section 7-16) not all of the directions and lengths of

lines between monuments, or between indicated corners of the subdivisions, can be carried to the plat without an overburden at the scale, or it may be unnecessary to represent all such data. In these cases it may be noted on the plat that the data will be found in the field notes of the survey.

In some cases where there are numerous and frequently very irregular lottings it may be desirable to carry the complete data to the plat. The scale of the base drawing, or that of the required additional sheets, is enlarged in these cases to accommodate the proper representation of the data. Traverse lines may be shown by marginal tabulation.

9-83. The certificate of acceptance on plats of fragmentary surveys will take the usual form; the necessary memorandum will be modeled after the examples given for the special cases already explained in chapter VII.

## RESURVEY PLATS

9-84. A somewhat different type of plat is required for representing resurveys as defined in chapter VI. The identity of lands in which valid rights have been acquired based upon a prior subdivision must be preserved. The subdivision of the remaining public lands may or may not be modified, according to the type of resurvey.

### Requirements on Plats of Dependent Resurveys

9-85. In addition to the usual data, the plat should carry a marginal memorandum that qualifies the character of the dependent resurvey, also a reference to the previous plat (or plats) to which it is related.

For example, in case of a whole township completely resurveyed, the following general statement is applicable:

This plat represents a dependent resurvey of the original township boundary and subdivisional lines designed to restore the corners in their true original locations according to the best available evidence.

Except as indicated hereon, the lottings and areas are as shown on the plat (or plats) approved \_\_\_\_\_ (date or dates).

If the original subdivisions were executed in two or more parts, or if the township has not been completely resurveyed, the memorandum is modified.

The reference to modified lottings or areas is omitted when there are no exceptions.

A necessary additional citation takes the following form:

Survey executed by \_\_\_\_\_  
beginning \_\_\_\_\_, and completed \_\_\_\_\_,  
pursuant to Special Instructions for Group No. \_\_\_\_\_,  
dated \_\_\_\_\_.

9-86. On plats of dependent resurveys the areas of the subdivisions are shown only in those exceptional cases where the differences between the actual quantity of the vacant subdivisions as found by resurvey and the former area as returned on the original approved plat are so great as to warrant revision. In that case the question of a revision rests upon the element of *quantity* rather than upon that of *distortion*. For practical purposes a variation of approximately 2.00 acres to the quarter-quarter section has been found advisable before making a change. A new lot number and area are assigned to each vacant subdivision which is to be revised. No total area within the section is shown. Alienated subdivisions cannot be revised.

An exception is sometimes made to the 2-acre minimum where it can be shown that more exact acreage is needed for proper management.

The total number of acres covered by a dependent resurvey need not be shown as marginal data on the plat.

### Requirements on Plats of Independent Resurveys

9-87. All claims should be accounted for on the plat of an independent resurvey 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 is made 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.

9-88. The additional memorandum that is placed on the plat of the independent resurvey is designed to clarify its very special and unusual character. It should especially show that a former record plat of approximately the same area has been annulled by official action as the basis for the identification, administration, or disposal of the vacant or unappropriated public lands. Moreover, in protection of whatever rights may have been acquired based upon the cancelled plat, the locations are identified in accordance with the marks of that survey.

The following should be regarded as a general suggestion:

This plat represents a resurvey which is independent of and that supersedes, so far as the public lands are concerned (hereon indicated by new subdivisional lines, lottings, and areas) all such similar units that are shown upon the plat (or plats) approved \_\_\_\_\_ (date or dates).

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 units and marked on the ground according to the best available evidence of their legal boundaries.

Where the boundaries of certain sections of the former survey have been restored as the best identification and form of protection to the alienated lands, and possibly including other sections entirely public land whose boundaries have not been changed, the memorandum, and the historical citations, take the forms that are outlined in section 9-90.

9-89. The above statement is modified if one or more of the claims shown on the status diagram are conformed to the lines of the resurvey 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.

9-90. If the whole township has been resurveyed, and where the plat shows no sections whose boundaries as a whole have been restored by dependent methods, a memorandum to qualify the nature of the independent resurvey, and the reference to the prior plat (or plats) may take the form that is given in section 9-88.

Where the boundaries of some of the sections

have been restored by dependent resurvey methods, and the remainder of the township has been subdivided on a new plan that is independent of the prior survey, the memoranda should be extended to make these facts clear, as for example:

This plat represents a resurvey that combines restored boundaries of certain sections with an entirely new subdivision of the remaining portions of the township as follows:

The boundaries and corners of sections \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, etc., restored to their true original locations according to the best available evidence, and (excepting as new or modified vacant subdivisions are shown in these sections) the lottings and areas in said sections are as originally shown on the plat (or plats) approved \_\_\_\_\_ (date or dates.)

The remainder of the township has been subdivided by the running of new lines and the marking of new corners, thereby annulling the former record lines and corners with reference to the public lands remaining undisposed of. The tracts identified hereon represent entered or patented parts of sections shown on the plat (or plats) approved \_\_\_\_\_ (date or dates.)

The memoranda referred to in sections 9-87, 9-88, and 9-89 are supplied as appropriate.

A necessary additional citation takes the following form:

Survey executed by \_\_\_\_\_, beginning \_\_\_\_\_, and completed \_\_\_\_\_, pursuant to Special Instructions for Group No. \_\_\_\_\_, dated \_\_\_\_\_.

9-91. Important items of topography and valuable permanent improvements are shown

along the lines of the metes-and-bounds survey. However, it is apparent that the amount of data shown in connection with the metes- and-bounds surveys make it impossible, at the usual scale, to show objects of little relative importance.

9-92. The requirements for showing the positions of alienated lands on the plats of independent resurveys are given in the memorandum forms which appear in sections 9-87, 9-88, and 9-89. The following sections show how the identification is accomplished in the cases of both tract segregations and conformed entries.

9-93. The tract segregations are laid out on the plats of resurveys as any private land claim would be shown upon an original plat. In order to show the detail of complicated situations one or more additional sheets are frequently necessary. If a claim is found to be conformable as defined in section 6-49 (5), its boundaries may be shown by giving greater weight to such parts of the regular subdivision-of-section lines of the resurvey. The outline of each tract segregation is shown on the first or principal sheet on the plan usually employed to show other types of private land claims.

9-94. On any of the several sheets, as appropriate, an index is supplied to tabulate the description of each tract in terms of the original plat. The following index form is acceptable:

*Index to segregated tracts*

No.	Tract		Original survey		
	Entry and status	Tp.	Rg.	Sec.	Subdivn.
39	Buffalo 2979.	58	75	29	NW $\frac{1}{4}$ NW $\frac{1}{4}$ .
	H. E.	58	75	29	S $\frac{1}{2}$ NW $\frac{1}{4}$ .
	W. J. Williams. Patented.	58	75	29	NW $\frac{1}{4}$ SW $\frac{1}{4}$ .
41	Buffalo 1567.	58	75	20	SE $\frac{1}{4}$ SW $\frac{1}{4}$ .
	D. L. E.	58	75	20	W $\frac{1}{2}$ SE $\frac{1}{4}$ .
	W. J. Williams. Pending.	58	75	29	NE $\frac{1}{4}$ NW $\frac{1}{4}$ .
77	Designated school section.	58	75	36	All.
95	Sundance 03186.	58	74	30	Lot 1.
	D. L. E.	58	74	30	Lot 2.
	C. R. Massey. Final certificate.				
101	Vacant.	58	75	24	Lot 4.
102	Vacant.	58	75	23	NE $\frac{1}{4}$ SE $\frac{1}{4}$ .

9-95. In some cases there is a demand for the description of a tract in terms of its component parts as determined by the original survey. In these exceptional cases, and only as ap-

propriate, the several parts may be indicated by letters A, B, C, etc., with the index modified as follows:

*Index to segregated tracts*

Tract		Original survey				Component parts	
No.	Entry and status	Tp.	Rg.	Sec.	Subdvn.	Sub-tract	Area
42	Buffalo 0833.	58	75	20	NE $\frac{1}{4}$ SE $\frac{1}{4}$ .	B	40.00
	H. E.	58	75	21	Lot 4.	A	32.00
	Thomas R. Williams.	58	75	21	NW $\frac{1}{4}$ SW $\frac{1}{4}$ .	C	40.00
	Pending.	58	75	21	SW $\frac{1}{4}$ SW $\frac{1}{4}$ .	D	40.00
46	Buffalo 08642.	58	75	24	Lot 3.	A	28.12
	H. E.	58	75	24	NW $\frac{1}{4}$ SW $\frac{1}{4}$ .	B	40.00
	Emmet Cain.	58	75	24	NE $\frac{1}{4}$ SW $\frac{1}{4}$ .	C	40.00
	Pending.	58	75	24	SE $\frac{1}{4}$ SW $\frac{1}{4}$ .	D	40.00

9-96. The above method is well adapted to the identification and subdivision of isolated tracts of public lands where the tracts have been surveyed by metes and bounds. In these cases the arrangement of the data carried by the index is the same, and the status of the tract

is shown as vacant.

9-97. If there are one or more conformable claims to be identified by amended description in terms of the resurvey, without segregation by metes and bounds, another form of index is required, as follows:

*Index to conformed entries under modified description*

Tract		Original survey				Resurvey			
Entry and status	Tp.	Rg.	Sec.	Subdvn.	Tp.	Rg.	Sec.	Subdvn.	
Buffalo 984.	45	79	12	NE $\frac{1}{4}$ SE $\frac{1}{4}$ .	45	79	12	SW $\frac{1}{4}$ SE $\frac{1}{4}$ .	
T. & S.	45	79	12	NW $\frac{1}{4}$ SE $\frac{1}{4}$ .	45	79	12	SE $\frac{1}{4}$ SW $\frac{1}{4}$ .	
Fred A. Jones.	45	79	12	NE $\frac{1}{4}$ SW $\frac{1}{4}$ .	45	79	12	SW $\frac{1}{4}$ SW $\frac{1}{4}$ .	
Pending.									
Buffalo.	45	79	12	SE $\frac{1}{4}$ SE $\frac{1}{4}$ .	45	79	13	NW $\frac{1}{4}$ NE $\frac{1}{4}$ .	
S. S. List 6.									
Approved.									

9-98. The several forms of index may be combined into one tabulation, if desirable, in which case it should be given a general title as *Index to Segregated Tracts and Appropriate Subdivisions*. The bracket for "component parts" may be filled in only as needed. Tract segregations are required where modified descriptions embrace subdivisions that are smaller than the regular 40-acre unit.

9-99. The special requirements for lotting fractional parts of sections invaded by tract segregations are set out in sections 6-52,, 6-53, and 6-54, and are illustrated by figures 89, 90, and 91.

9-100. Occasionally there is need for de-

noting the several parts of a tract in terms of quarter-quarter sections and fractional lots of the *resurvey*. This may be accomplished by protraction, showing lot numbers and areas as determined by the resurvey. The lottings within the tract should be made to complete the adjoining fractional quarter-quarter sections of the resurvey. This type of lotting requires no change in the index.

9-101. Where a tract is subdivided, preference is given to the method best suited to the situation: (1) If it is essential to perpetuate the units of the original survey, then the lines of the original quarter-quarter sections are shown; but (2) in those cases of relinquish-

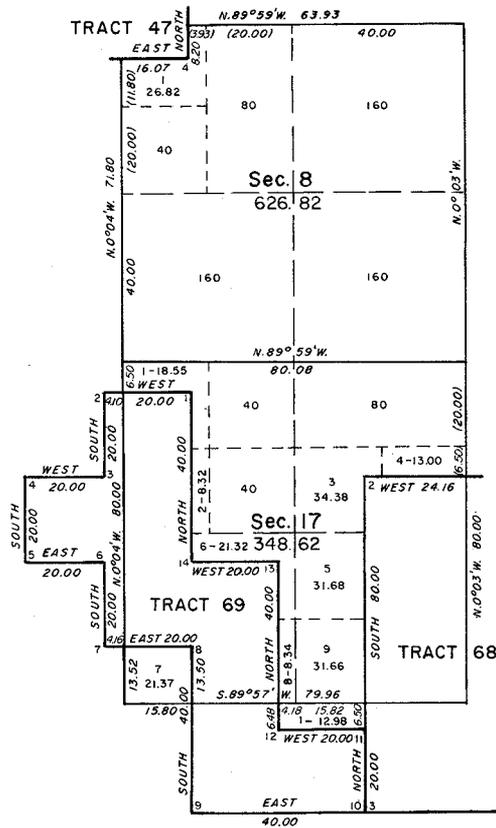


FIGURE 89.—Normal tract segregations, with fractional lotting of the adjoining public land. The tract segregations are laid out on the plat as any private land claim would be shown on an original plat.

ment or cancellation where it is probable that any new entry will be coupled with adjoining lottings by the resurvey, then a lotting within the segregated tract as determined by the section boundaries of the resurvey should be adopted. In the great majority of cases the patent eventually issues in accordance with the original entry, and the necessity for the subdivision of segregated tracts is exceptional. If it is necessary to subdivide a tract on the resurvey plat, the method should be based upon the type of disposal and the purpose to be served. Where such necessity is not clearly apparent no subdivision of this nature should be made, but a supplemental plat may be prepared at a later date to meet specific requirements.

9-102. If there are overlapping claims as defined in section 6-49(6), the conflict is indicated on the plat of the resurvey; but no new

lot numbers should be assigned nor quantities shown within the segregated tracts that are involved in the conflict (figure 90). The showing of the component parts must await the construction of a supplemental plat.

A memorandum is added to the index as follows: *See field notes for area of any part of a tract in conflict with another tract.* The uninvolved public land outside of the segregated tracts is lotted regularly except that the description of any subdivision of the original survey embraced in a tract or conformed entry under modified description is not repeated on the resurvey plat; instead it is assigned an appropriate lot number.

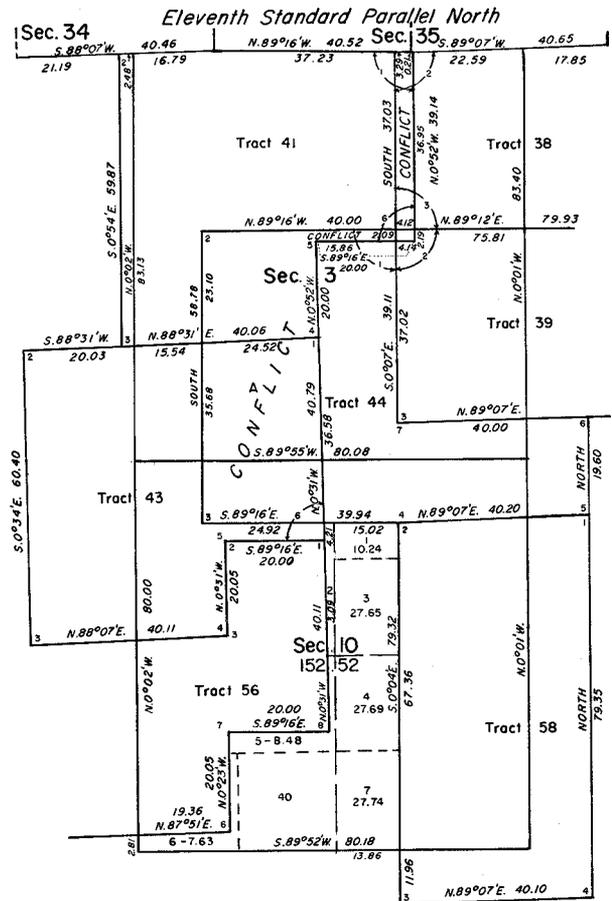


FIGURE 90.—Tract segregations in conflict, but not an adequate basis for amendment of descriptions. If there are overlapping claims the conflict is indicated on the plat of the resurvey.



of previous conflicts. The appropriate section numbers, lot numbers, and areas of the reduced tract subdivisions which are conflict free are listed in the columns of resurvey descriptions and areas of component parts. A footnote will follow the index referring to each new lot indicating the lot is a portion of the original subdivision free of conflict.

9-109. The usual rules of field procedure are observed in the protraction of the tract subdivisions. Where adequate control is shown in the record, the original sections are subdivided regularly. But if tracts have been segregated by in-

dependent resurvey with limited control, the points for intermediate sixteenth-section, quarter-section, and section corners on the original tract boundaries are determined by proportionate intervals between the established angle points, and the interior lines are drawn to connect corresponding points on the opposite sides of the tract boundaries, fixing the corners of each component part by intersections. The computed areas are based upon the data derived in the resurvey.

9-110. The following table is a revised index conforming to figure 91:

*Index to segregated tracts*

Tract		Original survey				Component parts <sup>1</sup>		Resurvey				
No.	Entry and status	Tp.	Rg.	Sec.	Subdvn.	Sub-tract	Area	Tp.	Rg.	Sec.	Subdvn.	
38	Buffalo 010118.	44	80	1	Lot 4.	A	35.16					
	H. E.	44	80	2	Lot 1.	B	35.86					
	Ralph R. Baldwin.	44	80	2	Lot 2.	C	36.06					
	Pending.		44	80	2	SW $\frac{1}{4}$ NE $\frac{1}{4}$ .	D	40.00				
			44	80	2	SE $\frac{1}{4}$ NE $\frac{1}{4}$ .	E	40.00				
			44	80	1	SW $\frac{1}{4}$ NW $\frac{1}{4}$ .	F	40.00				
			44	80	2	Lot 3.		28.81	44	80	3	Lot 5.*
	44	80	2	SE $\frac{1}{4}$ NW $\frac{1}{4}$ .		30.97	44	80	3	Lot 7.*		
41	Buffalo 09311.	44	80	3	Lot 1.	A	36.66					
	H. E.	44	80	3	Lot 2.	B	36.85					
	Henry J. Brun-	44	80	3	Lot 3.	C	37.00					
	ning.	44	80	3	SE $\frac{1}{4}$ NW $\frac{1}{4}$ .	D	40.00					
	Pending.		44	80	3	SW $\frac{1}{4}$ NE $\frac{1}{4}$ .	E	40.00				
			44	80	3	NW $\frac{1}{4}$ SE $\frac{1}{4}$ .	F	40.00				
			44	80	3	NE $\frac{1}{4}$ SW $\frac{1}{4}$ .	G	40.00				
		44	80	3	SE $\frac{1}{4}$ NE $\frac{1}{4}$ .		39.76	44	80	3	Lot 6.*	
43	Buffalo 011734.	44	80	3	SW $\frac{1}{4}$ SW $\frac{1}{4}$ .	A	40.00					
	H.E.	44	80	10	NW $\frac{1}{4}$ NW $\frac{1}{4}$ .	B	40.00					
	Perry Barnes.	44	80	10	SE $\frac{1}{4}$ NW $\frac{1}{4}$ .	C	40.00					
	Pending.		44	80	10	SW $\frac{1}{4}$ NW $\frac{1}{4}$ .	D	40.00				
			44	80	3	SE $\frac{1}{4}$ SW $\frac{1}{4}$ .		28.82	44	80	3	Lot 9.*
							2.94	44	80	4	Lot 9.*	
							4.47	44	80	3	Lot 10.*	
							0.41	44	80	4	Lot 10.*	
							2.12	44	80	9	Lot 8.*	
							25.37	44	80	10	Lot 9.*	
						8.42	44	80	10	Lot 8.*		
						*0.00						
44	Buffalo 07532.	44	80	11	NW $\frac{1}{4}$ NE $\frac{1}{4}$ .	A	40.00					
	H. E.	44	80	11	NE $\frac{1}{4}$ NW $\frac{1}{4}$ .	B	40.00					
	Antoine Faure.	44	80	11	NW $\frac{1}{4}$ NW $\frac{1}{4}$ .	C	40.00					
	Pending.		44	80	10	NE $\frac{1}{4}$ NE $\frac{1}{4}$ .	D	40.00				
			44	80	2	NW $\frac{1}{4}$ SW $\frac{1}{4}$ .		27.51	44	80	3	Lot 8.*
			44	80	3	SE $\frac{1}{4}$ SE $\frac{1}{4}$ .		32.90	44	80	3	Lot 11.*
			44	80	2	SW $\frac{1}{4}$ SW $\frac{1}{4}$ .		38.12	44	80	3	Lot 12.*
	44	80	3	NE $\frac{1}{4}$ SE $\frac{1}{4}$ .		*0.00						

<sup>1</sup> See section 9-95.

\* Portion of original subdivision that is free of conflict.

9-111. Not all resurvey plats can be treated similarly. Methods suited to situations not involved in a particular case should be set aside to avoid unnecessary complications. The nor-

mal resurvey may be brought within a fairly definite, standardized drafting practice, but each unusual case needs a special analysis as to how the detail may be most suitably platted.

## Mineral Surveys

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### DISTINGUISHING FEATURES OF THE MINERAL SURVEY

10-1. This chapter sets out the field and office procedure to be followed in the execution of *mineral surveys*, and the filing of the returns. These surveys are made to mark the legal boundaries of mineral deposits or ore-bearing formations on the public domain where the boundaries are determined by lines other than the normal subdivision of the public lands.

Mineral surveys are required most frequently where the deposits occur in ore-bearing rock veins, known as mineral lodes, where the prospector who has made a legal discovery is permitted to stake out a claim of specified dimensions, to develop the same to his exclusive use, and, if desired in the protection of his right, to apply for a mineral survey and obtain a patent.

R.S. 2331 (30 U.S.C. 35) provides that all placer-mining claims located after May 10, 1872, shall conform as nearly as practicable with the United States system of public land surveys and the rectangular subdivision of such surveys, and such locations shall not include more than 20 acres for each individual claimant. Surveys of placer claims are conformed to the public survey unless they are located on unsurveyed land or the configuration of the mineral deposit makes conformation impracticable. Consequently, the mineral survey procedures apply especially to lode claims although they are followed generally in appropriate surveys of placer claims.

Millsites embracing land occupied for milling purposes or used incidental to mining operations may be located, surveyed, and patented in a manner similar to lode claims.

The early discoveries of free gold were made far in advance of settlement, mainly in the stream beds of the western territories that included the Black Hills, the Rocky Mountains, and the Pacific Slope. Mineral deposits in these regions were appropriated and their values extracted under varied local camp or mining district rules with the tacit approval but without any regulations by the Federal Government. Finally, with the spread and development of the mining industry, Congress adopted legislation not only recognizing the possessory right of citizens of the United States to minerals on public lands (R.S. 910; 30 U.S.C. 53), but also providing for their disposition. (R.S. 2319-2340 and 2343-2344; 30 U.S.C. 22-24, 26-30, 33-43, 46, 47, 51, 52). Present procedures are derived from this basic legislation.

10-2. Subsequent legislation has necessitated a detailed revision of the regulations governing the administration of mineral surveys, but the field surveying operations remained fixed.

The appointment and bonding of mineral surveyors, suspension or revocation of their appointments, payment for their services, employment of their assistants, and the cost of office work to mineral claimants, including refund of unearned deposits, are matters of internal office procedure. Rules for these administrative procedures and also the procedures for locating, maintaining, and obtaining patent to mining claims are contained in the Code of Federal Regulations, Title 43.

The order for a mineral survey issues from the state office administering the public lands where the claim is located.

## REQUIREMENTS OF FIELD WORK

10-3. The mineral survey includes not only the usual technical procedure but also the examination required for preparing affidavits of the value of expenditures for development purposes and any other reports to be made by the mineral surveyor.

10-4. The survey must be an actual survey on the ground in full detail, made by the mineral surveyor in person after the receipt of the order. It must be made without reference to any knowledge he may have previously acquired by having made the location survey or otherwise. The record must show the actual facts existing at the time of the survey. This precludes a calculation of the connections to corners of the public survey and to location monuments, or of any other lines of the survey, through prior surveys, unless it is satisfactorily shown in his report that he has retraced such lines and found them to be correct. *Veta Grande Lode*, 6 L.D. 718 (1888); *Lincoln Placer*, 7 L.D. 81 (1888).

10-5. The survey of a mining claim may include several contiguous locations owned in common, but in conformity with statutory requirements the survey record must distinguish the several locations and exhibit the boundaries of each. *S.F. Mackie*, 5 L.D. 199 (1886); *Golden Sun Mining Co.*, 6 L.D. 808 (1888); *Argillite Stone Co.*, 29 L.D. 585 (1900).

10-6. Lengths of lines are returned as their true horizontal equivalents in the *foot unit*, as determined by the methods of measurement prescribed in chapter II. The high degree of accuracy required in making mineral surveys calls for careful steel-tape measurements or the use of an electronic measuring device. If needed for acceptable results, a spring balance should be used and temperature corrections applied when measuring with the steel tape.

10-7. Mineral surveys must be made with an instrument by which the meridian may be determined independently of the magnetic needle, and the directions of lines must be referred to the true meridian. A transit with or without a solar attachment may be used in any of the methods described in chapter II. The true course of at least one line of each survey is to be ascertained at the time of the survey by observation of the sun, Polaris, or an equatorial

star with proper verification of the time and latitude. The methods employed and the results are recorded in the field notes of the survey. Specimen field notes of a mineral survey will be found in the appendix.

10-8. The magnetic declination is to be noted at each corner of the survey. If it is the same at the several corners, that fact and the value of the declination are stated in the field notes. The magnetic declination must be noted and recorded at each corner of the survey where differences are found.

10-9. The survey must be made in strict conformity with, or be embraced within, the lines of the location upon which the order is based. If the survey and location are identical that fact is to be clearly stated in the field notes. If not identical, a bearing and distance are to be given in the field notes from each established corner of the survey to the corresponding corner of the location. The lines of the location as found upon the ground should be laid down upon the preliminary plat only in such manner as to contrast and show their relation to the lines of survey. *Philip Dephanger*, 1 L.D. 581 (1882).

10-10. The survey is given but one number. A location under the mining laws can legally be made only of a tract or piece of land embraced within one set of boundary lines. Two or more tracts merely cornering with each other cannot legally be embraced in a single location. *Gomeira Placer Claim*, 33 L.D. 560 (1905); *Hidden Treasure Mine*, 35 L.D. 485 (1907). An owner of several claims who has received patent for certain contiguous claims in the group may apply for patent to the remainder in one application, even though they are not contiguous to each other, if each is contiguous to the body of land embraced in the patented claims. *Wagner Assets Realization Corp.*, 53 L.D. 614 (1932).

10-11. In accordance with the principle that courses and distances must give way when in conflict with fixed objects and monuments, the mineral surveyor may not change the corners of the location for the purpose of making them conform to the description in the record. If the difference from the location certificate is slight, it may be explained in the field notes, as indicated in the specimen field notes.

10-12. R.S. 2324 (30 U.S.C. 28), expressly provides that "the location must be distinctly marked on the ground so that its boundaries can be readily traced," and "that all records of mining claims made after May 10, 1872, shall contain the name or names of the locators, the date of the location, and such a description of the claim or claims located by reference to some natural object or permanent monument as will identify the claim." Each location certificate should give the name of the location.

10-13. A single discovery working cannot support more than one location, *Poplar Creek Mine*, 16 L.D. 1 (1893), unless the vein or lode can be traced on outcroppings on contiguous claims.

10-14. These provisions of law must be strictly complied with in each case to entitle the claimant to a survey and patent. Should a claimant under a location made subsequent to May 10, 1872, who has not complied with said requirements in regard to marking the location upon the ground and recording the location certificate, apply for a survey, the mineral surveyor must decline to make it prior to reporting the facts to the survey office and receiving further instructions. *Philip Dephanger*, 1 L.D. 581 (1882).

10-15. If after having obtained an order for survey the applicant should find that the record of location does not practically describe the location as staked upon the ground, he should file a certified copy of an amended location certificate, correctly describing the claim, and obtain an amended order for survey. In fact any change in the original order including the addition or dropping of locations or designation of a different surveyor calls for an amended order.

10-16. If the survey is applied for under a location made prior to May 10, 1872 (see R.S. 2319-2328, 2331), the mineral surveyor is governed by the special instructions accompanying the order for survey.

### LODE LINES AND END LINES

10-17. No lode claim located subsequent to May 10, 1872, may exceed the statutory limit of 300 ft. in width on each side of the center of the vein, or 1,500 ft. in length. All surveys

must close within 0.50 ft. in 1,000 ft., and the error must not be such as to make the claim exceed the statutory limit. In the absence of proof to the contrary, the discovery point is held to be the center of the vein on the surface. The course and length of the lode line or presumed course of the vein should be marked upon the plat and specifically described in the field notes. The record of the intersections of the end lines with the lode line are given in the field notes from the lowest numbered corner on each end line running toward the next higher numbered corner. Where conditions permit, the distances are shown on the plat.

10-18. It was held in *Beliggerent and Other Claims*, 35 L.D. 22 (1906), (syllabus), that —

There is no warrant in the mining laws for extending, arbitrarily and without any basis of fact therefor, the vein or lode line of a location in an irregular and zigzag manner for the purpose of controlling the length or situation of the exterior lines of the location to suit the convenience, real or imagined, of the locator.

The end lines of a lode location must be straight and parallel to each other and when at right angles with the side lines may not exceed 600 feet in length.

The mining laws contemplate that the end lines of a lode claim shall have substantial existence in fact, and in length shall reasonably comport with the width of the claim as located.

### METHOD AND ORDER OF PROCEDURE

10-19. The position of the official survey upon the ground is fixed by connecting it by course and distance either to a corner of the public survey, preferably the nearest, or to a location monument. In either case the connecting line may not exceed a length of 2 miles. If both a corner of the public survey and a location monument are within the limiting distance, the connection should, if practicable, be made to the public survey corner. Each location of a survey embracing two or more locations must be so connected.

10-20. When a mining claim is situated within the limits of a township the survey of which is in good standing, but where no corner of the survey can be found within 2 miles of the claim, after diligent search, connection may be made with a location monument, which in

turn must be connected with an established public survey corner.

10-21. As a matter of convenience in the preparation of subsequent metes-and-bounds descriptions it is preferable that the corner of each location from which the connection is made be established as corner No. 1.

10-22. The three preceding sections are intended to permit the surveyor to obtain connections in a practicable manner based upon existing field conditions. Any unusual conditions that may be encountered in obtaining connections should be explained in the field notes.

10-23. From corner No. 1 the successive boundaries of each location are run in regular manner, numbering the remaining corners in consecutive order.

10-24. A lode and a millsite embraced in one survey are distinguished by the letters A and B, respectively, following the number of the survey. The corners of the millsite are numbered independently of those of the lode. A corner of the millsite, preferably corner No. 1, is connected with a corner of the public survey or location monument, and a corner of the millsite with a corner of the lode claim.

10-25. When a placer claim includes lodes, or when several contiguous placer or lode locations are included as one claim in one survey, the corners of each location are given a separate consecutive numerical designation, beginning with corner No. 1 in each case. The placer claim should be described in the field notes before describing the lodes.

## CONFLICTS

10-26. When an exterior line of a claim intersects the surveyed line of another claim, the field notes must show (1) the distance to the point of intersection and (2) the course and distance along the line to a corner of the conflicting claim. Where a corner of the conflicting survey falls within the claim being surveyed, this corner should be selected from which to give the tie. When the same line of a conflict is intersected by two lines of the survey, the tie is given from the same corner of the conflicting survey at both intersections.

10-27. When the lines of two locations of the survey intersect, only the point of intersection is given on the line being described.

10-28. Conflicts with unsurveyed locations are not reported unless excluded from the area claimed.

10-29. Surveyed claims owned by the applicant, in conflict with or contiguous to the survey, must be reported in the field notes.

10-30. A connecting line should be run from some corner of the survey to a corner of each conflicting survey, also to a corner of each conflicting unsurveyed location that is to be excluded.

10-31. Connection is also made to any survey, the record position of which is within 100 feet of the lines of the survey being executed; also to any other neighboring survey, the location of which is not definitely fixed by the record. Such connections should be made and conflicts shown according to the boundaries of the neighboring or conflicting claims as each is marked, defined, and actually established upon the ground.

The field notes must fully and specifically state how and by what visible evidence the several conflicting surveys were identified on the ground, as well as those which appear to conflict, according to their returned tie or boundary lines, and report all material errors or discrepancies found in such surveys. In the survey of a group of contiguous claims where any corners are common to two or more claims of the group, bearings should be mentioned but once and the corner described as a common corner in the claim first mentioned in the field notes.

## LOCATION MONUMENTS

10-32. When a survey is situated in a district where there are no corners of the public survey and no other monuments within 2 miles, a location monument is established. The site, when practicable, should be some prominent point, visible from every direction, where the permanency of the monument will not be endangered by snow, rock, or land movements or other natural causes. The geographic position of the location monument is recorded in the field notes. The latitude and longitude should

be determined as accurately as the known data and the instruments used will permit.

10-33. The monument should consist of an iron post similar to the type used for rectangular surveys or a stone not less than 30 inches long, 20 inches wide, and 6 inches thick, set three-fourths in the ground with a conical mound of stone 4 feet high and having a 6-foot base alongside. The letters "USLM" followed by the number of the survey are marked on the brass cap or plainly chiseled upon the stone. The exact reference point is indicated on the top of the monument by a cross. Any necessary departure from the prescribed material and size of monument is to be explained.

10-34. From the monument the precise course and distance is to be taken to two or more bearing trees or rocks, and to any well-known and permanent objects in the vicinity, such as buildings, shafts, mouths of adits, prominent rocks, or the confluence of streams. Bearing trees are scribed "BT" and the bearing rocks chiseled "BO" together with the number of the location monument. The exact point on the tree or stone to which connection is made is indicated by a cross or other unmistakable mark. Bearings should also be taken to prominent mountain peaks or other landmarks and the approximate distance and direction ascertained to the nearest town or mining camp. A detailed description of the location monument, with a topographic map of its location, is to be furnished in the record of the survey.

### CORNER MONUMENTS

10-35. Corner monuments may consist of the following, given in the order of preference:

(1) Tubular iron post with flared base and brass cap for marking with steel dies of the type adopted for public land surveys.

(2) A stone at least 24 inches long, 6 inches wide, and 4 inches thick, set 16 inches in the ground, with a conical mound of stone, 1½ feet high, 2-foot base, alongside; or,

(3) A rock in place.

If none of these is available, a concrete post, at least 24 inches long, 6 inches square, set 16 inches in the ground, and surrounded by a sub-

stantial mound of earth or stone, may be used. If it is necessary to vary from these instructions, the returns should contain an explanation.

10-36. All corners must be monumented in a permanent and workmanlike manner. The monument is marked by stamping the distinguishing initial letter or letters, corner numbers, and survey numbers on the cap of a brass-capped monument. The marks on a stone or post are chiseled on the sides facing the claim or claims. The precise corner point is permanently indicated on the monument. When a rock in place is used, its dimensions above ground should be stated, and a cross chiseled at the exact corner point. Corners common to two or more locations are marked with the initial letter and corner number of each location.

10-37. In case the point for the corner is inaccessible or unsuitable, a witness corner is established, which will bear the letters "WC" in addition to the regular markings. When practicable the witness corner should be located upon a line of the survey and as near as possible to the true corner point, with which it must be connected by course and distance. The reason for the establishment of a witness corner should be stated in the field notes.

10-38. The position of each corner should be recorded by course and distance to bearing trees, rocks, and other permanent objects, as prescribed in the establishment of location monuments, and when no objects are available the field notes should so state. In the latter event a memorial, if practicable, should be deposited at the corner and described in the field notes.

### TOPOGRAPHY

10-39. The topographic features of the claim should be noted carefully. Distances on the lines are shown to intersections with all streams, gulches, ditches, ravines, trails, etc., with their widths, courses, and other data required for mapping. If the claim lies within a townsite, all important municipal improvements, and the street and block system, within the claim should also be located for mapping purposes.

## FIELD NOTES AND PRELIMINARY PLAT

10-40. Field notes and other reports must be typewritten in black-record ink, and upon the proper blanks, which are furnished with the order for survey or upon application. No interlineations or erasures are permissible, and no abbreviations or symbols may be used excepting those shown in section 8-11 and as employed in the specimen field notes in appendix II.

10-41. The mineral surveyor prepares and files a preliminary plat on tracing cloth, drawn on a scale of 200 feet to an inch, if practicable, in conformity with the specimen plat (insert No. 2), the lines of the claim surveyed being shown heavier in contrast with conflicting claims. A copy of calculations of areas (made by double meridian distances) and of all triangulations or traverse lines should also be furnished.

10-42. In order that the results of the survey may be reported in a uniform manner, the field notes and preliminary plat are to be prepared in strict conformity with the specimen field notes and plat. These are designed to furnish all needed information concerning the manner of describing the boundaries, corners, lode lines, connections, intersections, conflicts, and improvements, and of stating the magnetic declination, area, location, and other data connected with the survey of mineral claims, and to prescribe certain forms of certificates for the surveyor, and for listing his assistants.

10-43. Throughout the description of the survey, after each reference to the lines or corners of a location, give the name thereof, and if unsurveyed state the fact. If reference is made to a location included in a prior official survey, the survey number is given, followed by the name of the location.

10-44. The total area of each location in a group embraced by its exterior boundaries, and also the area in conflict with each intersecting survey or claim, should be stated. When locations of the survey conflict with each other, such conflicts should be stated only in connection with the location from which the conflicting area is excluded.

10-45. The field notes and plat of survey should not show exclusions, or attempt to specify

the net area of the claim. These are matters for the applicant to state in connection with his application for patent, and the notices posted and published. The field notes should merely show the total and net areas of conflict, so that any exclusion desired may be made readily.

10-46. The field notes should state specifically whether the claim is upon surveyed or unsurveyed public lands, giving in the former case the quarter section, township, and range in which it is located, and in the latter the township and range as nearly as can be determined by the information at hand. When upon surveyed lands, the section boundaries should be indicated by full lines and quarter sections by broken lines.

10-47. The title-page should contain the post-office address of the claimant or his authorized agent.

## IMPROVEMENTS

10-48. In R.S. 2325 (30 U.S.C. 29), it is directed that at least \$500 shall be expended upon a mineral claim as a prerequisite to patent.

10-49. In preparing the certificate of the value of the improvements, the form shown in the specimen field notes is followed.

10-50. Only actual expenditures and mining improvements made by the claimant or his grantors, having a direct relation to the development of the claim, are to be included in the estimate. Labor performed or improvements made outside the boundaries of the claim are within the meaning of the statute when they facilitate the extraction of the metals in the claim. *Emily Lode*, 6 L.D. 220 (1887).

10-51. The expenditures required may be made on the surface or in running a tunnel, drifts, or crosscuts for the development of the claim. Improvements of any other character, such as buildings, machinery, or roadways are excluded from the estimate unless it is clearly shown that they are associated with actual excavations, such as cuts, tunnels, and shafts, and are essential to the practical development and to actually facilitate the extraction of mineral. Mills for ore treatment, or roadways, tramways, or trails built for transporting the extracted ore from the mine, are not to be included.

10-52. All mining and other improvements on the claim are located by course and distance from corners of the survey, or from points on the indicated lode line, specifying with particularity the dimensions and character of each. The improvements upon each location should be numbered consecutively, the point of discovery always being No. 1. Improvements made by a former locator who has abandoned his claim are not to be included in the estimate, but should be described by separate statement in the field notes and shown on the plat.

10-53. The field notes should show in detail the value of each mining improvement included in the estimate of expenditures, and when a tunnel or other improvement has been made for the development of other claims in connection with the one for which survey is made, the name, ownership, and survey number, if any, of each claim to be credited, and the value of the interest credited to each should be stated.

10-54. When a lode and millsite are included in the same survey, an expenditure of \$500 at the time of application for patent is required upon the lode claim only.

10-55. When a survey embraces several locations held in common, constituting one entire claim whether lode or placer, an expenditure of \$500 at the time of application for patent for each location embraced in the group is required.

10-56. It is held in *James Carreto*, 35 L.D. 361 (1907), (syllabus), that —

Where several contiguous mining claims are held in common and expenditures are made upon an improvement intended to aid in the common development of all of the claims so held, and which is of such character as to redound to the benefit of all, such improvement is properly called a common improvement.

Each of a group of contiguous mining claims held in common and developed by a common improvement has an equal, undivided interest in such improvement, which is to be determined by a calculation based upon the number of claims in the group and the value of the common improvement.

There is no authority in law for an unequal assignment of credits out of the cost of an improvement made for the common benefit of a number of mining claims, or the apportionment of a physical segment of an improvement of that character to any particular claim or claims of the number, such an arbitrary adjustment of credits as the exigencies of the case may seem to require being utterly at variance with the

essential idea inherent in the term "a common improvement."

In any patent proceedings where a part of a group of mining claims is applied for and reliance is had upon a common improvement, the land department should be fully advised as to the total number of claims embraced in the group, as to their ownership, and as to their relative situations, properly delineated upon an authenticated map or diagram. Such information should always be furnished in connection with the first proceeding involving an application of credit from the common improvement, and should be referred to and properly supplemented in each subsequent patent application in which a like credit is sought to be applied.

10-57. It is also held in *Aldebran Mining Co.*, 36 L.D. 551 (1908), (syllabus), that —

A common improvement or system, offered for patent purposes, although of sufficient aggregate value and of the prerequisite benefit to all the mining claims of a group, can not be accepted as it then stands in full satisfaction of the statutory requirement as to such of the claims the location of which it preceded, the law requiring that an expenditure of at least \$500 shall succeed the location of every claim.

If the requisite benefit to the group is shown, or to the extent of such of the claims as are so benefited, and the elements of contiguity and common interest in the claims concerned appear; if the improvement represents a total value sufficient for patent purposes for the number of claims so involved; if for each claim located after the partial construction of the improvement the latter has been subsequently extended so as to represent an added value of not less than \$500, each is entitled under the law to a share of the value of the common improvement in its entirety, no claim receiving more or less than another from that source, participating therein without distinction or difference, and as to each the statutory requirement is satisfied.

10-58. The explanatory statement in such cases should be given in the field notes or affidavit at the conclusion of the description of the improvements included in the estimate of expenditure, and should be as full and explicit as the facts in the case warrant, dealing only with improvements, conditions, and circumstances as they actually existed at the time of survey or subsequent field examination.

10-59. If the value of the labor and improvements upon a mineral claim is less than \$500 at the time of survey, authority is given to file thereafter supplemental proof showing \$500 expenditure made prior to the expiration of the period of publication. The information on which to base this proof must be derived by the mineral surveyor, who makes the actual sur-

vey, from a careful examination upon the premises.

10-60. Only improvements made by the claimant or his grantors subsequent to the location of the claim are available under the statutes for patent expenditure. The survey office certifies to this fact according to the record, and, as the certificate is based on the report of the mineral surveyor, the latter should exercise special care to see that such improvements only are reported.

### AMENDED SURVEYS

10-61. Amended surveys are ordered in the same manner as original mineral surveys. The conditions and circumstances peculiar to each separate case and the object sought by the required amendment are set forth in the office authorization, and alone govern all special matters relative to the manner of making such surveys and the form and subject matter to be embraced in the field notes.

10-62. An amended survey must be made in strict conformity with, or be embraced within, the lines of the original survey. If any portion of the amended and original surveys are identical, that fact must be distinctly stated in the field notes. If not identical, the bearing and distance are given from each established corner of the amended survey to the corresponding corner of the original survey. The lines of the original survey, as found upon the ground, are laid down upon the preliminary plat in such manner as to contrast and show their relation to the lines of the amended survey.

10-63. The field notes of the amended survey are prepared on the same size and form of blanks as are required for the field notes of the original survey, and the abbreviation "Am." will be used after the survey number wherever it occurs.

### PLATS

10-64. Chapter IX covers the essentials of plat making. In addition, the following instructions relating especially to mineral plats should be observed. The returns of the survey when filed in the public survey office are carefully examined and compared with the records to determine that all conflicts with prior approved surveys are correctly shown, that all connecting lines given are in harmony with the record, that all material errors found in prior surveys are fully reported, and that the calculations of intersections and of conflicting areas are correct. The final plat is drawn on a scale of 200 feet to an inch when practicable. See Specimen Mineral Plat, insert No. 2.

The scale should be large enough to illustrate clearly the improvements, conflicts, and physical features described in the field notes, together with all courses and distances of intersecting lines and connecting lines, where space permits. Any topographic features described in the field notes tending to confuse or obscure the plat may be omitted, but as the copy of the plat posted on the claim is a notice to the public of the ground applied for, all of the roads, streams, and other objects that may aid in locating the surveyed ground should be shown.

In case the entire survey cannot be shown on one sheet on a scale large enough to be clear, two or more sheets may be used and numbered consecutively, each sheet bearing the inscription "Survey No.\_\_\_\_, Sheet No.\_\_\_\_ of \_\_\_\_ Sheets." The last sheet should carry the certificate of approval, with the extra sheets of the same width and not longer than the last sheet.

10-65. The mineral survey is approved in the survey office. When approved, the plat is reproduced and the returns of the survey are distributed in accordance with existing regulations.

## Adjustment of the Solar Unit

First, make certain that the transit itself is in good order. Before making any adjustments of the solar unit, determine that:

(1) The solar telescope revolves smoothly in its collar bearings, neither too tightly nor too loosely.

(2) There is free and smooth motion to the latitude and declination arcs.

(3) The clamps are positive, and the tangent motions smooth.

(4) The eyepiece is carefully focused upon the crosswires.

(5) The objective is carefully focused upon a distant object, then secured in this position.

### Field Tests

If the general adjustments, accomplished as hereinafter described, have not been disturbed appreciably, *there are only three field tests preliminary to checking the solar unit for orientation*. Two of these are made by the prime vertical method, more fully described under that heading; the third is the noon observation.

(1) To ascertain whether the line of collimation of the solar telescope (or polar axis) is truly parallel to the vertical plane of the transit telescope when the solar is set and clamped in the latitude of the station. Any difference here *is a constant*, i.e., any discrepancy to the right or to the left should remain the same in all orientation, both a.m. and p.m.

Select a suitable sighting point, then in order to find its reflected image, determine the vertical angle counting from the H.I. or reflector; compute the setting for a north declination on the value:  $\sin \delta = \sin \phi \sin v$ .

Start with the main telescope on the sighting point, plate reading at zero, reflector in the

direction of the sighting point; the solar telescope clamped in the latitude of the station; a north declination set on the above value.

On the first check, turn the transit  $90^\circ$ , and turn the solar telescope in hour angle to pick up the image of the sighting point. It is usually helpful to shade the reflector so as to protect it from all light excepting those rays coming from the direction of the sighting point. Next, set the central equatorial wire on the image of the sighting point by movement of the declination tangent motion. This brings the solar unit in a position for beginning the reversals, alternately at  $90^\circ$  to the right and left of the line from the transit station to the sighting point.

In making the reversals, each on the exact plate setting of  $90^\circ$ , correct as necessary, half on the declination tangent motion, half on the lower tangent motion of the transit. When good in both positions, set back to zero on the horizontal plate. Observe the sighting point; if good in the main telescope, the adjustment for parallelism in this latitude is good. If the main telescope is to one side of the sighting point, note which side, and the amount; that will be the discrepancy in parallelism for the latitude of the station.

Ordinarily no change in the adjustment should be made at this stage, nor until it has been demonstrated that there is a consistent discrepancy that can be improved by a "touch up" adjustment. Before doing that analyze the results given by the prime vertical method for parallelism both in this position and in zero latitude to ascertain which of the two points of adjustment can be improved.

(2) To ascertain the index error of the declination arc, suitable for the date, and for the range of the sun's declination in that immediate

period. In this test the solar telescope is set and clamped in zero latitude. The declination arc is set at or near the desired declination.

If the sighting point is in the horizon, the angle to be turned on the plates for the successive reversals will be  $90^\circ \pm \delta$ ; plus for north declination; minus for south declination. If the sighting point is above the horizon, the value of the angle to be turned on the plates should be determined by the equation:  $\cos A = \frac{\sin \delta}{\cos v}$ , "A"

being the horizontal angle counting from the sighting point. The equation gives the right *supplemental value* for the plate angles for the same north or south declination value; over  $90^\circ$  for north declination; less than  $90^\circ$  for south declination.

Start with the main telescope on the sighting point, plate reading at zero, reflector in the direction of the sighting point. On the first check, turn the solar telescope in hour angle, and pick up the sighting point by the tangent motion of the declination arc. On the subsequent reversals, each on the exact plate setting as determined by the equation, correct as necessary, half on the declination tangent motion, half on the lower tangent motion of the transit. When the sighting point is in good position on the reversals, without having to change the tangent motions as described, read the declination arc carefully. The difference between this reading and the value of the declination that was used in the equation is the exact index error for that position in declination; this gives the index error to employ for that date or period.

(3) To ascertain the *instrumental latitude* of the station. The instrumental latitude is the one observed by the solar unit at apparent noon. It may agree with, or it may be slightly more or less than the true latitude. The instrumental latitude is the one to employ in solar orientation, as this value disposes of any possible discrepancy between exact zero setting for latitude (index error at horizontal) and correct reading for the station.

With the instrument carefully levelled and set in the meridian, and having carefully set the declination arc for the sun's noon declination for that date, with refraction duly added to a north declination, or subtracted from a south dec-

lination, and with the index error of the declination arc determined as above explained (2), duly applied to the declination as calculated, bring in the sun at meridian passage with the tangent motion of the latitude arc. The reading of the latitude arc will then be the proper instrumental latitude. This is tested daily in regular field practice.

### Orientation

The solar unit is now ready for p.m. and a.m. tests for orientation, by comparison with a carefully determined meridian. Any discrepancy in (1) will be a constant, as already noted. A discrepancy in either (2) or (3) will result in a variable orientation. (Table 22, Standard Field Tables).

If the field tests (1), (2), and (3) have been carried through successfully, the solar unit should give satisfactory orientation within the Manual tolerance (1'30" during the usual hours), without going through the general adjustments.

The tests for orientation should duplicate actual line practice on the survey. Care in leveling, and close setting of the arcs to the nearest half-minute; everything counts just as in making an altitude observation for azimuth, recalling that the variables in the latter will also be appreciable and can be brought within small limits only by close attention to every element of the observation.

The general adjustments are designed for the instrument assembly in the beginning, and after repairs have been made, or in remounting a solar unit if it has been removed. These give attention to the correct relation of all working parts, good for any latitude. The general tests and adjustments are also made after the return of an instrument at the end of a long season; after cleaning and lubrication; and to ascertain if repairs are required. Again, after repairs have been made, to see that an instrument is ready for field assignment.

Any large discrepancies in the field test (1), (2), and (3), or in the orientation trials, will demonstrate that something is fundamentally wrong in the condition of the solar unit, or in the general adjustment. Ordinarily this will be unusual, indicating that some important detail

has escaped attention. The smaller discrepancies, or residuals, are best taken care of by close attention to the performance, day after day in the tests on the camp meridian, and in the observations that should be made frequently on the lines of the survey to verify the instrumental performance.

A uniform discrepancy in orientation, i.e., always holding about the same amount to the right or left of the meridian, may be traced only to field test (1), to be treated as an index error, or to be corrected by careful touch up adjustment when fully demonstrated.

The variables are more difficult to analyze. Those traceable to either (2) or (3) may be due to poor fitting of the clamps or tangent motions; back lash in the tangent screws; opposing springs not in good order; or a weaving in the tangent motions; these are mechanical difficulties. Another mechanical difficulty, not at all unusual on worn instruments, which will be manifest in variable orientation, may be traced directly to poor fitting of the collar bearings, too snug in a portion of the turn, too loose in places, or not truly round. All other tests may appear to be good, but if the outside equatorial wires may not be spaced equally from the true line of collimation it will establish a residual that is disturbing until fully identified by performance.

### Detail of the Adjustments

The general adjustments of the solar unit should be considered in the following order:

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

(2) The line of sight of the solar telescope must lie in its true turning axis.

(3) The polar axis, or line of sight of the solar telescope, must be normal to the axis of the latitude arc, describe a true vertical plane when turned in latitude, and this plane must be parallel to the vertical plane of the transit.

(4) The latitude arc should read zero when the solar telescope is horizontal, and should be tested for reading true latitude of station.

(5) The declination arc should be tested for reading the true declination of the sun, plus the refraction in polar distance, in all positions.

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

Additionally, tests are required to ascertain:

(7) If the collar bearings are free from inequality or roughness that would cause a displacement in the turning in hour angle from 6 a.m. to 6 p.m., i.e., truly round.

(8) If there is appreciable inequality in the spacing of the equatorial wires.

The above may be termed performance requirements and tests, as distinguished from the maker's adjustments which are designed to accomplish the correct construction and assembly. There are several methods of approach to the general adjustments, all with regard to the same geometric problem wherein each step is intended to bring one element into appropriate relationship with the other parts.

### The Solar Diagram

The general adjustments, and preliminary tests, may be accomplished most readily with the help of the solar diagram, dimensioned for the particular instrument or instruments of that model. The diagram is mounted by means of a board, similar to a plane-table board but held vertically by a bracket, on a light tripod, placed at a measured distance from the instrument, and adjustable to the same H.I. The diagram has the appearance shown below for the arrangement of the lines and the lettering. The letters read normally when viewed through the solar telescope with its inverting eyepiece, and when receiving reflected light rays in certain positions of the tests. See Figure 92. To be placed in pocket.

The measured base is required only for the tests (7) and (8); it may be used also for a check of the transit stadia-wire interval; the same diagram is correct for any model in these particular tests. The base measurement from the vertical axis of the transit to the face of the drawing board is 2.50 chains (165 feet).

The diagram may be placed at any distance for the remaining tests, the conditions being to secure the same H.I., good light, and sharp images, including the reading of the letters, which will appear normal, and will identify the line that is to be used in each test. The several offset lines are placed to conform with the dimensions of one standard model.

The board is to be oriented to face the transit, carefully set to exact right angle with the line of sight, vertical, and moved into the exact H.I. of the transit. The lower horizontal lines then indicate the H.I. of the solar telescope. The "D" and "R" vertical lines show the offset of the solar telescope when in direct and reversed positions measured from the vertical axis of the transit. The lower vertical lines are for testing the declination arc at  $0^\circ$  and at  $15^\circ$  each for north and south declinations. The "X" lines are for testing the parallelism of the telescopes when the solar is set and clamped at latitude  $40^\circ$ .

(1) *The equatorial wires, for parallel to axis of reflector.* With the solar telescope clamped at  $0^\circ$  latitude,  $0^\circ$  in declination, and the transit oriented  $90^\circ$  from the line to the target, pick up the reflected image of the main vertical line. Use the transit tangent motion to bring the central equatorial wire onto the vertical line. Then turn the solar telescope in hour angle. The equatorial wire should follow the central intersection across the field. If not in good adjustment, the solar cross-wire assembly, or reticle, requires a slight rotation to bring it into good position.

The test may be made on the sun, as follows: set up the instrument as in a regular solar observation, setting off the latitude, declination and apparent time; bring the sun's image accurately between the equatorial wires by orienting the transit, in which position the instrument should be clamped. Turn the solar telescope in hour angle, causing the sun's image to travel across the field from side to side. If the image follows the equatorial wires accurately the latter are parallel to the axis of the reflector as required.

If the image departs materially from the equatorial wires, the capstan screws which hold the reticle should be loosened, and the reticle rotated until the equatorial wires are made to agree with the path of the image across the field; then return each capstan to a proper seat.

(2) *Collimation.* With the solar telescope clamped at  $0^\circ$  latitude, make a direct sighting on the solar diagram, using the transit tangent motion to set on the vertical line; the latitude tangent motion to set on the horizontal line.

Turn the solar telescope 12 hours in hour angle; the displacement, if any, on the center intersection, is *double* the error in collimation, in both directions, for the equatorial wires, and for the time wire.

The same test may be made by sighting on a distant point: set the line of sight on a distant point and clamp the instrument. Revolve the solar telescope 12 hours in hour angle. If the line of sight remains fixed on the point it agrees with the turning axis as required. If after revolution, the line of sight appears to be above or below, or to the right or left of the point, one-half of each difference should be taken up with the capstan screws. The test should be repeated. This test and adjustment is similar to collimating the telescope of the Wye level.

As the eyepiece of the solar telescope gives an inverted image, the *direction* for the movement of the reticle to correct for collimation is *apparently to reduce* the error, i.e., if there is appreciable displacement, turn the capstan screws so as to move the reticle in the direction towards the image of the sighting point, both vertical and horizontal. The correction is for *only half the amount* of the displacement. Be very careful not to over-adjust, i.e., not to pass the point of perfect adjustment. Exercise the same precautions as in adjusting the transit telescope for collimation.

(7) and (8) *Collar bearings, and spacing of the equatorial wires.* The next step is to test the spacing of the equatorial wires. These should fit the outside line of the inner circle, spaced on a radius of  $15'45''$ , which is the sun's semi-diameter at the July 1 date. Check carefully for equality of spacing on the two sides.

There is no way to correct an inequality except by the maker. If there is an appreciable inequality, the collimation test should be by the reversal of one outside equatorial wire into the position of the other, rather than on the central point of intersection.

Carefully turn in hour angle, pausing at each hour interval, to check the rotation of the solar telescope in its collar bearings. Any roughness or inequalities will be manifest in the direct sighting on the circle, i.e. the equatorial wires will appear to jump or to be displaced in relation to the circle. If there is appreciable dis-

placement at any point, note the place on the hour circle. There will be a corresponding displacement, or variable, in the orientation tests on the meridian at the same position in hour angle. Irregularities in the collar bearings cannot be corrected in the field.

(3) *The polar axis.* Several steps are combined in this adjustment. The line of collimation should be normal to the latitude axis; the latter should be horizontal; and the plane of the solar line of collimation when moved in latitude should be parallel to the vertical plane of the transit. This makes for general adjustment in any latitude. For just one latitude or area it is only necessary that the line of collimation (as a line, called the *polar axis*) be made parallel to the vertical plane of the transit. The field test (1), preliminary to the test for orientation, heretofore described, takes care of that.

Make a direct sighting of the solar telescope on the D line of the target, first setting the transit telescope on the main vertical line. If the solar telescope points to one side of the D line, note the amount and whether to the right or to the left. Turn the transit 180° and repeat, sighting with the solar telescope in the reversed position. Note the amount that the pointing is to one side of the R line, and whether to the right or to the left. The two pointings now require analysis. For illustration, assume pointings as indicated by diagram "a", Figure 93. To be placed in pocket.

NOTE. First, the diagram projections are in true relation. With the inverting eye-piece (image inverted) the right and left appear reversed, and the image is upside down; Second, if the line of sight is not normal to the latitude axis, the line will describe a *cone* in the reversal.

The short dash line is the normal to the latitude axis; the full line shows the assumed pointings.

Adjust first on the base plate at the foot post that controls the pointing at horizontal sighting; make the correction to the position where the sighting will conform to the full line in diagram "b".

In the projection, the latitude axis will be normal to the vertical plane of the transit (although not necessarily horizontal). The point-

ings should be symmetrical with respect to the D and R lines.

Adjust second at one end of the frame that supports the solar telescope. Make the correction to bring the pointing exactly to the D and R lines, as shown in diagram "c". This brings the line of sight of the solar telescope into normal with the latitude axis.

In using the solar diagram, the adjustment that is required to *bring the latitude axis into horizontal* must be preceded by the test for the zero position of the declination arc, but when that has been accomplished (the declination vernier remaining clamped in that position) then set and clamp the solar telescope in latitude 40°. From this point on, the steps are as previously described for the primary field test (1) to ascertain if the line of collimation of the solar telescope, when set and clamped in the latitude of the station, is parallel to the vertical plane of the transit.

Make the test on the X lines, either a.m. or p.m. position; *reflected light rays* as in regular solar orientation; all clamps set; transit turned 90° from the main line of sight. This setting will be either 6 a.m. or 6 p.m. in hour angle. The adjustment should check in both a.m. and p.m. positions, which accomplishes a reversal of the horizontal axis. The slant of one line of the X represents the direction of the sun's movement at sunrise or sunset, zero declination, 40° latitude. The reflected image of the second line of the X will appear to be horizontal. The intersection is in the same H.I. as the reflector in the line of the polar axis.

When taking the sight, the center equatorial wire will be on, or parallel to, one line of the X, and will follow that line, or continue to be parallel to it, when the solar telescope is turned in hour angle.

The adjustment is good when the center equatorial wire is on the line of the X. If adjustment is required, bring the center equatorial wire to the line of the X; adjust on the base plate at the foot post that controls the position of the latitude axis for true horizontal.

The adjustments at the foot posts on the base plate of the solar unit should now be fully accomplished, or completed except for the slightest "touch up" if and when the need becomes

demonstrated by performance in orientation, and then only to secure final accuracy in the position of the polar axis for parallelism with the vertical plane of the transit.

Note also, that the adjustments on the foot posts should be in final position, or nearly so, before making the test (4) for the index error, if any, in the setting of the *latitude vernier*.

The mechanical construction at the points of contact of the base frame of the solar unit with the *inner* capstans or hexagon nuts at the foot posts is designed to accommodate an adjustment *without straining* the base frame, but care is necessary not to place too much pressure on the points of contact while making adjustments. A strain here will cause difficulty in coming into good position, or a jump in position when the strain is relieved. The safest plan is to ease off the pressure at the point or points that must be relieved in order to make the adjustment, also a slight easing off at the other point or points (including the one at the 90° angle); follow with the adjustment turns; then re-seat with equal pressure at each point.

The statement of the adjustments of the polar axis is intended to show the successive steps that are appropriate when the whole unit requires examination and testing. Later, an explanation will be given for the more rigid test of the polar axis by the prime vertical method. If a residual error is then present, the latter test will show which point of adjustment on the foot posts will control the improvement.

While the statement here may seem involved, the steps are simple enough if taken in proper order. A demonstration by some one experienced in solar transit work will be an aid to those who may need that assistance. The way to accuracy in solar transit orientation, as in all observations for azimuth, is to give close attention to every essential detail.

The latitude axis may be adjusted to horizontal as described in the next paragraph, striding level method, including also the other steps to bring the polar axis into good position, if the solar diagram is not available. Note that the striding level method for this and the next adjustment is applicable only to model A.

Carefully level the transit and then sight the main telescope to a distant point and clamp the

instrument; sight toward the same point with the solar telescope, and place the striding level on the latitude axis. The striding level should be reversed to see if there is any error in the level itself, and if so take the mean position for the true indication of the level.

If the latitude axis is not horizontal it may be made so by adjusting the capstan nuts on the base frame.

If the line of sight of the solar telescope is not parallel to that of the main telescope it may be made parallel by means of the capstan nuts on the base frame of the solar. Next, turn the transit 180° in azimuth and reverse both telescopes so as to sight again to the same distant object, setting the main telescope upon the object. If the solar telescope does not again sight upon the distant object, one-half the error is due to its line of sight's not being at right angles to the axis of the latitude arc. Take up half of the amount of the error by means of the capstan nuts at one end of the solar telescope, and take up half of the error by correcting the capstan nuts on the base frame of the solar. The line of sight should now be normal to the axis of the latitude arc, should describe a vertical plane when turning on said axis, and this should be parallel to the vertical plane of the transit. The tests should be carefully repeated until the adjustments are perfected.

The several steps for the adjustment of the polar axis may be accomplished, and rigidly checked by the prime vertical method, hereinafter described more fully.

(4) *The latitude vernier-Solar diagram.* With the transit carefully leveled, make a direct sighting with the solar telescope; use the latitude tangent motion to bring the central equatorial wire on the lower horizontal lines (hour angle at noon). The reading of the vernier will indicate the index error in zero latitude.

As a rule it is better not to change the vernier setting if the fitting is good and only a small difference exists. The primary field test (3) is made to secure an *instrumental latitude* at the station. Ordinarily that will agree with the true latitude  $\pm$  the index error at 0°, or check this very closely. A discrepancy will appear in case there should be a slight eccentricity in the mounting of the latitude arc on its frame,

i.e., there will be a slight variable in the index error between  $0^\circ$  and the part of the arc as from  $30^\circ$  to  $50^\circ$ .

The test may be made with the striding level as follows: Carefully level the transit, clamp the latitude arc at zero, and place the striding level in position on the solar telescope. The striding level should be reversed to see if there is any error in the level itself, and if so take the mean position for the true indication of the level. If the telescope is not horizontal it may be made so by means of the tangent motion of the latitude arc. When it has been made truly horizontal the reading will indicate the index error of the vernier of the latitude arc. The vernier may be shifted to read zero, or the difference from zero may be carried as an index error.

Without the solar diagram or striding level, the test may be made by first ascertaining a sighting point (or line) in the true horizontal plane of the solar telescope.

(5) *The declination vernier-Solar diagram.* Set and clamp at  $0^\circ$  latitude, and the declination at or near  $0^\circ$ . Set the main telescope on the long vertical line, then turn the transit  $90^\circ$  to the left, and the solar in hour angle to 6 p.m. Pick up the image of the central short vertical line, p.m. position; set the central equatorial wire exactly on that line by the declination tangent motion. Now reverse the transit, oriented  $90^\circ$  to the right of the solar diagram; turn the solar telescope 12 hours in hour angle to the 6 a.m. position. Pick up the image of the central short vertical line, a.m. position; note the central equatorial wire, and if not in coincidence make the correction *half* with the declination tangent motion, *half* with the lower tangent motion of the transit. Repeat the reversals, and the half-and-half corrections until there is coincidence in both a.m. and p.m. positions. The reading of the declination arc will give *the index error, if any, in the setting of the vernier in zero declination.* If the discrepancy is small, and the vernier well fitted, it is usually better not to disturb the adjustment.

On the solar transit constructed between 1914 and 1945 (Model A) the declination arc and vernier are both movable. The arc should not be moved unless necessary to correct for radius, or to correct for concentric position with the axis

of the reflector. The vernier may be shifted as necessary to correct for index error.

On the solar transit constructed between 1937 and 1945 (Model B) the declination arc is fixed in position. The vernier is held in position by two small screws; it may be shifted if necessary.

On the model constructed since 1946 (Model C) the declination arc is permanently seated at proper radius, and proper spacing. It is not intended that this relationship will be disturbed by field adjustment. The vernier is graduated on the declination-vernier arm. The vernier adjustment is controlled at the reflector axis, where the declination-vernier arm is locked in position by three setscrews. The setting is carefully made at the time of construction. It should rarely require attention except at the time of repair by the maker.

When setting the vernier in zero position, a test is made to bring the reflector into an exact  $45^\circ$  with the line of collimation of the solar telescope. The reflector and the tangent-clamp-arm are left clamped in that position.

The first step in making the adjustment is to loosen the three hold-down screws, just enough to allow the declination-vernier arm to be shifted. The reflector position is not disturbed. Next, remove the "dummy" screw that is placed about midpoint of the arm, and in its place insert the special adjusting post (the latter will be found inserted, for safe keeping, near the top of the right standard of the transit). When in position the end of the post projects into a hole in the tangent-clamp-arm. There are two opposing capstan screws in the tangent-clamp-arm which are to be brought into play against the adjusting post.

The parts are now in position for an exact setting of the vernier to zero reading on the declination arc. Two capstan pins are used in opposing movement to accomplish the exact adjustment.

After adjustment, tighten the three hold-down screws at the reflector axis. Back off the two opposing capstan screws. Remove the special adjusting post. Replace the "dummy" screw. Replace the adjusting post for safe keeping. Tighten the two capstan adjusting screws to avoid loss.

Repeat the original test to make sure that the declination clamp held properly during test and that the reflector position was not disturbed from any cause.

The next step is to check the reading at  $15^\circ$  north declination. Proceed in the same manner as above, except to make the turns  $105^\circ$  to the left and right of the solar diagram, and use the N lines in the p.m. and a.m. positions. Record the reading when the reversals indicate true position  $15^\circ$  north declination.

Check again on  $15^\circ$  south declination. The turns are  $75^\circ$  for the S lines.

The arc and vernier are *well mounted* when the index error, if any, runs along the same, or nearly the same in three positions. An appreciable variable will indicate an inaccuracy in the mounting of the declination arc, either in the setting for radius or an element of eccentricity, or both.

The field test (2), preliminary to the test for orientation, heretofore described, will ascertain the index correction in any position of the arc. In field practice it should be determined for the period when the instrument is being used.

A careful analysis of the variables in orientation in actual performance of the instrument during the early a.m. and late p.m. hours will show if the index correction for the declination reading is about right, or if it can be improved slightly. Those periods are best for that check because any slight discrepancy in the reading of the latitude arc, which would be apparent during the 6 or 8 hours of the middle portion of the day, disappears in the early a.m. and late p.m. The check should not be made when too close to sunrise or sunset as the refractions then become large and more or less uncertain.

(6) *The hour circle-Solar diagram.* This adjustment may be made at any stage of the tests after the completion of (1). Make a direct sighting. Bring the time cross wire into coincidence with the long vertical line. In that position the circle should read 12 hours. There is a set screw which holds the graduated circle in position; the circle can be shifted as needed.

Without the solar diagram, make an observation for the meridian passage of the sun. A few minutes before apparent noon set the instrument in the meridian, elevated to the sun's al-

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

### The Prime Vertical Method

A complete adjustment may be accomplished by the prime vertical method. These tests are made by using a distant sighting point, and do not require the solar diagram or the striding levels. Some of the tests are by direct sighting; the remainder are in the positions where the arcs are clamped as in normal orientation, light rays reflected.

The plan is based on the conception of using the solar unit for an observation upon a star when in or passing the prime vertical, equal altitude method, permitting all necessary reversals. A suitable sighting point serves for the star position. It is intended especially for use when duplicating field conditions, and mainly for the touch up adjustments, rather than for running through the general adjustments.

The conditions for the sighting point are that it may give a sharp point that can be seen clearly as a reflected image. If it is a long distance away it may be used as a point in all of the sightings, but if substantially less than one-half mile an allowance should be made for the instrumental offsets as presented in the solar diagram method. A sky-line point may be used under many field conditions, as the station will frequently be remote from a church spire, flag pole, water tower, and such ideal sighting points. If no suitable point can be picked up from the instrument station, a piece of white paper may be tacked up where the light is good. There is no better sighting point than a

small hand-mirror reflecting sunlight from the top of a stake that has been set to hold the position. If the paper sighting point is placed as much as one-fourth mile distant all necessary offsets may be provided by trimming as follows: width between the vertical edges to be double the right-angle offset of the reflector axis counting from the latitude axis; the lower right-and-left corners to be cut off for several inches on an angle from the vertical equal to the latitude of the station. Observe on the vertical edges for tests in the  $0^\circ$  latitude settings; on the slanting edges when the solar telescope is set in the latitude of the station.

(a) The vertical angle counts from the H.I. of the reflector.

(b) To set the correct north declination for the pick-up of the sighting point, solar unit, reflected image, when clamped in the latitude of the station, use the equation:

$$\sin \delta = \sin \phi \sin v$$

(c) To ascertain the horizontal angle, counting from the sighting point, that is to be turned in the tests of the declination arc, more than  $90^\circ$  for north declination, less than  $90^\circ$  for south declination, employ the equation:

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

The purposes and the order of the tests, and in most cases the principles that are involved, have already been set out, included in (1) primary field tests, solar unit in good order; and (2) the general adjustments, solar diagram method, including the alternatives, both with and without the striding levels. These should be understood in principle. The explanations that follow are explicit to the extent that the prime vertical method gives a different approach to the problem.

(1) *The equatorial wires, for parallel to axis of reflector.* Start with the solar telescope clamped in the latitude of the station; the main telescope set on the sighting point, plate reading  $0^\circ$ , reflector in the direction of the sighting point; and a north declination set to the value:  $\sin \delta = \sin \phi \sin v$ ; then turn the transit  $90^\circ$  to the right or left. Pick up the image of the sighting point by turning the solar telescope in hour angle; use the transit lower tangent motion to bring the central equatorial wire onto the

image of the sighting point. Then turn the solar telescope in hour angle. The equatorial wire should follow the image of the sighting point across the field. This is the equivalent of test (1) of the general adjustments.

(2) *Collimation.* Make a direct sighting of the solar telescope on the sighting point; use the transit tangent motion for horizontal movement, the latitude tangent motion for movement in vertical angle. The test and adjustment then become the equivalent of test (2) of the general adjustments.

When the collimation is nearing close adjustment, complete the check by moving over to an outside equatorial wire. Use the transit tangent motion; set the equatorial wires on vertical, one outside wire on the sighting point. In this position the collimation test should be made by the reversal of one outside equatorial wire into the position of the other.

(3) *The polar axis.* Proceed as explained for test (3) of the general adjustments when using the solar diagram. Make the tests with the main telescope set on the sighting point, and direct sights through the solar telescope. The need for an allowance for the offset between the two telescopes depends upon the distance to the sighting point; it may be disregarded if more than one-half mile. In the endeavor to make allowance for an offset, much depends upon the sharpness of the image, the light, and the quality of the solar telescope for optical performance. A low vertical angle to the sighting point is preferred for this adjustment, but any vertical angle up to  $20^\circ$  is fully compensated in the steps that follow. Complete the first and second adjustments as previously explained when using the solar diagram. These two steps will bring the line of sight of the solar telescope into normal with the latitude axis, and the two telescopes substantially parallel at horizontal.

The next step is to check carefully for parallelism at horizontal, and to test (5) the reading of the declination arc in true  $0^\circ$  position.

Set and clamp at  $0^\circ$  latitude, and declination arc at or near  $0^\circ$ . Set the horizontal plate to read  $0^\circ$ , the main telescope on the sighting point, the reflector toward the sighting point. Then turn the transit  $90^\circ$  to the left; the solar in hour angle to late p.m. position. Pick up the

reflected image of the sighting point; set the central equatorial wire on the sighting point by the declination tangent motion. Now reverse the transit, oriented  $90^\circ$  to the right of the sighting point; turn the solar telescope in hour angle to early a.m. position. Again pick up the image of the sighting point. Note the position of the central equatorial wire; if not in coincidence make the correction *half* with the declination tangent motion, *half* with the lower tangent motion of the transit. Repeat the reversals, and the half-and-half corrections until there is coincidence in both a.m. and p.m. positions. *The reading of the declination arc will give the index error, if any, in the setting of the vernier for zero declination.*

Also, now turn back to  $0^\circ$  horizontal plate reading. Observe the sighting point with the main telescope. *The discrepancy here, if any, is the error in parallelism at horizontal.* This shows what final "touch up", if any, may be required at the foot post that controls the pointing at horizontal sighting. If small, as it should be if the direct sighting tests were successfully executed, proceed with the final test for parallelism before changing the adjustment.

Clamp and set the solar telescope in the latitude of the station; then start with the main telescope set on the sighting point, plate reading  $0^\circ$ , reflector in the direction of the sighting point, and declination arc set to the value:  $\sin \delta = \sin \phi \sin v$ . Then turn the transit  $90^\circ$  to the left. Pick up the image of the sighting point by turning the solar telescope in hour angle; use the tangent motion of the declination arc to bring the central equatorial wire onto the image of the sighting point. Now reverse the transit, oriented  $90^\circ$  to the right of the sighting point; turn the solar telescope in hour angle, and again pick up the image of the sighting point. Note the position of the central equatorial wire; if not in coincidence make the correction *half* with the declination tangent motion, *half* with the lower tangent motion of the transit. Repeat the reversals, and the half-and-half corrections, until there is coincidence in both a.m. and p.m. positions. Now turn back to  $0^\circ$  horizontal plate reading. Observe the sighting point with the *main* telescope. *The discrepancy, if*

*any, is the error in parallelism when set in the latitude of the station.*

If the parallelism is good when set in the latitude of the station it is better to let well-enough alone, i.e., no further touch-up adjustment is required. If not quite good, the previous test for parallelism at horizontal will show whether the final touch up should be made at the foot post that controls *the pointing at horizontal sighting*, or if the improvement is required at the foot post which controls *the axis of the latitude arc for horizontal*.

It is believed that this prime vertical method affords the most rigid test and adjustment of *the polar axis* that can be applied.

(4) *The latitude vernier.* The test for the reading of the vernier in true position of zero latitude may be made by direct sighting, first ascertaining a sighting point (or line) in the true horizontal plane of the solar telescope. This is the equivalent of test (4) of the general adjustments. Note also, that the primary field test (3) is made to secure an *instrumental latitude* at the station, which gives the value to be employed in solar orientation.

(5) *The declination vernier.* Note that in the adjustment (3) for the rigid test of the polar axis, one step required and gave an exact determination of the index error or setting of the vernier *for zero declination*. Note also, that the field test (2), preliminary to the test for orientation, is made to ascertain the index correction, if any, in that position of the arc for the period when the instrument is to be used. In field practice this is combined with the test for instrumental latitude. The test of the declination arc in the appropriate order of sequence is called the "prenoon test".

Begin by making a calculation of the sun's declination, for the apparent noon of the date, refraction applied. Then compute the horizontal angle A that is to be employed in making the reversals in this test, using the equation:  $\cos A = \frac{\sin \delta}{\cos v}$ ; in this, "δ" is the calculated noon declination; A will exceed  $90^\circ$  for north declinations; less than  $90^\circ$  for south declinations.

Start the test with the main telescope on the sighting point, plate reading at  $0^\circ$ , reflector in

the direction of the sighting point. On the solar unit, set and clamped in  $0^\circ$  latitude; declination set at or near the desired noon value. On the first check, turn the transit to the left in the amount of the computed horizontal angle  $A$ . Turn the solar telescope in hour angle to late p.m., then pick up the image of the sighting point, set the central equatorial wire exactly on the image of the sighting point by the declination tangent motion. Now orient the transit to the right of the sighting point on the horizontal angle  $A$ ; turn the the solar telescope to the early a.m. position. Pick up the image of the sighting point; note the central equatorial wire; if not in coincidence make the correction *half* with the declination tangent motion, *half* with the lower tangent motion of the transit. Repeat

the reversals, and the half-and-half corrections until there is coincidence in both a.m. and p.m. positions. Now read the declination arc carefully. *This is the right setting of the declination arc for the noon determination of the instrumental latitude.* The discrepancy, if any, between this reading and the value of the declination as computed is the *exact index error for use in that part of the arc.*

(6) *The hour circle.* This is the same test as in the general adjustment (6) when made without the use of the solar diagram. Observe the watch reading and correction in apparent time at the meridian passage of the sun, for comparison with the reading of the hour circle. An altitude observation on the sun for apparent time may be substituted.

*Summary List of Adjustments and Tests for the Transit and Solar Unit:*

*Principal Adjustments and Tests*

Plate levels  
 Cross wires, horizontal and vertical  
 Collimation  
 Horizontal axis  
 Horizontal sighting { single bubble  
                           } reversion bubble  
 Fitting of vernier, vertical circle  
 Zero of vernier at two positions of vertical circle  
 Vert. ang. readings at  $+40^\circ$  and  $-40^\circ$   
 Stadia ratio  
 Needle: pivot, magnetism, and balance

*Tests for Repairs and Reconditioning*

TRANSIT

Centers  
 Focusing movements  
 Collimation, both long and short focus  
 Pivots and bearings  
 Readings, A and B verniers, at intervals of  $30^\circ$   
 Repetition of angles, at  $30^\circ$ ,  $60^\circ$ , and  $90^\circ$   
 Reading of graduations, both circles and verniers (condition)  
 Horizontal and vertical clamps and tangent motions (condition)  
 Leveling screws (condition)  
 Clean and lubricate (condition)

SOLAR UNIT

Equatorial wires, parallel to axis of mirror  
 Collimation  
 Spacing of equatorial wires  
 Line of sight, right angle to latitude axis  
 Latitude axis horizontal  
 Parallel sighting at horizontal  
 Parallel sighting at  $40^\circ$  N.  
 Zero, latitude vernier  
 Reading of latitude arc at  $40^\circ$  N.  
 Zero, declination vernier  
 Reading of declination arc, noon test, latitude known  
 Azimuth tests: a. m. and p. m.

Fitting of telescope in collar bearings  
 Focusing movements  
 True image, direct sighting  
 True image, reflected  
 Fitting of axis of mirror  
 Fitting of latitude arc, vernier, clamp, and tangent motion  
 Fitting of declination arc, vernier, clamp, and tangent motion  
 Reading of graduations, both arcs and verniers (condition)  
 Reading of decl. arc at  $15^\circ$  N. and  $15^\circ$  S.  
 Reading of decl. arc on  $30^\circ$  true hor. ang.  
 Reading of hour circle

Sample Field Notes

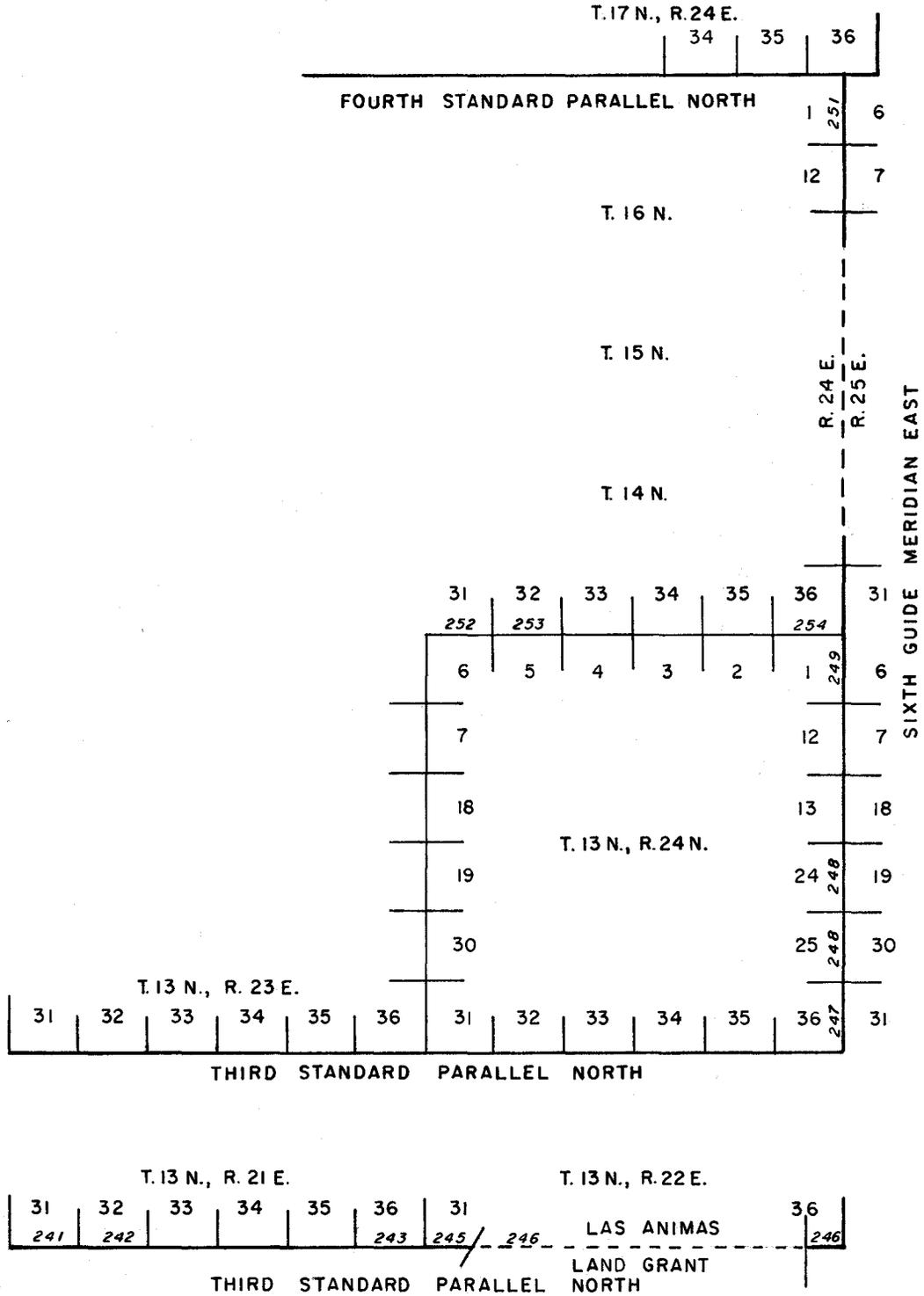
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SPECIMEN  
FIELD NOTES  
OF THE SURVEY OF THE  
THIRD STANDARD PARALLEL NORTH  
ALONG THE SOUTH BOUNDARY OF TOWNSHIP 13 NORTH,  
THROUGH RANGES 21, 22, 23, AND 24 EAST;  
  
THE SIXTH GUIDE MERIDIAN EAST  
THROUGH TOWNSHIPS 13, 14, 15, AND 16 NORTH,  
BETWEEN RANGES 24 AND 25 EAST;  
  
AND THE  
  
WEST AND NORTH BOUNDARIES OF  
TOWNSHIP 13 NORTH, RANGE 24 EAST.

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(Note: Remainder of title omitted.)

INDEX TO SPECIMEN FIELD NOTES



3d Stan. Par. N., S. Bdy. of T. 13 N., R. 21 E., \_\_\_ Mer., (State)

<p>CHAINS</p>	<p>The Third Standard Parallel North, through Range 20 East, was surveyed by Joseph P. Smith in 1884. The Fourth Standard Parallel North, through Range 24 East, was surveyed by John C. Collins in 1887 and was resurveyed by Andrew Porter in 1906.</p> <p>The following field notes describe the survey of the Third Standard Parallel North along the south boundary of Township 13 North, through Ranges 21, 22, 23, and 24 East; the Sixth Guide Meridian East between Ranges 24 and 25 East, through Townships 13, 14, 15, and 16 North; and the west and north boundaries of Township 13 North, Range 24 East.</p> <p>The survey was executed in accordance with the Manual of Surveying Instructions, (Year), and Special Instructions for Group No. ____, (State), dated _____.</p> <p>The directions of lines refer to the true meridian as determined by observations of Polaris, projected by fore- and backsights. Standard lines were chained twice, and the mean of the measurements is given in the field notes.</p> <p>The geographic position of the standard corner of Tps. 13 N., Rs. 24 and 25 E., as scaled from the quadrangle map, "SHEEPSHEAD ROCK," published by the Geological Survey in 1963, is as follows:</p> <p style="padding-left: 40px;">Latitude 36° 59.6' N.      Longitude 104° 38.3' W.</p> <p>The mean magnetic declination is 18° 10' E.</p> <hr/> <p style="text-align: center;">Third Standard Parallel North, on the South Boundary of T. 13 N., R. 21 E., ___ Meridian, (State)</p> <hr/> <p>Beginning at the stan. cor. of Tps. 13 N., Rs. 20 and 21 E., monumented with a granite stone, 12 x 10 x 8 ins. above ground, firmly set, mkd. SC 13N on N, 20E on W, and 21E on E face, from which the original bearing trees</p> <p style="padding-left: 40px;">A yellow pine, 10 ins. diam., bears N. 10° E., 30 lks. dist., with healed blaze.</p> <p style="padding-left: 40px;">A yellow pine, 18 ins. diam., bears N. 25° W., 50 lks. dist., with healed blaze.</p> <p>East, with the establishment of the 3d Stan. Par. N., on the S. bdy. of sec. 31, T. 13 N., R. 21 E., on a transit line describing the secant, which starts from a point 4 lks. South of the Tp. cor., and bears N. 89° 58' E.</p> <p>Over gently rolling land, through scattering timber.</p> <p>28.10 Enter heavy timber, edge bears NW and SE.</p> <p>40.00 Point for the stan. ¼ sec. cor. of sec. 31, North 2 lks. from the secant.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;">SC T 13 N R 21 E ¼ S 31 ----- 1972</p> <p>from which</p>
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## MANUAL OF SURVEYING INSTRUCTIONS

3d Stan. Par. N., S. Bdy. of T. 13 N., R. 21 E., \_\_\_\_\_ Mer., (State)

CHAINS	
	<p>A yellow pine, 10 ins. diam., bears N. <math>64\frac{1}{2}^{\circ}</math> E., 48 lks. dist., mkd. <math>\frac{1}{4}</math> S31 SC BT.</p>
	<p>A blue spruce, 8 ins. diam., bears N. <math>114\frac{1}{4}^{\circ}</math> W., 127 lks. dist., mkd. <math>\frac{1}{4}</math> S31 SC BT.</p>
46.50	Enter clearing, edge bears N. $35^{\circ}$ E. and S. $35^{\circ}$ W.
47.00	Road, dirt, 25 lks. wide, follows edge of clearing.
58.00	SE cor. of cabin, 20 x 10 ft., bears North, 16 chs. dist., long side bears E and W.
63.50	Enter heavy timber, edge bears N and S.
80.00	Point for the stan. cor. of secs. 31 and 32, on the secant.
	<p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p>
	<p style="text-align: center;">SC T 13 N   R 21 E S 31   S 32 ----- 1972</p>
	from which
	<p>A yellow pine, 9 ins. diam., bears N. <math>31\frac{3}{4}^{\circ}</math> E., 22 lks. dist., mkd. T13N R21E S32 SC BT.</p>
	<p>A yellow pine, 8 ins. diam., bears N. <math>67^{\circ}</math> W., 114 lks. dist., mkd. T13N R21E S31 SC BT.</p>
	<p>Land, gently rolling. Soil, loam. Timber, yellow pine and blue spruce, with some juniper; no undergrowth.</p>
	<p>East, on the S. bdy. of sec. 32, on a transit line describing the secant, which bears N. <math>89^{\circ}58.7'</math> E.</p>
	Over rolling land, through heavy timber.
12.00	Begin descent of 60 ft. over NE. slope.
18.40	Turkey Creek, 20 lks. wide, course S. $50^{\circ}$ E.; asc. 175 ft. over broken SW slope.
40.00	Point for the stan. $\frac{1}{4}$ sec. cor. of sec. 32, South 1 lk. from the secant, falls on a sandstone boulder, 7 x 5 x 2 ft. above ground.
	<p>Set a brass tablet, <math>3\frac{1}{4}</math> ins. diam., <math>3\frac{1}{2}</math>-in. stem, in drill hole in boulder, with top mkd.</p>
	<p style="text-align: center;">SC T 13 N R 21 E <math>\frac{1}{4}</math> S 32 ----- 1972</p>
	from which
	<p>A juniper, 8 ins. diam., bears N. <math>33\frac{1}{4}^{\circ}</math> E., 22 lks. dist., mkd. <math>\frac{1}{4}</math> S32 SC BT.</p>
	<p>A juniper, 11 ins. diam., bears N. <math>81\frac{1}{2}^{\circ}</math> W., 192 lks. dist., mkd. <math>\frac{1}{4}</math> S32 SC BT.</p>

3d Stan. Par. N., S. Bdy. of T. 13 N., R. 21 E., \_\_\_\_\_ Mer., (State)

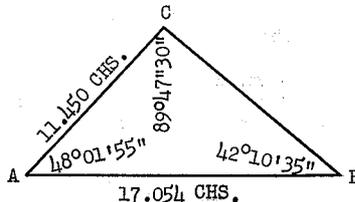
CHAINS 46.20	Top of sandstone rimrock, 12 ft. high, bears N. 45° W. and S. 60° E.; thence over nearly level land.
55.72	A bench mark of the U.S. Geological Survey, published elevation 7,946.987 ft. above mean sea level, bears South, 5.62 chs. dist.; a brass tablet seated in a sandstone boulder, conforming to the Geological Survey record.
80.00	Point for the stan. cor. of secs. 32 and 33, South 2 lks. from the secant.  Set an iron post, 28 ins. long, 2½ ins. diam., 18 ins. in the ground to bedrock, encircled by a mound of stone, 3 ft. base to top of brass cap, mkd.  <div style="text-align: center;">           SC            T 13 N   R 21 E            S 32   S 33            1972         </div>
	from which  A yellow pine, 9 ins. diam., bears N. 43 3/4° E., 27 lks. dist., mkd. T13N R21E S33 SC BT.  A large sandstone outcropping, the highest point of which bears N. 57° 35' W., 87 lks. dist., mkd. X B0.  Land, rolling west of creek; level table land above top of slope east of creek. Soil, rich sandy loam and rocky loam. Timber, mostly juniper, with some yellow pine and blue spruce; undergrowth, sagebrush.
	NOTE. — The field notes of the survey of the S. bdy. of secs. 33, 34, and 35 continue on the same form, and are omitted. The field notes of the survey of the S. bdy. of sec. 36 have been varied in order to show certain other forms of record.
	East, along the S. bdy. of sec. 36, on a transit line describing the secant, which bears S. 89° 58.7' E.  Over level land, through dense undergrowth.
40.00	Point for the stan. ¼ sec. cor. of sec. 36, North 2 lks. from the secant.  Set a sandstone, 24 x 10 x 6 ins., 16 ins. in the ground, mkd. SC ¼ on N face.  Raise a mound of stone, 4 ft. base, 2 ft. high, N of cor.
45.00	Begin gradual descent.
48.92	Bank of Crystal Lake, bears N. 42° E. and S. 37° W.; point for the meander cor. of sec. 36, North 2.4 lks. from the secant.  Set a sandstone, 27 x 8 x 8 ins., 18 ins. in the ground, mkd.  6 grooves on N, MC on E, and 6 grooves on W face.

3d Stan. Par. N., S. Bdy. of T. 13 N., R. 21 E., \_\_\_ Mer., (State)

CHAINS

Raise a mound of stone, 3 ft. base, 2½ ft. high, W of cor.

To determine the dist. across the lake by triangulation: using the above station on the secant as point A, set a flag on the secant on the opposite side of the lake at point B; point C is taken northeasterly on the west side; the dist. from A to C is 11.450 chs.



All angles by 3 repetitions, with a closing error of 0°00'20" balanced to 180°, as follows:

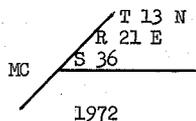
- At point A = 48°01'55"
- At point B = 42°10'35"
- At point C = 89°17'30"

Dist. across lake = 17.054 chs.

65.974 Point B.

66.00 Bank of lake, bears N. 50° E. and S. 45° W.; point for the meander cor. of sec. 36, North 3.3 lks. from the secant.

Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.



from which

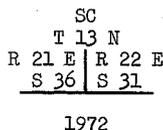
A yellow pine, 8 ins. diam., bears N. 62½° E., 29 lks. dist., mkd. T13N R21E S36 MC BT.

A blue spruce, 14 ins. diam., bears N. 78 3/4° E., 313 lks. dist., mkd. T13N R21E S36 MC BT.

Enter heavy timber, edge bears N. 50° E. and S. 45° W.; asc. 215 ft. over rocky NW slope.

80.00 Point for the stan. cor. of Tps. 13 N., Rs. 21 and 22 E., North 4 lks. from the secant.

Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.



from which

3d Stan. Par. N., S. Bdy. of T. 13 N., R. 21 E., \_\_\_ Mer., (State)

CHAINS	
	<p>A blue spruce, 12 ins. diam., bears N. <math>37\frac{1}{2}^{\circ}</math> E., 114 lks. dist., mkd. T13N R22E S31 SC BT.</p> <p>A blue spruce, 9 ins. diam., bears N. <math>64\frac{3}{4}^{\circ}</math> W., 127 lks. dist., mkd. T13N R21E S36 SC BT.</p> <p>Land, nearly level, west of lake; broken, east of lake. Soil, sandy loam, somewhat rocky east of lake. Timber, blue spruce with some yellow pine and aspen; undergrowth, oak brush.</p>
	<p>Third Standard Parallel North, on the South Boundary of T. 13 N., R. 22 E., ___ Meridian, (State)</p>
	<p>East, with the establishment of the 3d Stan. Par. N., on the S. bdy. of sec. 31, T. 13 N., R. 22 E., on a transit line describing the secant, which starts from a point 4 lks. South of the stan. Tp. cor. and bears N. <math>89^{\circ}58'</math> E.</p> <p>Asc. 65' ft. over rocky NW slope, through heavy timber and scattering clumps of undergrowth.</p>
3.50	Ridge, bears N. $60^{\circ}$ E. and S. $60^{\circ}$ W.; desc. 240 ft. over SE slope.
22.30	Base of ridge, bears N. $65^{\circ}$ E. and S. $65^{\circ}$ W.; descent becomes gradual.
38.40	Point for the witness stan. $\frac{1}{4}$ sec. cor. of sec. 31, North 2.1 lks. from the secant.
	<p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <p>WC SC T 13 N R 22 E <math>\frac{1}{4}</math> S 31 → 1972</p> </div> <p>from which</p> <p>A yellow pine, 9 ins. diam., bears North, 16 lks. dist., mkd. X BT.</p> <p>A yellow pine, 10 ins. diam., bears N. <math>57\frac{1}{2}^{\circ}</math> W., 92 lks. dist., mkd. X BT.</p>
40.00	True point for the stan. $\frac{1}{4}$ sec. cor. of sec. 31, falls at center of stream, 60 lks. wide, course N. $70^{\circ}$ E., where it is impracticable to establish a permanent monument; asc. gradually over bottom land.
54.96	Intersect W. bdy. of the Las Animas Land Grant, North 1.2 lks. from the secant; point for the closing cor. of sec. 31, T. 13 N., R. 22 E.
	<p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <p>T 13 N R 22 E S 31 CC ——— LA PL ——— LG 1972</p> </div>

## MANUAL OF SURVEYING INSTRUCTIONS

3d Stan. Par. N., S. Bdy. of T. 13 N., R. 22 E., \_\_\_ Mer., (State)

CHAINS	
392.78	<p>from which</p> <p>A yellow pine, 11 ins. diam., bears N. 22 3/4° W., 57 lks. dist., mkd. T13N R22E S31 CC BT.</p> <p>A yellow pine, 7 ins. diam., bears N. 7 1/2° W., 135 lks. dist., mkd. T13N R22E S31 CC BT.</p> <p>From this point the 14th Mi. Cor. of the grant bdy. bears N. 33°38' E., 27.84 chs. dist., monumented with a sandstone, 16 x 12 x 6 ins. above the top of a mound of stone, 5 ft. base, 3 ft. high, mkd. 14M on NW and 14 LG on SE face.</p> <p>From the same point the 15th Mi. Cor. of the grant bdy. bears S. 33°38' W., 51.96 chs. dist., occupied by the original cor. tree, a yellow pine, 34 ins. diam., with healed blazes on NW and SE sides, from which the original bearing trees</p> <p>A yellow pine, 20 ins. diam., bears N. 10° E., 15 lks. dist., with healed blaze.</p> <p>A yellow pine, 15 ins. diam., bears S. 50° E., 10 lks. dist., with healed blaze.</p> <p>Land, gently rolling and broken. Soil, sandy loam. Timber, yellow pine; undergrowth, sagebrush.</p> <hr/> <p>Continue the secant on a blank line across the grant.</p> <p>Intersect E. bdy. of the Las Animas Land Grant, North 2.4 lks. from the secant; point for the closing cor. of sec. 36, T. 13 N., R. 22 E.</p> <p>Set a sandstone, 32 x 10 x 8 ins., 22 ins. in the ground, mkd.</p> <p>13 N on N, CC 22E and 1 groove on E, and 14 LG on W face.</p> <p>Raise a mound of stone, 2 ft. base, 1 1/2 ft. high, E of cor.</p> <p>From this point the 7th Mi. Cor. of the grant bdy. bears S. 0°42' E., 19.12 chs. dist., monumented with a sandstone boulder, 8 x 5 x 3 ft. above ground, mkd. + 7M, from which the original bearing trees</p> <p>A yellow pine, 12 ins. diam., bears N. 75° E., 15 lks. dist., with healed blaze.</p> <p>A yellow pine, 14 ins. diam., bears S. 30° W., 20 lks. dist., with healed blaze.</p> <p>From the same point the 8th Mi. Cor. of the grant bdy. bears N. 0°42' W., 60.62 chs. dist., monumented with a sandstone, 12 x 8 x 6 ins. above ground, firmly set, mkd. 14 LG on W and 8M on E face, with a mound of stone, 3 ft. base, 2 ft. high, W of cor.</p> <hr/> <p>Thence East, on the S. bdy. of sec. 36, on a transit line describing the secant, which bears S. 89°58.3' E. and counting measurement (47.74 chs.) from the theoretical point for the stan. cor. of secs. 35 and 36.</p> <p>Over nearly level land.</p>

3d Stan. Par. N., S. Bdy. of T. 13 N., R. 22 E., \_\_\_ Mer., (State)

CHAINS 80.00	<p>Point for the stan. cor. of Tps. 13 N., Rs. 22 and 23 E., North ¼ lks. from the secant.</p> <p>Set a sandstone, 36 x 10 x 8 ins., 2¼ ins. in the ground, mkd.</p> <p style="padding-left: 40px;">SC 13N on N, 23E on E, and 22E on W face.</p> <p>Raise a mound of stone, 5 ft. base, 3 ft. high, N of cor.</p> <p>Land, nearly level. Soil, sandy loam with many small stones. No timber or undergrowth.</p>				
	<p>NOTE.— The field notes of the survey of the 3d Stan. Par. N., on the S. bdy. of Tps. 13 N., Rs. 23 and 24 E., continue on the same form and are omitted.</p>				
	<p style="text-align: center;">MEMORANDUM</p> <p>The form of the record of the survey of a standard parallel by the tangent method is similar to that of the specimen field notes describing the secant method. If the solar transit method is used, the line will conform to the parallel without the making of offsets.</p> <p>A summary description of the region crossed by a standard parallel is supplied at the close of the field notes, or the information may be carried in the general description of the subdivisional survey.</p>				
	<p style="text-align: center;">Sixth Guide Meridian East, Through T. 13 N., Between Rs. 24 and 25 E., ___ Meridian, (State)</p>				
	<p>From the stan. cor. of Tps. 13 N., Rs. 24 and 25 E.</p> <p>North, with the establishment of the 6th Guide Mer. E., through T. 13 N., bet. Rs. 24 and 25 E.</p> <p>Over nearly level land.</p>				
40.00	<p>Point for the ¼ sec. cor. of secs. 31 and 36.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 2¼ ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <p>T 13 N</p> <p>¼</p> <p>↓</p> <table style="margin: auto;"> <tr> <td>R 24 E</td> <td>R 25 E</td> </tr> <tr> <td>S 36</td> <td>S 31</td> </tr> </table> <p>↓</p> <p>1972</p> </div> <p>Dig pits, 18 x 18 x 12 ins., N and S of iron post, 3 ft. dist.</p>	R 24 E	R 25 E	S 36	S 31
R 24 E	R 25 E				
S 36	S 31				
43.50	<p>Begin gradual ascent.</p>				
67.00	<p>Top of ascent; enter heavy timber, edge bears NE and SW; desc. over gradual NW slope.</p>				
80.00	<p>Point for the cor. of secs. 25, 30, 31, and 36.</p>				

MANUAL OF SURVEYING INSTRUCTIONS

6th G.M. East, T. 13 N., bet. Rs. 24 and 25 E., \_\_\_ Mer., (State)

CHAINS	<p>Set a sandstone, 24 x 10 x 6 ins., 16 ins. in the ground, mkd. with 5 notches on N and 1 notch on S edge.</p> <p>from which</p> <p style="padding-left: 40px;">A juniper, 10 ins. diam., bears N. 64 3/4° E., 70 lks. dist., mkd. T13N R25E S30 BT.</p> <p style="padding-left: 40px;">A juniper, 12 ins. diam., bears S. 69 3/4° E., 44 lks. dist., mkd. T13N R25E S31 BT.</p> <p style="padding-left: 40px;">A juniper, 10 ins. diam., bears S. 79 1/2° W., 59 lks. dist., mkd. T13N R24E S36 BT.</p> <p style="padding-left: 40px;">A juniper, 20 ins. diam., bears N. 74 3/4° W., 220 lks. dist., mkd. T13N R24E S25 BT.</p> <p>Land, level and gently rolling. Soil, sandy loam, and rocky. Timber, juniper and pinon; undergrowth, sagebrush.</p>																
21.50	<p>North, bet. secs. 25 and 30.</p> <p>Desc. gradually through heavy timber.</p> <p>Road, ungraded, 20 lks. wide, bears NW and SE, from Fort Meyer to Valley City.</p>																
23.20	<p>Arroyo, drains SW; asc. 100 ft. over SE slope.</p>																
40.00	<p>Point for the 1/4 sec. cor. of secs. 25 and 30.</p> <p>Set a sandstone, 21 x 8 x 6 ins., 14 ins. in the ground, mkd. 1/4 on W face.</p> <p>from which</p> <p style="padding-left: 40px;">A juniper, 8 ins. diam., bears N. 60 1/4° E., 28 lks. dist., mkd. 1/4 S30 BT.</p> <p style="padding-left: 40px;">A juniper, 11 ins. diam., bears West, 89 lks. dist., mkd. 1/4 S25 BT.</p>																
64.20	<p>Top of ascent; leave timber, edge bears N. 60° W. and S. 60° E.; desc. gradually.</p>																
76.00	<p>Arroyo, drains S. 65° W.; asc. 50 ft. to sec. cor.</p>																
80.00	<p>Point for the cor. of secs. 19, 24, 25, and 30.</p> <p>Set an iron post, 28 ins. long, 2 1/2 ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center; margin: 10px 0;"> <table style="margin: auto; border-collapse: collapse;"> <tr> <td colspan="4">T 13 N</td> </tr> <tr> <td style="border-right: 1px solid black; border-bottom: 1px solid black;">R 24 E</td> <td style="border-bottom: 1px solid black;">R 25 E</td> <td colspan="2"></td> </tr> <tr> <td style="border-right: 1px solid black;">S 24</td> <td>S 19</td> <td colspan="2"></td> </tr> <tr> <td style="border-right: 1px solid black; border-bottom: 1px solid black;">S 25</td> <td style="border-bottom: 1px solid black;">S 30</td> <td colspan="2"></td> </tr> </table> <p>1972</p> </div> <p>Raise a mound of stone, 4 ft. base, 2 ft. high, W of cor.</p> <p>Land, broken and rolling. Soil, sandy loam, and rocky. Timber, juniper and pinon; undergrowth, sagebrush.</p>	T 13 N				R 24 E	R 25 E			S 24	S 19			S 25	S 30		
T 13 N																	
R 24 E	R 25 E																
S 24	S 19																
S 25	S 30																
	<p>North, bet. secs. 19 and 24.</p> <p>Asc. over broken land.</p>																

6th G.M. East, T. 13 N., bet. Rs. 24 and 25 E., \_\_\_ Mer., (State)

<p>CHAINS 2.10</p>	<p>Top of ascent; enter scattering timber and dense undergrowth; edge bears E and W.</p>						
<p>40.00</p>	<p>Point for the <math>\frac{1}{4}</math> sec. cor. of secs. 19 and 24.</p> <p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <p>T 13 N <math>\frac{1}{4}</math></p> <table style="margin: auto;"> <tr> <td>R 24 E</td> <td>R 25 E</td> </tr> <tr> <td>S 24</td> <td>S 19</td> </tr> </table> <p>1972</p> </div> <p>Raise a mound of stone, 4 ft. base, 2 ft. high, W of cor.</p>	R 24 E	R 25 E	S 24	S 19		
R 24 E	R 25 E						
S 24	S 19						
<p>56.00</p>	<p>Leave scattering timber; edge bears E and W.</p>						
<p>64.20</p>	<p>Arroyo, drains N. <math>60^\circ</math> W.; asc. 85 ft. to sec. cor.</p>						
<p>80.00</p>	<p>Point for the cor. of secs. 13, 18, 19, and 24.</p> <p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <p>T 13 N</p> <table style="margin: auto;"> <tr> <td>R 24 E</td> <td>R 25 E</td> </tr> <tr> <td>S 13</td> <td>S 18</td> </tr> <tr> <td>S 24</td> <td>S 19</td> </tr> </table> <p>1972</p> </div> <p>Raise a mound of stone, 4 ft. base, 2 ft. high, W of cor.</p> <p>Land, broken. Soil, sandy loam, and rocky. Timber, scattering pinon; undergrowth, sagebrush.</p>	R 24 E	R 25 E	S 13	S 18	S 24	S 19
R 24 E	R 25 E						
S 13	S 18						
S 24	S 19						
<p>NOTE.— The field notes of the survey of the line bet. secs. 13 and 18, and bet. secs. 7 and 12, continue on the same form and are omitted.</p>							
<p>7.90</p>	<p>North, bet. secs. 1 and 6.</p> <p>Desc. 40 ft. over broken NE slope, through dense undergrowth.</p> <p>Road, graded, 25 lks. wide, bears N. <math>80^\circ</math> W. and S. <math>80^\circ</math> E., from Fort Meyer to Douglass Post Office.</p>						
<p>9.10</p>	<p>Right bank of the South Fork Trapper River, course S. <math>80^\circ</math> E.; banks 2 to 6 ft. high; water at present low stage from 1 to 3 ft. deep; point for the meander cor. of secs. 1 and 6.</p> <p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <p>MC</p> <table style="margin: auto;"> <tr> <td>S 1</td> <td>S 6</td> </tr> <tr> <td>R 24 E</td> <td>R 25 E</td> </tr> <tr> <td colspan="2">T 13 N</td> </tr> </table> <p>1972</p> </div>	S 1	S 6	R 24 E	R 25 E	T 13 N	
S 1	S 6						
R 24 E	R 25 E						
T 13 N							

MANUAL OF SURVEYING INSTRUCTIONS

6th G.M. East, T. 13 N., bet. Rs. 24 and 25 E., \_\_\_ Mer., (State)

CHAINS																						
	<p>Raise a mound of stone, 4 ft. base, 2 ft. high, S of cor.</p> <p>Dist. across river by steel tape measurement, 4.60 chs.</p>																					
13.70	<p>Left bank of the South Fork Trapper River; point for the meander cor. of secs. 1 and 6.</p> <p>Set a washed flint boulder; 32 x 14 x 8 ins., 24 ins. in the ground, mkd.</p> <p style="padding-left: 40px;">1 groove on N, 6 grooves on E, MC on S, and 6 grooves on W face.</p> <p>Raise a mound of stone, 5 ft. base, 3 ft. high, N of cor.</p> <p>Asc. 160 ft. over broken S slope.</p>																					
29.80	<p>Ridge, bears E and W; desc. 60 ft. through scattering timber, edge bears E and W.</p>																					
40.00	<p>Point for the <math>\frac{1}{4}</math> sec. cor. of secs. 1 and 6, falls on a sandstone boulder, 8 x 5 x 2 ft. above ground.</p> <p>Set a brass tablet, <math>3\frac{1}{4}</math> ins. diam., <math>3\frac{1}{2}</math>-in. stem, in drill hole in boulder, with top mkd.</p> <div style="text-align: center; margin: 10px 0;"> <table style="border-collapse: collapse; margin: auto;"> <tr><td></td><td style="text-align: center;">T 13 N</td><td></td></tr> <tr><td></td><td style="text-align: center;"><math>\frac{1}{4}</math></td><td></td></tr> <tr><td style="text-align: center;">R 24 E</td><td style="border-left: 1px solid black; border-right: 1px solid black; text-align: center;"> </td><td style="text-align: center;">R 25 E</td></tr> <tr><td style="text-align: center;">S 1</td><td style="border-left: 1px solid black; border-right: 1px solid black; text-align: center;"> </td><td style="text-align: center;">S 6</td></tr> <tr><td></td><td></td><td></td></tr> <tr><td></td><td style="text-align: center;">1972</td><td></td></tr> </table> </div> <p>from which</p> <p style="padding-left: 40px;">A pinon, 8 ins. diam., bears S. <math>54\ 3/4^\circ</math> E., 297 lks. dist., mkd. <math>\frac{1}{4}</math> S6 BT.</p> <p style="padding-left: 40px;">A juniper, 9 ins. diam., bears S. <math>65^\circ</math> W., 84 lks. dist., mkd. <math>\frac{1}{4}</math> S1 BT.</p>		T 13 N			$\frac{1}{4}$		R 24 E		R 25 E	S 1		S 6					1972				
	T 13 N																					
	$\frac{1}{4}$																					
R 24 E		R 25 E																				
S 1		S 6																				
	1972																					
46.60	<p>Arroyo, drains N. <math>75^\circ</math> E.; continue over nearly level land.</p>																					
67.50	<p>Leave scattering timber; edge bears E and W.</p>																					
80.00	<p>Point for the cor. of Tps. 13 and 14 N., Rs. 24 and 25 E.</p> <p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center; margin: 10px 0;"> <table style="border-collapse: collapse; margin: auto;"> <tr><td></td><td style="text-align: center;">T 14 N</td><td></td></tr> <tr><td style="text-align: center;">R 24 E</td><td style="border-left: 1px solid black; border-right: 1px solid black; text-align: center;"> </td><td style="text-align: center;">R 25 E</td></tr> <tr><td style="text-align: center;">S 36</td><td style="border-left: 1px solid black; border-right: 1px solid black; text-align: center;"> </td><td style="text-align: center;">S 31</td></tr> <tr><td style="text-align: center;">S 1</td><td style="border-left: 1px solid black; border-right: 1px solid black; text-align: center;"> </td><td style="text-align: center;">S 6</td></tr> <tr><td></td><td></td><td></td></tr> <tr><td></td><td style="text-align: center;">T 13 N</td><td></td></tr> <tr><td></td><td style="text-align: center;">1972</td><td></td></tr> </table> </div> <p>Raise a mound of stone, 5 ft. base, 3 ft. high, S of cor.</p> <p>Land, southern portion broken, balance level. Soil, sandy loam, and rocky. Timber, juniper and pinon; undergrowth, sagebrush.</p>		T 14 N		R 24 E		R 25 E	S 36		S 31	S 1		S 6					T 13 N			1972	
	T 14 N																					
R 24 E		R 25 E																				
S 36		S 31																				
S 1		S 6																				
	T 13 N																					
	1972																					

6th G.M. East, T. 16 N., bet. Rs. 24 and 25 E., \_\_\_ Mer., (State)

CHAINS	
	<p>NOTE.— The field notes of the survey of the 6th Guide Mer. E., through Tps. 14, 15, and 16 N., bet. Rs. 24 and 25 E. continue on the same form, and all but the last mile are omitted.</p>
	<p>North, bet. secs. 1 and 6.</p> <p>Asc. 25 ft. along broken W slope, through heavy juniper and pinon timber and dense undergrowth.</p>
3.00	Spur, slopes W; desc. slightly along steep W slope.
12.70	Gulch, course S. 30° W.; asc. 350 ft. along W slope; timber changes to mostly pine.
29.80	Spur, slopes SW; continue ascent of 125 ft. along steep W slope.
40.00	Point for the ¼ sec. cor. of secs. 1 and 6.
	<p>Set an iron post, 28 ins. long, 2½ ins. diam., 12 ins in the ground to bedrock, and in a mound of stone, 8 ft. base, 1½ ft. high, with brass cap mkd.</p>
	<p style="text-align: center;">T 16 N  <math>\frac{1}{4}</math>  R 24 E   R 25 E  S 1   S 6  1972</p>
	<p>from which</p> <p>A yellow pine, 14 ins. diam., bears S. 36 ¾° E., 54 lks. dist., mkd. ¼ S6 BT.</p> <p>A yellow pine, 12 ins. diam., bears S. 72¼° W., 96 lks. dist., mkd. ¼ S1 BT.</p> <p>Corner falls in a small wash which drains SW. Asc. slightly.</p>
41.00	Spur, slopes W; desc. 125 ft. along W slope.
44.20	Deep draw, drains W; asc. 300 ft. over steep SW slope.
57.00	Top of steep ascent; asc. gradually.
67.00	Divide bet. South Fork and North Fork Trapper River, bears East and S. 75° W.; desc. 225 ft. over NW slope.
81.44	Intersect the Fourth Standard Parallel North; point for the closing cor. of Tps. 16 N., Rs. 24 and 25 E.
	<p>Set an iron post, 28 ins. long, 2½ ins. diam., 12 ins. in the ground to bedrock, encircled by a mound of stone, 4 ft. base, to top of brass cap, mkd.</p>
	<p style="text-align: center;">T 17 N R 24 E  S 36  —  S 1   S 6  R 24 E   R 25 E  T 16 N  CC  1972</p>
	<p>from which</p>

## MANUAL OF SURVEYING INSTRUCTIONS

6th G.M. East, T. 16 N., bet. Rs. 24 and 25 E., \_\_\_ Mer., (State)

## CHAINS

A juniper, 12 ins. diam., bears S.  $33\frac{1}{4}^{\circ}$  E.,  
58 lks. dist., mkd. T16N R25E S6 CC BT.

A yellow pine, 9 ins. diam., bears S.  $72\frac{3}{4}^{\circ}$  W.,  
129 lks. dist., mkd. T16N R24E S1 CC BT.

From this point the stan.  $\frac{1}{4}$  sec. cor. on the S. bdy. of  
sec. 36, T. 17 N., R. 24 E., bears S.  $89^{\circ}56'$  E., 12.76  
chs. dist., monumented with a sandstone, 12 x 8 x 6 ins.  
above ground, firmly set, mkd.  $\frac{1}{4}$  on N face, with a mound  
of stone, 3 ft. base, 2 ft. high, N of cor.

From the same point the stan. cor. of secs. 35 and 36,  
T. 17 N., R. 24 E., bears N.  $89^{\circ}56'$  W., 27.18 chs. dist.,  
monumented with a sandstone, 14 x 8 x 8 ins. above the  
top of a mound of stone, 4 ft. base, 2 ft. high, mkd. with  
1 groove on E and 5 grooves on W face, with a mound of  
stone, 3 ft. base, 2 ft. high, N of cor.

Land, mountainous.  
Soil, sandy and rocky.  
Timber, yellow pine, juniper, and pinon; undergrowth,  
service and oak brush.

## MEMORANDUM

A summary description of the region crossed by a  
guide meridian is supplied at the end of the field notes,  
or it may be included in the general description of the  
subdivisional survey.

(West Boundary of T. 13 N., R. 24 E.)

NOTE.— The field notes of the survey of a meridi-  
onal township boundary ordinarily take the form of the  
specimen field notes of the 6th Guide Meridian East, with  
only one set of measurements. The specimen field notes  
for the survey of this boundary are omitted.

North Boundary of T. 13 N., R. 24 E.,  
\_\_\_ Meridian, (State)

NOTE.— Latitudinal township boundaries are general-  
ly run by the random and true method, but the random line  
is not described in the field notes unless required for  
some special circumstance. Detail of the random line is  
given here to show the form.

May 19, 1972, at the cor. of Tps. 13 and 14 N., Rs. 24  
and 25 E., in latitude  $37^{\circ}04.8'$  N., and longitude  
 $104^{\circ}38.3'$  W., as computed by reference to the values  
given for the stan. cor. of Tps. 13 N., Rs. 24 and 25 E.,  
turn  $90^{\circ}$  from flag point previously located on the 6th  
Guide Meridian East, and run

West, on a random line, making proper offsets to the north  
from the tangent to the parallel at intervals of 40.00  
chs., setting temp.  $\frac{1}{4}$  sec. and sec. cors. on the line bet.  
Tps. 13 and 14 N., R. 24 E. At 479.25 chs. the parallel  
falls 25 lks. South of the cor. of Tps. 13 and 14 N., Rs.  
23 and 24 E. The correction is 4.2 lks. North per mile,  
counting from the point of beginning.

Thence S.  $89^{\circ}58'$  E., bet. secs. 6 and 31, marking and  
blazing the true line.

## APPENDIX

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N. Bdy. of T. 13 N., R. 24 E., \_\_\_ Mer., (State)

CHAINS	
	Asc. over SW slope, through dense growth of sagebrush.
30.25	Ridge, bears N. 15° E. and S. 15° W.
34.00	Head of draw, drains S.
39.25	Point for the ¼ sec. cor. of secs. 6 and 31. Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.  <div style="text-align: center;">           T 14 N R 24 E                S 31            ¼ ——— S 6                T 13 N              1972         </div>
	Raise a mound of stone, 5 ft. base, 3 ft. high, N of cor.
46.90	Ridge, bears N. 15° E. and S. 15° W.; desc. 100 ft. over gradual E slope.
77.50	Draw, drains NE; asc. gradually.
79.25	Point for the cor. of secs. 5, 6, 31, and 32. Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.  <div style="text-align: center;">           T 14 N R 24 E            S 31   S 32            ———   ———            S 6   S 5              T 13 N              1972         </div>
	Raise a mound of stone, 4 ft. base, 2 ft. high, W of cor. Land, rolling mountainous. Soil, sandy. No timber; heavy cover of sagebrush.
	S. 89° 58' E., bet. secs. 5 and 32. Over rolling N slope, changing to E slope; through dense growth of sagebrush.
29.50	Gulch, drains SE; asc. to spur.
35.50	Spur, slopes S; leave sagebrush and enter scattering timber; desc. gradually.
40.00	Point for the ¼ sec. cor. of secs. 5 and 32. Set a sandstone, 24 x 8 x 6 ins., 16 ins. in the ground, mkd. ¼ on N face. Dig pits 18 x 18 x 12 ins., E and W of stone, 3 ft. dist.
44.50	Draw, drains S; asc. gradually.
53.00	Top of slope; desc. 50 ft. to creek.
60.00	Crooked Wash Creek, dry, 30 lks. wide, course S. 20° W.; asc. 150 ft.
77.00	Ridge, bears N and S; desc. gradually to cor.

## MANUAL OF SURVEYING INSTRUCTIONS

N. Bdy. of T. 13 N., R. 24 E., \_\_\_ Mer., (State)

<p>CHAINS 80.00</p>	<p>Point for the cor. of secs. 4, 5, 32, and 33.</p> <p>Set a sandstone, 20 x 10 x 8 ins., 13 ins. in the ground, mkd. with 4 notches on E and 2 notches on W edge</p> <p>from which</p> <p style="padding-left: 40px;">A juniper, 20 ins. diam., bears N. 36° W., 423 lks. dist., mkd. T14N R24E S32 BT.</p> <p>No other suitable bearing trees available.</p> <p>Raise a mound of stone, 4 ft. base, 2 ft. high, W of cor.</p> <p>Land, rolling mountainous. Soil, sandy and rocky. Timber, scattering juniper; undergrowth, sagebrush.</p>
	<p>NOTE.— The field notes of the survey of the line bet. secs. 4 and 33, 3 and 34, and 2 and 35 continue on the same form and are omitted.</p>
	<p>S. 89°58' E., bet. secs. 1 and 36.</p> <p>Desc. gradually through heavy pinon timber and dense undergrowth.</p>
11.40	<p>Road, graded, 25 lks. wide, bears N. 55° W. and S. 55° E., from Fort Meyer to Douglass Post Office.</p>
16.20	<p>Right bank of the South Fork Trapper River, course S. 50° E.; banks 2 to 5 ft. high, water at present low stage from 1 to 3 ft. deep; point for the meander cor. of secs. 1 and 36.</p>
	<p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p>
	<div style="text-align: center;"> <p>1972</p> </div>
	<p>from which</p> <p style="padding-left: 40px;">A juniper, 14 ins. diam., bears N. 76¼° W., 142 lks. dist., mkd. T14N R24E S36 MC BT.</p> <p style="padding-left: 40px;">A juniper, 10 ins. diam., bears S. 21 3/4° W., 98 lks. dist., mkd. T13N R24E S1 MC BT.</p> <p>Width of river about 4.50 chs.; dist. across on line by steel tape measurement, 7.15 chs.</p>
23.35	<p>Left bank of the South Fork Trapper River; point for the meander cor. of secs. 1 and 36.</p> <p>Set a washed flint boulder, 28 x 16 x 8 ins., 21 ins. in the ground, mkd.</p> <p style="padding-left: 40px;">6 grooves on N, 1 groove on E, 6 grooves on S, and MC on W face.</p> <p>Raise a mound of stone, 5 ft. base, 3 ft. high, E of cor.</p>

N. Bdy. of T. 13 N., R. 24 E., \_\_\_ Mer., (State)

CHAINS	
40.00	<p>Asc. 150 ft. over broken SW slope, through scattering pinon timber.</p> <p>Point for the <math>\frac{1}{4}</math> sec. cor. of secs. 1 and 36.</p> <p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <p>T 14 N R 24 E</p> <p><math>\frac{1}{4}</math> <math>\frac{S\ 36}{S\ 1}</math></p> <p>T 13 N</p> <p>1972</p> </div> <p>from which</p> <p style="padding-left: 40px;">A pinon, 9 ins. diam., bears S. <math>29\frac{1}{2}^{\circ}</math> W., 387 lks. dist., mkd. <math>\frac{1}{4}</math> S1 BT.</p> <p>Raise a mound of stone, 4 ft. base, 2 ft. high, N of cor.</p>
45.70	<p>Ridge and edge of heavy timber, bear NW and SE; desc. 35 ft.; timber changes to pine, spruce, and fir.</p>
65.20	<p>Base of slope and edge of timber, bear NW and SE; leave timber; continue over nearly level land.</p>
80.00	<p>The cor. of Tps. 13 and 14 N., Rs. 24 and 25 E.</p> <p>Land, mostly broken; eastern part nearly level. Soil, sandy loam, and rocky. Timber, juniper, pinon, yellow pine, blue spruce, and fir; undergrowth, sagebrush.</p>
<p>MEMORANDUM</p> <p>A summary description of the region crossed by the township exteriors is supplied at the close of the field notes except where it may be included in the general description of the subdivisional survey.</p>	

SPECIMEN  
FIELD NOTES  
OF THE SURVEY OF THE  
SUBDIVISIONAL AND MEANDER LINES  
OF  
TOWNSHIP 15 NORTH, RANGE 20 EAST,  
  
Of the PRINCIPAL Meridian  
In the State of MONTANA

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EXECUTED BY

Robert Acres, Cadastral Surveyor

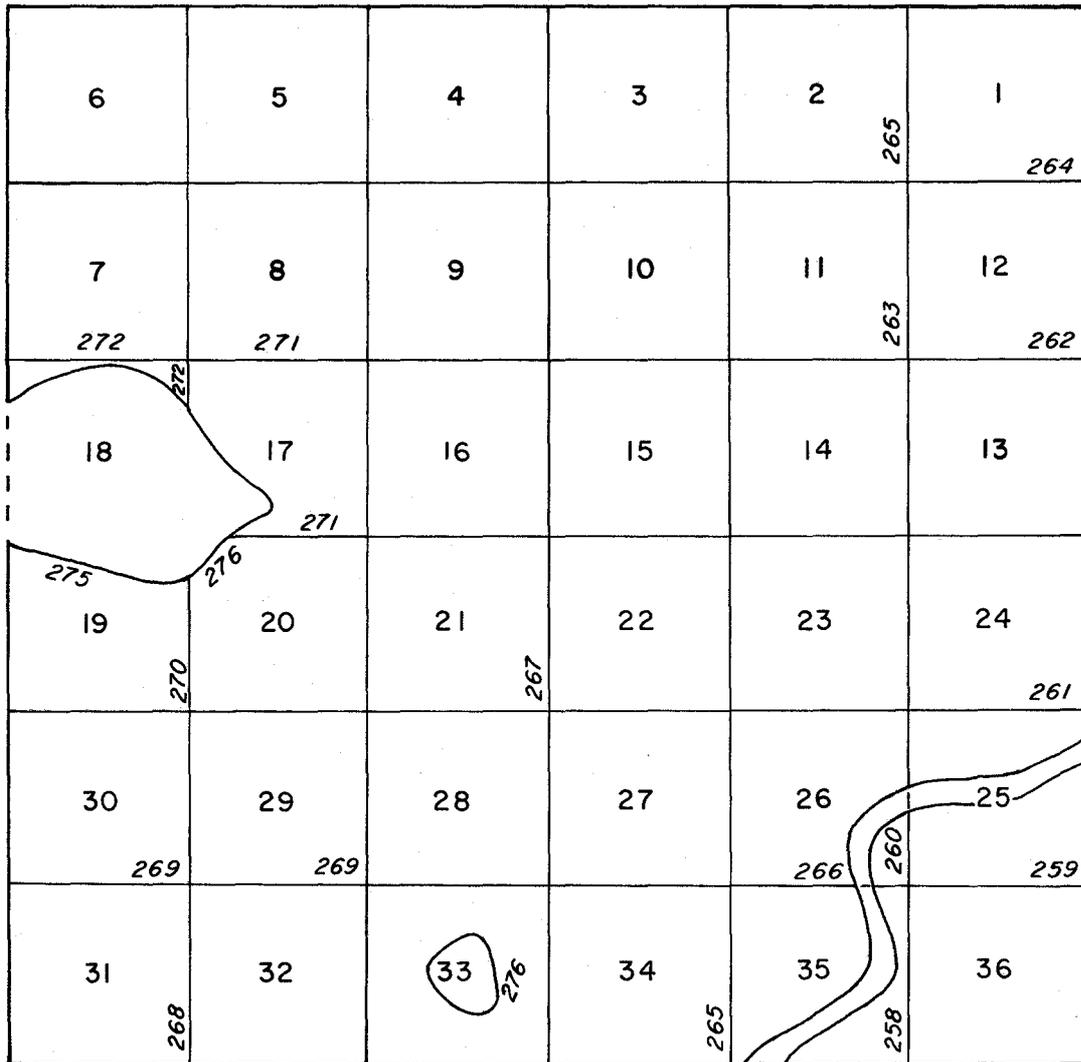
Under special instructions dated April 1, 1972, which provided for the surveys included under Group Number 123, approved April 10, 1972, and assignment instructions dated May 20, 1972.

Survey commenced June 1, 1972

Survey completed June 30, 1972

INDEX TO SPECIMEN FIELD NOTES

T. 15 N., R. 20 E.



- Ivy Island \_\_\_\_\_ page 272
- Diamond Rock \_\_\_\_\_ page 274
- Lake City Townsite \_\_\_\_\_ page 278

## MANUAL OF SURVEYING INSTRUCTIONS

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS	
	<p>The boundaries of the township have been established by earlier surveys as follows:</p> <p>The north boundary was surveyed by _____ in _____.  The south and east boundaries were surveyed by _____  in _____. The west boundary was surveyed by _____ in _____.</p> <p>The following field notes are those of the survey of the subdivisional lines and meander lines of Township 15 North, Range 20 East, Principal Meridian, Montana.</p> <p>The survey was executed in accordance with specifications set forth in the Manual of Surveying Instructions, 1972, and the Special Instructions for Group No. 123, dated April 1, 1972.</p> <p>The directions of lines were determined by the solar transit method and by means of lines projected by fore- and backsights from azimuths obtained by direct solar observations or observations on Polaris.</p> <p>The geographic position of the southeast corner of the township as determined by a tie to the United States Coast and Geodetic Survey triangulation station "FLAT TOP" is as follows:</p> <p style="text-align: center;">Latitude 45°45.4' N. Longitude 107°54.3' W.</p> <p>The mean magnetic declination is 18°10' E.</p>
	<p>Beginning at the cor. of secs. 1, 2, 35, and 36, on the S. bdy. of the Tp., monumented with a sandstone, 8 x 6 x 5 ins. above ground, firmly set, mkd. with 1 notch on E and 5 notches on W edge, from which the original bearing trees</p> <p style="padding-left: 40px;">A sawed cottonwood stump, 14 ins. diam., bears N. 10° E., 25 lks. dist., with the marks T15N visible on opened blaze.</p> <p style="padding-left: 40px;">A cottonwood, 10 ins. diam., bears S. 55° E., 10 lks. dist., with healed blaze.</p> <p style="padding-left: 40px;">A green ash, 13 ins. diam., bears S. 35° W., 33 lks. dist., with fragmentary scribe marks visible on open and partly rotted blaze.</p> <p style="padding-left: 40px;">A cottonwood, 12 ins. diam., bears N. 25° W., 50 lks. dist., with healed blaze.</p> <p>Raise a mound of stone, 3 ft. base, 2 ft. high, W of cor.</p> <p>N. 0°01' W., bet. secs. 35 and 36.</p> <p>Over level bottom land.</p>
20.00	Enter scattering timber; edge bears N and S.
29.30	SE cor. of field; leave scattering timber.
31.50	NE cor. of cabin, 15 x 12 ft., bears West, 6.15 chs. dist.; long side bears N. 10° E. and S. 10° W.
39.50	Enter State Highway No. 25, 35 lks. wide, bears North along sec. line, and East.
40.00	Point for the ¼ sec. cor. of secs. 35 and 36.

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS					
	<p>Bury a granite stone, 12 x 12 x 12 ins., mkd. X, 2 ft. below surface of highway, from which</p> <p style="padding-left: 40px;">An iron post, 28 ins. long, 2½ ins. diam., set 24 ins. in the ground, for a reference monument, bears East, 46 lks. dist., with brass cap mkd. ¼ S36 RM 1972 and an arrow pointing to the cor.</p> <p style="padding-left: 40px;">An iron post, 28 ins. long, 2½ ins. diam., set 24 ins. in the ground, for a reference monument, bears West, 46 lks. dist., with brass cap mkd. ¼ S35 RM 1972 and an arrow pointing to the cor.</p>				
51.50	Leave highway, bears N. 70° W. and South.				
57.50	Enter heavy timber and dense undergrowth, edge bears N. 54° E. and S. 54° W.				
72.00	Leave undergrowth; continue through heavy timber.				
80.00	Point for the cor. of secs. 25, 26, 35, and 36.				
	<p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <p>T 15 N R 20 E</p> <table style="margin: auto; border-collapse: collapse;"> <tr> <td style="border-right: 1px solid black; padding: 0 5px;">S 26</td> <td style="padding: 0 5px;">S 25</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 0 5px;">S 35</td> <td style="padding: 0 5px;">S 36</td> </tr> </table> <p>1972</p> </div> <p>from which</p> <p style="padding-left: 40px;">A green ash, 13 ins. diam., bears N. 22° E., 26 lks. dist., mkd. T15N R20E S25 BT.</p> <p style="padding-left: 40px;">A green ash, 23 ins. diam., bears S. 71½° E., 37 lks. dist., mkd. T15N R20E S36 BT.</p> <p style="padding-left: 40px;">A green ash, 17 ins. diam., bears S. 64° W., 41 lks. dist., mkd. T15N R20E S35 BT.</p> <p style="padding-left: 40px;">A cottonwood, 13 ins. diam., bears N. 21¼° W., 36 lks. dist., mkd. T15N R20E S26 BT.</p> <p>Land, level bottom; northern 20 chs. subject to overflow. Soil, alluvial, silt and loam. Timber, green ash and cottonwood; undergrowth, willow.</p>	S 26	S 25	S 35	S 36
S 26	S 25				
S 35	S 36				
	<p>From the cor. of secs. 25, 30, 31, and 36, on the E. bdy. of the Tp., monumented with a sandstone, 8 x 5 x 5 ins. above ground, firmly set, mkd. with 1 notch on S and 5 notches on N edge, from which the original bearing tree</p> <p style="padding-left: 40px;">A green ash, 20 ins. diam., bears S. 15° E., 32 lks. dist., with healed blaze.</p> <p>N. 89°56' W., bet. secs. 25 and 36.</p> <p>Over level bottom land, through scattering timber.</p>				
16.20	Cherry Creek, 12 lks. wide, course NW.				
39.98	<p>Point for the ¼ sec. cor. of secs. 25 and 36.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p>				

MANUAL OF SURVEYING INSTRUCTIONS

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS	
	<p>T 15 N R 20 E</p> $\frac{1}{4} \begin{array}{c} S 25 \\ S 36 \end{array}$ <p>1972</p> <p>from which</p> <p>A green ash, 8 ins. diam., bears N. <math>64 \frac{3}{4}^{\circ}</math> W., 124 lks. dist., mkd. <math>\frac{1}{4}</math> S25 BT.</p> <p>A green ash, 7 ins. diam., bears S. <math>65 \frac{1}{4}^{\circ}</math> W., 189 lks. dist., mkd. <math>\frac{1}{4}</math> S36 BT.</p>
79.96	<p>The cor. of secs. 25, 26, 35, and 36.</p> <p>Land, level, mostly subject to overflow. Soil, alluvial, silt and loam. Timber, green ash and cottonwood; undergrowth, willow.</p>
25.36	<p>N. <math>0^{\circ}01'</math> W., bet. secs. 25 and 26.</p> <p>Over level bottom land, through heavy timber.</p> <p>Right bank of Yellowstone River, course N. <math>81^{\circ}</math> E.; banks 2 to 12 ft. high; water is high at present stage and from 1 to 8 ft. deep; point for the meander cor. of secs. 25 and 26.</p> <p>Set an iron post, 28 ins. long, <math>2 \frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <p>MC</p> <p style="margin-left: 40px;">S 26   S 25</p> <p style="margin-left: 40px;">T 15 N   R 20 E</p> <p style="margin-left: 40px;">1972</p> </div> <p>from which</p> <p>A cottonwood, 12 ins. diam., bears S. <math>18 \frac{1}{4}^{\circ}</math> E., 16 lks. dist., mkd. T15N R20E S25 MC BT.</p> <p>A green ash, 11 ins. diam., bears S. <math>74 \frac{1}{2}^{\circ}</math> W., 25 lks. dist., mkd. T15N R20E S26 MC BT.</p> <p>Dist. across river 24.10 chs. by triangulation.</p> <p style="text-align: center;">[Detail omitted]</p>
49.46	<p>Left bank of Yellowstone River; point for the meander cor. of secs. 25 and 26.</p> <p>Set a washed granite boulder, 34 x 9 x 7 ins., 24 ins. in the ground, mkd.</p> <p style="margin-left: 40px;">5 grooves on N, 1 groove on E, MC on S, and 5 grooves on W face</p> <p>from which</p>

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS

A green ash, 10 ins. diam., bears N.  $34\frac{1}{4}^{\circ}$  E.,  
228 lks. dist., mkd. T15N R20E S25 MC BT.

Raise a mound of stone, 5 ft. base, 3 ft. high, N of cor.

Enter scattering timber, edge bears N.  $81^{\circ}$  E. and  
S.  $81^{\circ}$  W.

52.60 Top of bluff, 20 ft. high, bears E and W; leave timber.

63.80 Telephone line, bears E and W.

80.00 Point for the cor. of secs. 23, 24, 25, and 26.

Set an iron post, 28 ins. long,  $2\frac{1}{2}$  ins. diam., 24 ins.  
in the ground, with brass cap mkd.

T 15 N R 20 E

S 23	S 24
S 26	S 25

1972

Dig pits, 18 x 18 x 12 ins., in each sec., 3 ft. dist.

Land, nearly level; 52 chs. bottom land subject to over-  
flow.

Soil, alluvial, silt and loam, and sandy.

Timber, green ash and cottonwood; undergrowth, willow.

From the cor. of secs. 19, 24, 25, and 30, on the E. bdy.  
of the Tp., monumented with a sandstone, 12 x 9 x 5 ins.,  
loosely set at the E side of a small mound of stone, poorly  
mkd. with 4 notches on N and 2 notches on S edge.

At the corner point

Set an iron post, 28 ins. long,  $2\frac{1}{2}$  ins. diam., 24 ins.  
in the ground, with brass cap mkd.

T 15 N  
R 20 E | R 21 E  
S 24 | S 19  
S 25 | S 30

1972

Raise a mound of stone, 3 ft. base, 2 ft. high, W of cor.

Bury the mkd. stone alongside the iron post.

N.  $89^{\circ}55'$  W., bet. secs. 24 and 25.

Over level land.

38.00 NE cor. of Fletcher's service station, bears South, 8.03  
chs. dist.

39.99 Point for the  $\frac{1}{4}$  sec. cor. of secs. 24 and 25.

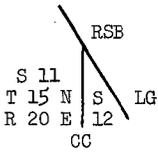
Set an iron post, 28 ins. long,  $2\frac{1}{2}$  ins. diam., 24 ins.  
in the ground, with brass cap mkd.

## MANUAL OF SURVEYING INSTRUCTIONS

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS	
	<p style="text-align: center;">T 15 N R 20 E</p> <p style="text-align: center;"><math>\frac{1}{4} \frac{S 24}{S 25}</math></p> <p style="text-align: center;">1972</p> <p>Dig pits, 18 x 18 x 12 ins., E and W of post, 3 ft. dist.</p>
70.00	U.S. Highway No. 87, 40 lks. wide, bears N. 73° W. and S. 73° E.
79.98	The cor. of secs. 23, 24, 25, and 26.
	<p>Land, level. Soil, sandy. No timber or undergrowth.</p>
	<p>NOTE. — The field notes continue in the regular order and in the same form; the record of 3 miles omitted.</p>
	<p>From the cor. of secs. 7, 12, 13, and 18, on the E. bdy. of the Tp., monumented with a sandstone, 8 x 8 x 5 ins. above ground, firmly set, mkd. with 2 notches on N and 4 notches on S edge, with a mound of stone, 2 ft. base, 1½ ft. high, W of cor.</p> <p>N. 89°52' W., bet. secs. 12 and 13.</p> <p>Over nearly level land.</p>
31.49	<p>Intersect the NE bdy. of the Rancho San Blas grant.</p> <p>Point for the closing cor. of secs. 12 and 13.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p>
	<p style="text-align: center;"> </p>
	<p>Raise a mound of stone, 3 ft. base, 2 ft. high, E of cor.</p> <p>From this point the 5th Mi. Cor. of the grant bdy. bears S. 33°00' E., 7.00 chs. dist., monumented with a limestone, 15 x 8 x 5 ins. above ground, firmly set, mkd. RSB LG on W and 5 M on E face, with a mound of stone, 2 ft. base, 1½ ft. high, SW of cor.</p> <p>Thence on a blank line across the grant.</p>
40.015	Point for the ¼ sec. cor. of secs. 12 and 13; no permanent monument established.
67.07	<p>Intersect the SW bdy. of the grant.</p> <p>Point for the closing cor. of secs. 12 and 13.</p> <p>Set a granite stone, 25 x 7 x 6 ins., 16 ins. in the ground, mkd.</p>

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS	
	<p>2 grooves on N, RSB LG on E, 4 grooves on S, and CC and 6 grooves on W face.</p> <p>Raise a mound of stone, 2 ft. base, 1½ ft. high, W of cor.</p> <p>From this point the ¾ Mi. Cor. of the grant bdy. bears N. 19°30' W., 12.00 chs. dist., monumented with a flint stone, 12 x 8 x 6 ins. above ground, firmly set, mkd. RSB LG on E and ¾ M on W face, with a mound of stone, 2 ft. base, 1½ ft. high, NE of cor.</p> <p>The closing cor. is located on the top of a ridge bearing N. 15° W. and S. 15° E.; thence over rough, rocky ground.</p>
76.00	Begin descent over broken SW slope.
80.03	The cor. of secs. 11, 12, 13, and 14.
	Land, eastern part, level; western part, mountainous.
	Soil, sandy loam and rocky.
	No timber or undergrowth.
	N. 0°01' W., bet. secs. 11 and 12.
	Asc. over broken SW slope.
11.00	Top of ascent, bears N. 50° W. and S. 50° E.; thence over nearly level land.
36.60	Intersect the SW bdy. of the Rancho San Blas grant.
	Point for the closing cor. of secs. 11 and 12.
	Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.
	
	1972
	from which
	A juniper, 20 ins. diam., bears S. 34¼° W.,
	484 lks. dist., mkd. T15N R20E S11 CC BT.
	Raise a mound of stone, 2 ft. base, 1½ ft. high, S of cor.
	From this point Cor. No. 7 of the grant bdy. bears
	N. 19°30' W., 7.40 chs. dist., monumented with a granite
	boulder, 6 x 4 x 1½ ft. above ground, mkd. COR 7 RSB LG
	on E face, with a mound of stone, 2 ft. base, 1½ ft.
	high, NE of cor.
	Thence on a blank line across the grant.
40.00	Point for the ¼ sec. cor. of secs. 11 and 12; no permanent monument established.
44.32	Intersect the NW bdy. of the grant.
	Point for the closing cor. of secs. 11 and 12.

## MANUAL OF SURVEYING INSTRUCTIONS

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS	
	<p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 15 ins. in the ground to bedrock, encircled by a mound of stone, <math>\frac{1}{4}</math> ft. base, to top, with brass cap mkd.</p> <p style="text-align: center;">CC</p> <p style="text-align: center;">T 15 N   R 20 E S 11   S 12</p> <p style="text-align: center;">RSB LG</p> <p style="text-align: center;">1972</p> <p>Deposit a granite stone, 10 x 7 x 6 ins., mkd. X, alongside the iron post, as a memorial.</p> <p>From this point Cor. No. 7 of the grant bdy. bears S. <math>73^{\circ}00'</math> W., 2.58 chs. dist., previously described.</p> <p>Thence over rolling ground.</p>
60.80	Creek, 6 lks. wide, course SE.
80.00	Point for the cor. of secs. 1, 2, 11, and 12.
	<p>Set a granite stone, 24 x 10 x 7 ins., 16 ins. in the ground, mkd. with 1 notch on E and 5 notches on S edge.</p> <p>Raise a mound of stone, 2 ft. base, <math>1\frac{1}{2}</math> ft. high, W of cor.</p> <p>Land, mountainous and rolling. Soil, sandy clay and rocky. Timber, a few scattering junipers; no undergrowth.</p>
	<p>From the cor. of secs. 1, 6, 7, and 12, on the E. bdy. of the Tp., monumented with a burr oak, 12 ins. diam., with healed blazes on NE, SE, SW, and NW sides, and with a mound of stone, 2 ft. base, <math>1\frac{1}{2}</math> ft. high, W of cor.</p> <p>N. <math>89^{\circ}49'</math> W., bet. secs. 1 and 12.</p> <p>Over rolling land.</p>
3.50	Enter grove of heavy timber, edge bears N and S. $20^{\circ}$ W.
18.07	A burr oak, 12 ins. diam., on line, mkd. with two hacks each, on E and W sides.
40.02	Point for the $\frac{1}{4}$ sec. cor. of secs. 1 and 12.
	<p>Set a granite stone, 28 x 11 x 9 ins., 18 ins. in the ground, mkd. <math>\frac{1}{4}</math> on N face</p> <p>from which</p> <p style="padding-left: 40px;">A burr oak, 9 ins. diam., bears N. <math>19\frac{1}{2}^{\circ}</math> W., 22 lks. dist., mkd. <math>\frac{1}{4}</math> S1 BT.</p> <p style="padding-left: 40px;">A burr oak, 11 ins. diam., bears S. <math>65\frac{3}{4}^{\circ}</math> W., 129 lks. dist., mkd. <math>\frac{1}{4}</math> S12 BT.</p>
41.10	Ravine, course S. $20^{\circ}$ W.
49.60	Ravine, course S. $30^{\circ}$ W.
69.00	Leave timber, edge bears NE and SE.
80.04	The cor. of secs. 1, 2, 11, and 12.

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS	Land, rolling mountainous. Soil, sandy clay and rocky. Timber, burr oak; no undergrowth.				
	N. 0° 02' E., bet. secs. 1 and 2. Desc. slightly over rolling land.				
40.00	Point for the ¼ sec. cor. of secs. 1 and 2.  Set a limestone, 20 x 10 x 6 ins., 13 ins. in the ground, mkd. ¼ on W face.  Raise a mound of stone, 3 ft. base, 2 ft. high, W of cor.				
49.30	Arroyo, course N. 70° E.				
79.77	Intersect N. bdy. of the Tp. at the cor. of secs. 1, 2, 35, and 36, monumented with a limestone, 16 x 6 x 5 ins., loosely set, mkd. with 1 notch on E and 5 notches on W edge, with a small mound of stone, 2 ft. base, 1½ ft. high, W of cor.  At the cor. point  Set an iron post, 28 ins. long, 2½ ins. diam., 10 ins. in the ground to bedrock, encircled by a mound of stone, 4 ft. base, to top, with brass cap mkd.				
	<div style="text-align: center;"> <p>T 16 N R 20 E</p> <table border="1" style="margin: auto;"> <tr> <td>S 35</td> <td>S 36</td> </tr> <tr> <td>S 2</td> <td>S 1</td> </tr> </table> <p>T 15 N</p> <p>1972</p> </div>	S 35	S 36	S 2	S 1
S 35	S 36				
S 2	S 1				
	Bury the marked stone alongside the iron post.  Land, rolling mountainous. Soil, sandy clay. No timber or undergrowth.				
	From the cor. of secs. 2, 3, 34, and 35, on the S. bdy. of the Tp., monumented with a sandstone, 14 x 8 x 8 ins. above ground, firmly set, mkd. with 2 notches on the E and 4 notches on the W edge, with a mound of stone, 2 ft. base, 1½ ft. high, W of cor.				
	N. 0° 02' W., bet. secs. 34 and 35.				
	Over level bottom land.				
40.00	Point for the ¼ sec. cor. of secs. 34 and 35.  Set a sandstone, 28 x 10 x 8 ins., 21 ins. in the ground, mkd. ¼ on W face.  Raise a mound of stone, 4 ft. base, 3 ft. high, W of cor.				
42.00	Leave bottom land, edge bears N. 70° E. and S. 70° W.; asc. sandy ridge.				
46.00	Top of windblown sandy ridge, bears N. 70° E. and S. 70° W.				
50.00	Foot of sandy ridge; thence over nearly level land.				

## MANUAL OF SURVEYING INSTRUCTIONS

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS					
80.00	<p>Point for the cor. of secs. 26, 27, 34, and 35.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., in a concrete form, 8 ins. upper diam., 14 ins. lower diam., 30 ins. long, 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <p>T 15 N R 20 E</p> <table border="1" style="margin: auto;"> <tr> <td>S 27</td> <td>S 26</td> </tr> <tr> <td>S 34</td> <td>S 35</td> </tr> </table> <p>1972</p> </div> <p>Bury a sandstone, 8 x 8 x 6 ins., mkd. X, at N side of concrete monument.</p> <p>Land, south half, level bottom subject to overflow; north half, level sandy plain. Soil, alluvial, silt and loam. No timber or undergrowth.</p>	S 27	S 26	S 34	S 35
S 27	S 26				
S 34	S 35				
	<p>S. 89°57' E., on a random line bet. secs. 26 and 35.</p>				
40.00	<p>Set temp. ¼ sec. cor.</p>				
48.13	<p>Left bank of river; set temp. meander cor.</p> <p>Dist. across river 18.19 chs. by triangulation.</p>				
	<p>[Details omitted]</p>				
66.32	<p>Right bank of river; set temp. meander cor.</p>				
80.06	<p>Fall 3 lks. South of cor. of secs. 25, 26, 35, and 36.</p> <hr style="width: 20%; margin: 10px auto;"/> <p>Thence N. 89°58' W., on true line bet. secs. 26 and 35.</p> <p>Over level bottom land, through heavy timber.</p>				
13.74	<p>Right bank of Yellowstone River, course N. 20° W.; banks 2 to 10 ft. high; water is high at present stage and from 1 to 8 ft. deep; point for the meander cor. of secs. 26 and 35.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <p>T 15 N</p> <table border="1" style="margin: auto;"> <tr> <td>S 26</td> </tr> <tr> <td>S 35</td> </tr> </table> <p>R 20 E</p> <p>1972</p> </div> <p>from which</p> <p>A green ash, 9 ins. diam., bears N. 49½° E., 26 lks. dist., mkd. T15N R20E S26 MC BT.</p> <p>A cottonwood, 13 ins. diam., bears S. 38½° E., 21 lks. dist., mkd. T15N R20E S35 MC BT.</p>	S 26	S 35		
S 26					
S 35					
31.93	<p>Left bank of Yellowstone River; point for the meander cor. of secs. 26 and 35.</p>				

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS	
	<p>Set a washed granite boulder, 40 x 12 x 8 ins., 30 ins. in the ground, mkd.</p> <p>5 grooves on N, MC on E, 1 groove on S, and 5 grooves on W face.</p> <p>Raise a mound of stone, 5 ft. base, 3 ft. high, W of cor.</p> <p>Asc. gradually through scattering timber.</p>
37.50	<p>Leave timber.</p>
40.03	<p>Point for the <math>\frac{1}{4}</math> sec. cor. of secs. 26 and 35.</p> <p>Set a granite stone, 24 x 12 x 8 ins., 16 ins. in the ground, mkd. <math>\frac{1}{4}</math> on N face, from which</p> <p>A green ash, 14 ins. diam., bears N. 28 <math>\frac{3}{4}</math>° E., 328 lks. dist., mkd. <math>\frac{1}{4}</math> S26 BT.</p> <p>A green ash, 9 ins. diam., bears S. 78° E., 278 lks. dist., mkd. <math>\frac{1}{4}</math> S35 BT.</p>
70.50	<p>State Highway No. 25, 35 lks. wide, bears N. 68° W. and S. 68° E.</p>
80.06	<p>The cor. of secs. 26, 27, 34, and 35.</p> <p>Land, east of river, level bottom subject to overflow; west of river, level upland. Soil, alluvial, silt and loam. Timber, green ash and cottonwood; undergrowth, willow.</p>
<p>NOTE.— The field notes continue in the regular order and in the same form; the record of 13 miles is omitted.</p>	
<p>N. 0°03' W., bet. secs. 21 and 22.</p> <p>Over level land.</p>	
13.90	<p>Enter marsh, edge bears N. 60° E. and N. 80° W.</p>
40.00	<p>Point for the <math>\frac{1}{4}</math> sec. cor. of secs. 21 and 22.</p> <p>Set a brass tablet, <math>3\frac{1}{4}</math> ins. diam., <math>3\frac{1}{2}</math>-in. stem, in a cylindrical concrete form, 30 ins. long, 6 ins. diam., 24 ins. in the ground, with top mkd.</p> <p style="text-align: center;">T 15 N R 20 E   <math>\frac{1}{4}</math>   S 21   S 22   1972</p> <p>Set a creosoted wood post, 7 ft. long, 8 x 6 ins. cross section, 3 ft. in ground, at W side of concrete monument.</p>
53.60	<p>Leave marsh, edge bears N. 30° W. and S. 60° E.</p>
80.00	<p>Point for the cor. of secs. 15, 16, 21, and 22.</p>

## MANUAL OF SURVEYING INSTRUCTIONS

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS

Set a brass tablet,  $3\frac{1}{4}$  ins. diam.,  $3\frac{1}{2}$ -in. stem, in a concrete form, 8 ins. upper diam., 1 $\frac{1}{4}$  ins. lower diam., 30 ins. long, 2 $\frac{1}{4}$  ins. in the ground, with top mkd.

T 15 N R 20 E

S 16	S 15
S 21	S 22

1972

No suitable bearing trees or bearing objects available within limits.

Land, level; swamp and overflowed, 39.70 chs.  
Soil, rich loam.  
No timber or undergrowth.

NOTE.— The field notes continue in the regular order and in the same form; the record of 17 miles is omitted.

From the cor. of secs. 5, 6, 31, and 32, on the S. bdy. of the Tp., monumented with a limestone, 15 x 8 x 6 ins., lying on the surface at E side of a small mound of stone, poorly marked with 5 notches on one edge and 1 notch on the opposite edge.

At the corner point

Set an iron post, 28 ins. long, 2 $\frac{1}{2}$  ins. diam., 2 $\frac{1}{4}$  ins. in the ground, with brass cap mkd.

T 15 N R 20 E

S 31	S 32
S 6	S 5

T 14 N

1972

Raise a mound of stone, 4 ft. base, 2 ft. high, W of cor.

Bury the mkd. stone alongside the iron post.

N. 0°05' W., bet. secs. 31 and 32.

Over level land.

40.00 Point for the  $\frac{1}{4}$  sec. cor. of secs. 31 and 32.

Set a brass tablet,  $3\frac{1}{4}$  ins. diam.,  $3\frac{1}{2}$ -in. stem, in a cylindrical concrete form, 36 ins. long, 6 ins. diam., 2 $\frac{1}{4}$  ins. in the ground, with top mkd.

T 15 N R 20 E

$\frac{1}{4}$	
S 31	S 32

1972

Bury 6 fragments of blue crockery at the base of the concrete monument.

80.00 Point for the cor. of secs. 29, 30, 31, and 32.

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS					
14.50	<p>Set an iron post, 28 ins. long, 2½ ins. diam., 2¼ ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;">T 15 N R 20 E</p> <table style="margin-left: auto; margin-right: auto;"> <tr> <td style="border-right: 1px solid black; padding: 0 5px;">S 30</td> <td style="padding: 0 5px;">S 29</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 0 5px;">S 31</td> <td style="padding: 0 5px;">S 32</td> </tr> </table> <p style="text-align: center;">1972</p> <p>Raise a mound of stone, 3 ft. base, 2 ft. high, W of cor.</p> <p>Land, level. Soil, sandy. No timber or undergrowth.</p>	S 30	S 29	S 31	S 32
S 30	S 29				
S 31	S 32				
16.50	<p>From the cor. of secs. 28, 29, 32, and 33.</p> <p>N. 89°54' W., bet. secs. 29 and 32.</p> <p>Over level land.</p>				
28.50	<p>Base of slope, edge bears N. 30° E. and S. 30° W.</p>				
39.98	<p>Top of slope.</p> <p>Spring, bears South, 2.50 chs. dist.</p> <p>Point for the ¼ sec. cor. of secs. 29 and 32.</p> <p>Set a brass tablet, 3¼ ins. diam., 3½ in. stem, in a cylindrical concrete form, 30 ins. long, 6 ins. diam., 2¼ ins. in the ground, with top mkd.</p> <p style="text-align: center;">T 15 N R 20 E</p> <table style="margin-left: auto; margin-right: auto;"> <tr> <td style="border-right: 1px solid black; padding: 0 5px;">¼</td> <td style="padding: 0 5px;">S 29</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 0 5px;"></td> <td style="padding: 0 5px;">S 32</td> </tr> </table> <p style="text-align: center;">1972</p>	¼	S 29		S 32
¼	S 29				
	S 32				
79.96	<p>Bury a cast-iron stove lid, 8 ins. diam., ½ in. thick, at the base of the concrete monument.</p> <p>The cor. of secs. 29, 30, 31, and 32.</p> <p>Land, level. Soil, sandy. No timber or undergrowth.</p>				
40.00	<p>N. 89°57' W., bet. secs. 30 and 31.</p> <p>Over level land.</p> <p>Point for the ¼ sec. cor. of secs. 30 and 31.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 2¼ ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;">T 15 N R 20 E</p> <table style="margin-left: auto; margin-right: auto;"> <tr> <td style="border-right: 1px solid black; padding: 0 5px;">¼</td> <td style="padding: 0 5px;">S 30</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 0 5px;"></td> <td style="padding: 0 5px;">S 31</td> </tr> </table> <p style="text-align: center;">1972</p> <p>Dig pits, 18 x 18 x 12 ins., E and W of cor., 3 ft. dist.</p>	¼	S 30		S 31
¼	S 30				
	S 31				

## MANUAL OF SURVEYING INSTRUCTIONS

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS									
78.35	<p>Intersect the W. bdy. of the Tp., at the cor. of secs. 25, 30, 31, and 36, identified by traces of four pits, one in each sec., NE, SE, SW, and NW, with a part of the original corner stake bearing fragmentary scribe marks lying in the SE pit.</p> <p>At the corner point</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <table border="0"> <tr><td colspan="2">T 15 N</td></tr> <tr><td>R 19 E</td><td>R 20 E</td></tr> <tr><td>S 25</td><td>S 30</td></tr> <tr><td>S 36</td><td>S 31</td></tr> </table> <p>1972</p> </div> <p>Deposit a sandstone, 6 x 6 x 6 ins., mkd. X, at the base of the iron post, as a memorial, and bury the old stake alongside.</p> <p>Land, level. Soil, sandy clay. No timber or undergrowth.</p>	T 15 N		R 19 E	R 20 E	S 25	S 30	S 36	S 31
T 15 N									
R 19 E	R 20 E								
S 25	S 30								
S 36	S 31								
	<p>NOTE.— The field notes continue in the regular order and in the same form; the record of 3 miles is omitted.</p>								
	<p>N. 0°05' W., bet. secs. 19 and 20.</p> <p>Desc. over rocky N slope.</p>								
2.00	Base of slope, bears N. 80° E. and S. 80° W.								
40.00	<p>Point for the ¼ sec. cor. of secs. 19 and 20.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <table border="0"> <tr><td>T 15 N</td><td>R 20 E</td></tr> <tr><td>¼</td><td></td></tr> <tr><td>S 19</td><td>S 20</td></tr> </table> <p>1972</p> </div>	T 15 N	R 20 E	¼		S 19	S 20		
T 15 N	R 20 E								
¼									
S 19	S 20								
44.50	<p>Raise a mound of stone, 4 ft. base, 2 ft. high, W of cor.</p> <p>S. bank of Lins Lake, bears N. 74° W. and East; point for the meander cor. of secs. 19 and 20.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <table border="0"> <tr><td colspan="2">MC</td></tr> <tr><td>S 19</td><td>S 20</td></tr> <tr><td>T 15 N</td><td>R 20 E</td></tr> </table> <p>1972</p> </div> <p>from which</p> <p>A box elder, 8 ins. diam., bears S. 77½° E., 221 lks. dist., mkd. T15N R20E S20 MC BT.</p>	MC		S 19	S 20	T 15 N	R 20 E		
MC									
S 19	S 20								
T 15 N	R 20 E								

## Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS	
	<p>A green ash, 10 ins. diam., bears West, 327 lks. dist., mkd. T15N R20E S19 MC BT.</p> <p>Land, gently rolling. Soil, rich loam. Timber, scattering green ash and box elder along lake shore; undergrowth, willow.</p>
20.50	<p>From the cor. of secs. 16, 17, 20, and 21.</p> <p>N. 89°54' W., bet. secs. 17 and 20.</p> <p>Desc. gradually over gently rolling land.</p>
28.70	<p>Road, ungraded, 15 lks. wide, bears N and S.</p>
36.50	<p>Ditch, course S. 30° W.; enter cultivated field, edge bears same as ditch.</p>
40.00	<p>Leave field; enter heavy timber, edge bears N. 30° E. and S. 30° W.</p>
	<p>Point for the <math>\frac{1}{4}</math> sec. cor. of secs. 17 and 20.</p> <p>Set an iron post, 28 ins. long, 2<math>\frac{1}{2}</math> ins. diam., 2<math>\frac{1}{2}</math> ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;">T 15 N R 20 E</p> <p style="text-align: center;"> <math>\frac{1}{4}</math> <math>\frac{S 17}{S 20}</math> </p> <p style="text-align: center;">1972</p> <p>from which</p> <p style="padding-left: 40px;">A box elder, 12 ins. diam., bears N. 22<math>\frac{1}{4}</math>° W., 119 lks. dist., mkd. <math>\frac{1}{4}</math> S17 BT.</p> <p style="padding-left: 40px;">A green ash, 13 ins. diam., bears S. 70<math>\frac{1}{2}</math>° W., 28 lks. dist., mkd. <math>\frac{1}{4}</math> S20 BT.</p>
43.20	<p>East bank of Lins Lake, bears N. 19° E. and S. 39 <math>\frac{3}{4}</math>° W.; point for the meander cor. of secs. 17 and 20, occupied by a green ash, 8 ins. diam., mkd.</p> <p style="padding-left: 40px;">S17 on N, T15N R20E on E, S20 on S, and MC on W side;</p> <p>from which</p> <p style="padding-left: 40px;">A green ash, 10 ins. diam., bears N. 40 <math>\frac{3}{4}</math>° E., 20 lks. dist., mkd. T15N R20E S17 MC BT.</p> <p style="padding-left: 40px;">A box elder, 6 ins. diam., bears S. 62<math>\frac{1}{4}</math>° E., 11<math>\frac{1}{2}</math> lks. dist., mkd. T15N R20E S20 MC BT.</p> <p>Land, gently rolling. Soil, loam. Timber, mostly green ash and box elder, with some cottonwood; undergrowth, willow.</p> <p>NOTE.— The line bet. secs. 8 and 17 is established next by running from the cor. of secs. 8, 9, 16, and 17, N. 89°54' W., parallel to the S. bdy. of sec. 17, 80.00 chs., with the <math>\frac{1}{4}</math> sec. cor. at 40.00 chs.</p>

MANUAL OF SURVEYING INSTRUCTIONS

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS

The line bet. secs. 17 and 18 is then established by running from the cor. of secs. 7, 8, 17, and 18, S. 0°05' E., parallel to the E. bdy. of sec. 17, 20.19 chs., to the north bank of Lins Lake.

The line bet. secs. 7 and 18 is established by the random and true line method with closing sec. cors. on the E. and W. bdrs. of the Lake City Townsite, but without a ¼ sec. cor. monument, as the point falls within the townsite. The field notes call for a point for the ¼ sec. cor. at 40.00 chs. from the east.

The remaining ¼ miles of the regular subdivisional lines are established in the normal manner, and at the ¼ sec. cor. on the line bet. secs. 5 and 8 the bearing and dist. to the U.S. Location Monument in the SW ¼ of sec. 5 is determined and recorded.

IVY ISLAND

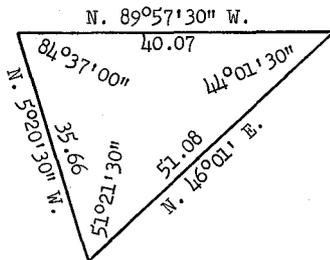
In order to establish the line bet. secs. 18 and 19, which crosses Ivy Island in Lins Lake, a bearing of N. 89°54' W. was sighted from the meander cor. of secs. 17 and 20, on an extension of the section line, to the SE bank of the island, where a temp. point was established.

From the temp. point on the island the bearing was observed to the meander cor. of secs. 19 and 20, on the south bank of the lake. By calculation it was determined that the temp. point was 80.04 chs. North of the S. bdy. of sec. 19, and the point was moved ¼ lks. South.

From the adjusted point the meander cor. of secs. 19 and 20 bears S. 5°20'30" E., and the meander cor. of secs. 17 and 20 bears S. 89°57'30" E.

The meanders of the lake in sec. 20, hereinafter described, were reduced to an equivalent direct line between the meander cors. with a bearing of N. 46°01' E., and a length of 51.08 chs. The equivalent line was used as a base for the triangulation.

The calculated angles of the triangle are shown in the following diagram:



The resulting connections across the lake are N. 89°57'30" W., 40.07 chs., and N. 5°20'30" W., 35.66 chs.

The latter course and dist. reduce to a northing of 35.50 chs. and a westing of 3.32 chs.; the allowance for the bearing of the E. bdy. of sec. 19, continued to the theoretical point for the cor. of secs. 17, 18, 19, and 20, in the lake, is 5 lks., making the net westing 3.27 chs.

N. 89°58' W., bet. secs. 18 and 19.

Over water.

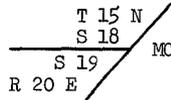
Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS

3.27

The adjusted point for the meander cor. of secs. 18 and 19, on the SE bank of Ivy Island; the bank bears N.  $47\frac{1}{4}^{\circ}$  E. and S.  $47\frac{1}{4}^{\circ}$  W.

Set an iron post, 28 ins. long,  $2\frac{1}{2}$  ins. diam., 24 ins. in the ground, with brass cap mkd.



1972

from which

A burr oak, 9 ins. diam., bears N.  $16\frac{1}{4}^{\circ}$  W., 29 lks. dist., mkd. T15N R20E S18 MC BT.

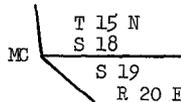
A green ash, 8 ins. diam., bears S.  $78\frac{3}{4}^{\circ}$  W., 127 lks. dist., mkd. T15N R20E S19 MC BT.

Thence over level land, across Ivy Island.

7.38

SW bank of the island, bears N.  $5\frac{1}{2}^{\circ}$  W. and S.  $52^{\circ}$  E.; point for the meander cor. of secs. 18 and 19.

Set an iron post, 28 ins. long,  $2\frac{1}{2}$  ins. diam., 24 ins. in the ground, with brass cap mkd.



1972

Raise a mound of stone, 6 ft. base, 3 ft. high, E of cor.

Land, nearly level, being higher at the north side of the island.

Soil, rich loam and rocky.

Timber, scattering burr oak and green ash; undergrowth, willow.

MEANDERS OF IVY ISLAND

Thence with the meanders of Ivy Island in sec. 18.

Along the top of a well-defined escarpment situated at the upper side of a gravelly beach.

N.  $5^{\circ}30'$  W., 2.90 chs.

N.  $35^{\circ}00'$  W., 1.60 chs.

S.  $45^{\circ}15'$  W., 1.40 chs.

S.  $56^{\circ}00'$  W., 2.30 chs.

N.  $73^{\circ}30'$  W., 4.50 chs.

N.  $38^{\circ}00'$  W., 6.40 chs. On this course the bank increases in height from 3 to 15 ft.; the beach becomes narrow and rocky.

N.  $12^{\circ}00'$  E., 4.20 chs.

## MANUAL OF SURVEYING INSTRUCTIONS

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS	<p>N. 59°15' E., 5.30 chs. On this course the bank becomes a nearly vertical cliff, 35 ft. above mean high water.</p> <p>East, 2.60 chs.</p> <p>S. 36°00' E., 3.80 chs.</p> <p>S. 56°15' E., 6.40 chs. On this course leave cliff; bank gradually becomes lower to a height of about 4 ft.</p> <p>S. 29°00' E., 7.00 chs.</p> <p>S. 47°15' W., 3.40 chs. The meander cor. of secs. 18 and 19.</p> <p>Land, rolling. Soil, loam and rocky. Timber, scattering burr oak and green ash; undergrowth, ivy.</p>
	<p>Thence in sec. 19.</p> <p>Along the top of a low bank, 1 to 4 ft. high, on the upper side of a gravelly beach.</p> <p>S. 47°15' W., 2.50 chs.</p> <p>N. 53°10' W., 2.84 chs. The meander cor. of secs. 18 and 19, and place of beginning.</p> <p>Land, level. Soil, loam and gravelly. Timber, scattering burr oak and green ash; undergrowth, ivy.</p>
	<p>NOTE.— The detail of the improvements on the island is carried to the general description at the close of the field notes, and to the plat of survey.</p>
21.44	<p style="text-align: center;">DIAMOND ROCK</p> <p>The survey of a small island called Diamond Rock, in Lins Lake, in sec. 18, was begun at the meander cor. of secs. 19 and 24, on the W. bdy. of the Tp. and the south bank of the lake, monumented with a limestone, 14 x 8 x 8 ins. above ground, firmly set, mkd. MC on N and with 3 grooves on S face, with a mound of stone, 2 ft. base, 1½ ft. high, S of cor.</p> <p>N. 71°30' E., on a connecting line.</p> <p>Over water.</p> <p>Dist. by triangulation. [Details omitted]</p> <p>SW bank of Diamond Rock at ordinary high water elevation; point for auxiliary meander cor. in sec. 18</p> <p>Set a brass tablet, ¾ ins. diam., ¾-in. stem, in drill hole in solid rock, with top mkd.</p> <p style="text-align: center;">AMC T 15 N R 20 E S 18 1972</p>

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS	<p>Raise a mound of stone, 3 ft. base, 2 ft. high, NE of cor.</p> <p>From this point the meander cor. of secs. 13 and 18, on the W. bdy. of the Tp. and on the north bank of the lake, bears N. 25°02' W. The connecting dist., by triangulation, with the crossing dist. on the W. bdy. of the Tp. as the base, is 48.06 chs. The meander cor. is mkd. by a juniper, 14 ins. diam., with healed blazes on N and S sides.</p> <p>Thence with the meanders of the island.</p> <p>Along the top of a low but well-defined bank, on the upper side of a gravelly beach.</p> <p>N. 16°30' W., 2.70 chs.</p> <p>N. 61°15' E., 2.90 chs.</p> <p>S. 48°30' E., 3.50 chs.</p> <p>S. 33°00' W., 2.20 chs.</p> <p>N. 86°46' W., 3.19 chs. The auxiliary meander cor.</p> <p>Land, level. Soil, gravelly loam. No timber or undergrowth.</p>
	<p style="text-align: center;">MEANDERS OF LINS LAKE</p> <p>From the meander cor. of secs. 19 and 24, on the W. bdy. of the Tp. and the south bank of Lins Lake.</p> <p>With the meanders of Lins Lake in sec. 19.</p> <p>Along the edge of a well-defined bank, 2 to 4 ft. high, on the upper side of a gravelly beach.</p> <p>S. 56°00' E., 7.20 chs.</p> <p>S. 46°30' E., 3.40 chs.</p> <p>S. 44°00' E., 2.40 chs.</p> <p>S. 43°15' E., 5.70 chs.</p> <p>S. 45°15' E., 4.40 chs.</p> <p>S. 44°45' E., 5.80 chs.</p> <p>S. 45°30' E., 2.00 chs.</p> <p>S. 49°30' E., 4.00 chs.</p> <p>S. 54°15' E., 5.00 chs.</p> <p>S. 67°45' E., 2.00 chs.</p> <p>S. 78°00' E., 6.67 chs. At end of course.</p> <p style="text-align: right;">Point for the special meander cor. on the meridional center line of sec. 19, 40.00 chs. in westing from the E. bdy. of the sec.</p>

## MANUAL OF SURVEYING INSTRUCTIONS

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS	
	<p>Set an iron post, 28 ins. long, 2½ ins. diam., 2¼ ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;">SMC</p> <p style="text-align: center;"> <math display="block">\begin{array}{c} C \\ \hline S \quad   \quad 19 \\ \hline C \end{array}</math> </p> <p style="text-align: center;">1972</p> <p>Raise a mound of stone, 6 ft. base, 2 ft. high, S of cor.</p> <p>N. 85°30' E., 1.93 chs.</p> <p>N. 77°45' E., 11.00 chs.</p> <p>S. 77°45' E., 7.20 chs.</p> <p>S. 74°00' E., 21.11 chs. The meander cor. of secs. 19 and 20.</p> <p>Land, level. Soil, gravelly loam. Timber, scattering green ash and burr oak; undergrowth, willow.</p>
	<p>Thence in sec. 20.</p> <p>Along the top of a well-defined bank, 2 to 4 ft. high, on the upper side of a gravelly beach; through scattering ash and oak.</p> <p>S. 89°45' E., 6.10 chs.</p> <p>N. 57°00' E., 12.00 chs.</p> <p>N. 37°30' E., 10.50 chs.</p> <p>N. 46°00' E., 5.00 chs.</p> <p>N. 23°15' E., 9.90 chs. On this course enter a belt of heavy timber, parallel to the bank.</p> <p>N. 39°45' E., 10.48 chs. The meander cor. of secs. 17 and 20.</p> <p>Land, level. Soil, gravelly loam. Timber, green ash and burr oak; undergrowth, willow.</p>
	<p>NOTE.— The meanders continue around the north bank of the lake through secs. 17 and 18 in the same form; the record is omitted.</p>
	<p style="text-align: center;">CLEAR LAKE</p> <p>From the ¼ sec. cor. of secs. 28 and 33.</p> <p>S. 0°03' E., on the theoretical bearing of the N. and S. center line of sec. 33.</p> <p>Over level land.</p>

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS 3.50	Creek, 8 lks. wide, course S. 80° E.
24.00	<p>North bank of Clear Lake, bears S. 53° E. and S. 52° W.; point for special meander cor. on the meridional center line of sec. 33.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <p style="text-align: center;">1972</p> </div> <p>Raise a mound of stone, 2 ft. base, 1½ ft. high, N of cor.</p>
	<p>Thence with the meanders of Clear Lake.</p> <p>Along the top of a well-defined bank, 6 to 10 ft. high, through scattering timber.</p> <p>S. 53°00' E., 13.00 chs. At 7.00 chs. leave scattering timber.</p> <p>S. 0°30' W., 7.20 chs. At end of course, the outlet of the lake, 20 lks. wide, course SE.</p> <p>S. 70°00' W., 15.10 chs. Along a belt of heavy timber, parallel to the bank.</p> <p>N. 63°45' W., 10.00 chs. At 7.00 chs. Leave timber.</p> <p>N. 13°00' W., 21.00 chs. At end of course, the mouth of a creek, 8 lks. wide.</p> <p>N. 52°00' E., 17.34 chs. At end of course, the special meander cor.</p> <p>Land, level and gently rolling. Soil, loam. Timber, green ash and burr oak; undergrowth, willow.</p>
	<p style="text-align: center;">MEANDERS OF THE YELLOWSTONE RIVER</p> <p>From the meander cor. of secs. 25 and 30, on the E. bdy. of the Tp. and the right bank of the Yellowstone River, monumented with a sandstone, 16 x 9 x 7 ins. above ground, firmly set, mkd. MC on N and with 2 grooves on S face, with a mound of stone, 2 ft. base, 1½ ft. high, S of cor.</p> <p>Thence upstream with the meanders of the right bank of the river, in sec. 25; over bottom land, along a well-defined cutbank, 2 to 12 ft. high, through heavy timber.</p> <p>S. 85°00' W., 13.00 chs.</p> <p>S. 72°00' W., 7.10 chs.</p> <p>S. 64°30' W., 13.00 chs.</p> <p>S. 40°30' W., 5.40 chs. At end of course, mouth of Cherry Creek, 14 lks. wide.</p>

MANUAL OF SURVEYING INSTRUCTIONS

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS	<p>S. 77°45' W., 7.00 chs.</p> <p>N. 76°00' W., 7.40 chs.</p> <p>S. 80°00' W., 12.00 chs.</p> <p>S. 81°08' W., 19.43 chs. The meander cor. of secs. 25 and 26.</p> <p>Land, level bottom; subject to overflow. Soil, alluvial silt and loam. Timber, green ash and cottonwood; undergrowth, willow.</p>
	<p>NOTE.— The meanders of the right bank are continued upstream in secs. 26 and 35, to the S. bdy. of the Tp. The field notes then show the meanders of the left bank running downstream in secs. 35, 26, and 25, in the same form. The record is omitted.</p>
	<p>LAKE CITY TOWNSITE</p> <p>An examination on the ground and consultation with the surveyor who was employed by the applicants for the subdivision of the Lake City townsite reveals that a preliminary survey was initiated at the ¼ sec. cor. of secs. 7 and 12, on the W. bdy. of the Tp., with the intention of conforming the N. bdy. of the townsite to the E. and W. center line of sec. 7, when officially established. A calculated position for the W. 1/16 sec. cor. on that line was adopted as the temp. NW cor. of the townsite, and the temp. NE cor. was placed at a point where a line running south would include all contemplated improvements. The temp. E. and W. bdrs. were run south to Lins Lake. This general plan was adhered to.</p> <p>Transit lines, without the use of the solar attachment, are employed in the survey of the boundaries and subdivision of secs. 7 and 18, and in the survey of the E. bdy. of the townsite, the azimuths being referred to a meridian established by Polaris observation.</p>
40.00	<p>From the ¼ sec. cor. of secs. 7 and 18.</p> <p>N. 0°05' W., on the N. and S. center line of sec. 7.</p> <p>Point for the center ¼ sec. cor. of sec. 7, at intersection with the E. and W. center line.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., in a concrete form, 8 ins. upper diam., 1¼ ins. lower diam., 30 ins. long, 2¼ ins. in the ground, with brass cap mkd.</p> <div style="text-align: center; margin: 10px 0;"> <math display="block">\frac{C \frac{1}{4} S 7}{LC TS}</math> <p>1972</p> </div>
80.04	<p>The ¼ sec. cor. of secs. 6 and 7.</p>
25.80	<p>From the ¼ sec. cor. of secs. 7 and 8.</p> <p>N. 89°56' W., on the E. and W. center line of sec. 7.</p> <p>Point for the NE cor. of the townsite.</p>

## Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS	
	<p>Set an iron post, 28 ins. long, 2½ ins. diam., in a concrete form, 8 ins. upper diam., 1¼ ins. lower diam., 30 ins. long, 2¼ ins. in the ground, with brass cap mkd.</p> $\begin{array}{c} C \quad S \quad 7 \quad C \\ LC \quad   \quad S7 \\ TS \quad   \end{array}$ <p>1972</p> <p>From this point the temp NE cor. monument bears North, 7 lks. dist., a limestone, 21 x 1¼ x 9 ins., mkd. NE COR LC on one side. The stone is now removed and buried alongside the iron post as a memorial.</p> <p>Continue on the E. and W. center line, along the N. bdy. of the townsite.</p>
40.00	The center ¼ sec. cor. of sec. 7.
60.00	Point for the center west 1/16 sec. cor. of sec. 7 and NW cor. of the townsite.
	<p>Set an iron post, 28 ins. long, 2½ ins. diam., in a concrete form, 8 ins. upper diam., 1¼ ins. lower diam., 30 ins. long, 2¼ ins. in the ground, with brass cap mkd.</p> $\begin{array}{c} CW \quad 1/16 \\ S \quad 7 \quad   \quad LC \\ TS \quad   \end{array}$ <p>1972</p> <p>From this point the temp. NW cor. monument bears N. 81°45' E., 1¼ lks. dist., an oak post, ¼ ins. sq., ¼ ft. long, mkd. NW COR LC on one side. The post is now removed and reset, inverted, alongside the iron post.</p> <p>Continue on the E. and W. center line of sec. 7.</p>
77.885	<p>The ¼ sec. cor. of secs. 7 and 12, on the W. bdy. of the Tp., monumented with a limestone, 12 x 10 x 8 ins. above ground, firmly set, mkd. ¼ on W face, with a mound of stone, 2 ft. base, 1½ ft. high, W of cor.</p>
	<p>From the NE cor. of the townsite.</p> <p>S. 0°05' E., on the E. bdy. of the townsite.</p>
40.00	The closing cor. of secs. 7 and 18.
7.53	<p>Thence in sec. 18.</p> <p>North bank of Lins Lake; point for auxiliary meander cor. in sec. 18 and SE cor. of the townsite.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., in a concrete form, 8 ins. upper diam., 1¼ ins. lower diam., 30 ins. long, 2¼ ins. in the ground, with brass cap mkd.</p> $\begin{array}{c} LC \quad   \quad T \quad 15 \quad N \\ TS \quad   \quad R \quad 20 \quad E \\ \quad \quad   \quad S \quad 18 \end{array}$ <p>AMC</p> <p>1972</p>

MANUAL OF SURVEYING INSTRUCTIONS

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS	<p>From this point the temp. SE cor. monument bears West, 6 lks. dist., a limestone, 18 x 9 x 6 ins., mkd. SE COR LC on one side. The stone is now removed and buried alongside the iron post as a memorial.</p>
40.00	<p>From the center west 1/16 sec. cor. of sec. 7 and NW cor. of the townsite.</p> <p>S. 0°05' E., on the N. and S. center line of the SW<math>\frac{1}{4}</math> of sec. 7, and the W. bdy. of the townsite.</p> <p>The closing cor. of secs. 7 and 18 at the point for the W. 1/16 sec. cor.</p>
29.50	<p>Thence in sec. 18, on the N. and S. center line of the NW<math>\frac{1}{4}</math> and W. bdy. of the townsite.</p> <p>North bank of Lins Lake; point for the special meander cor. on the meridional center line of the NW<math>\frac{1}{4}</math> of sec. 18, and SW cor. of the townsite.</p> <p>Set an iron post, 28 ins. long, 2<math>\frac{1}{2}</math> ins. diam., in a concrete form, 8 ins. upper diam., 14 ins. lower diam., 30 ins. long, 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center; margin: 10px 0;"> </div> <p>1972</p> <p>From this point the temp. SW cor. monument bears East, 4 lks. dist., a limestone, 16 x 8 x 6 ins., mkd. SW COR LC on one side. The stone is now removed and buried alongside the iron post as a memorial.</p>
MEMORANDUM	
<p>The segregation of the mineral claims in secs. 4 and 5 and the computation of the areas of the surrounding fractional lots that are subject to entry as agricultural land are derived by aid of the field notes and plats of the mineral patent surveys, which show the connecting courses and distances to the U.S. Location Monument located in the SW<math>\frac{1}{4}</math>SE<math>\frac{1}{4}</math> of sec. 5. The position of the latter monument, with reference to the quarter-section corner on the south boundary of the section, is shown in the record of the subdivisional survey. Ordinarily, the courses and distances along the boundaries of the mineral claims cannot be shown at the scale of the township plat, in addition to the more essential information.</p> <p>The survey of the boundaries of the Rancho San Blas grant was made under the provisions of the public land laws (R.S. 223; Mar. 3, 1925, 43 Stat. 1144; 43 U.S.C. 52), prior to the subdivision of the township.</p> <p>The location of the right-of-way of the Montana and Manitoba Railroad with reference to the subdivisional survey is ascertained by notation of the intersections on the section boundaries, and by aid of the map filed with the application for a right-of-way across public land. The land occupied by the railroad is not segregated from the public lands excepting within a townsite.</p>	

Subdivision of T. 15 N., R. 20 E., Principal Meridian, Montana

CHAINS

## GENERAL DESCRIPTION

A considerable variety of land and soil are found in T. 15 N., R. 20 E., of the Principal Meridian, Montana. The general elevation of the township ranges from about 4,500 to 4,800 feet above sea level. The summit of the Little Snowy Mountains, which extend into Sections 2 and 3, is about 1,200 feet higher. Most of the northern and northeastern portion of the township is rough and rocky, the central part gently rolling, and the southern part nearly level. The soil of the bottom land along the Yellowstone River is an alluvial silt and loam; much of the soil in the central part of the township is a black loam, but the southwestern part is very sandy. There is one small alkali flat which is located along the line between Sections 23 and 24. There is a heavy stand of cottonwood and green ash along the right bank of the river in Section 25, a heavy grove of burr oak along the line between Sections 1 and 12, and a good growth of yellow pine, burr oak, and fir timber over most of the mountainous region.

The Yellowstone River crosses the southeastern portion of the township; it is a meanderable stream under surveying rules, but there is no navigation on the river, owing principally to the swift current and occasional rapids. A ferry is operated in Section 35. There is some navigation on Lins Lake, which is a deep and permanent body of water; only the upper end of the lake extends into this township. Clear Lake is a permanent body of water, meanderable under the Manual regulations. There is an extensive marsh in Sections 16, 21, and 22, which evidently was the bed of a former shallow lake. The marsh and several springs situated along the line between Sections 9 and 16 drain into Lins Lake. Three good springs in Sections 28 and 32, all of considerable flow, are tributary to Clear Lake.

The most important developments at the present time are the gold-bearing quartz mineral claims in Sections 4 and 5, and the Montana and Manitoba Railroad, which crosses the northwestern part of the township. A limestone quarry in the NW<sup>1</sup>/<sub>4</sub>SW<sup>1</sup>/<sub>4</sub> of Section 9 may be expanded considerably if there should be a demand for building stone in this vicinity. The proposed Lake City townsite is well chosen and offers many advantages. The applicants for the townsite subdivision are making a bona fide effort to encourage an interest in the area.

There are three settlers in Sections 17 and 20 who have small fields in cultivation, under irrigation; three other settlers, one each in Sections 19, 25, and 35, have made their first improvements, and one of them has about 40 acres in cultivation. At present the predominant interest is in stock grazing on the excellent growth of native grasses over most of the township. The township has an excellent water supply. There are several cottages on Ivy Island, in Lins Lake, which are occupied during the summer months.

Because of site conditions or a lack of available accessories, superior monuments were constructed at several corner point in the township by setting iron posts or brass tablets in concrete cylinders or cones. When available, memorials were deposited, but the soil was not sufficiently firm for pits.

The average of a considerable number of readings over all parts of the township gives a value of 18°10' E. for the mean magnetic declination. There is a range of 20' in local attraction.

MANUAL OF SURVEYING INSTRUCTIONS

FIELD ASSISTANTS

NAMES	CAPACITY
	Surveying Technician
	Survey Aid

CERTIFICATE OF SURVEY

(I) ~~(we)~~, Robert Acres, Cadastral Surveyor, HEREBY CERTIFY upon honor that, in pursuance of special instructions bearing date of the 1st day of April, 1972, (I) ~~(we)~~ have surveyed the subdivisional and meander lines of Township 15 North, Range 20 East,

of the Principal Meridian, in the State of Montana, which are represented in the foregoing field notes as having been executed by (me), ~~(us)~~ and under (my) ~~(our)~~ direction; and that said survey has been made in strict conformity with said special instructions, the Manual of Instructions for the Survey of the Public Lands of the United States, and in specific manner described in the foregoing field notes.

July 31, 1972  
(Date)

/s/ Robert Acres  
(Cadastral Surveyor)

\_\_\_\_\_  
(Date)

\_\_\_\_\_  
(Cadastral Surveyor)

CERTIFICATE OF APPROVAL

BUREAU OF LAND MANAGEMENT  
Washington, D.C.  
September 15, 1972

The foregoing field notes of the survey of the subdivisional and meander lines of T. 15 N., R. 20 E., of the Principal Meridian, Montana,

executed by Robert Acres, Cadastral Surveyor, having been critically examined and found correct, are hereby approved.

\_\_\_\_\_  
(Date)

\_\_\_\_\_  
(Chief, Division of Cadastral Survey)

## SPECIMEN FIELD NOTES, DEPENDENT RESURVEY

The examples illustrate how the resurvey record is coordinated with the original record in the introductory statement and in the body of the field notes. The resurveys are restorations according to the best available evidence, with proportionate distribution of differences in measurement between the original surveys and the resurveys. Several miles of field notes are included to show forms of record and to compare and contrast the style with the specimen field notes of original surveys. The corner descriptions are intended to furnish a variety of examples. One of the examples is the modified record of an actual resurvey in Arkansas, the other an entirely fictitious record of a resurvey in Montana.

## MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey of T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas

## CHAINS

The history of surveys of Township 1 South, Range 26 West, Fifth Principal Meridian, Arkansas, is as follows:

The south boundary was surveyed by Rudolph N. Rowland in 1837. The north boundary (Base Line), east boundary, and west boundary were surveyed by John E. Graham in 1838. The township was subdivided by Benjamin F. Owen in 1845. The north boundary was resurveyed by R.W. Livingston in 1929.

The following field notes describe the dependent resurvey of the east, west, and south boundaries and the subdivisional lines of the township.

The survey was executed in accordance with specifications set forth in the Manual of Surveying Instructions, 19\_\_, and the Special Instructions for Group No. \_\_\_\_, Arkansas, dated \_\_\_\_\_.

Preliminary to the resurvey the lines of the original survey were retraced and search was made for all corners and other calls of the record. Identified corners were remonumented in their original positions; lost corners were restored and monumented at proportionate positions based on the original record. The retracement data were thoroughly verified and only the true line field notes are given herein.

The directions of lines were determined by solar instrument methods and by means of fore- and backsights and angular deflections from azimuths obtained by direct solar observations.

The geographic position of the southeast corner of the township, as scaled from the U.S. Geological Survey quadrangle map \_\_\_\_\_, prepared in \_\_\_\_, is as follows:

Latitude \_\_\_\_\_ Longitude \_\_\_\_\_

The mean magnetic declination is \_\_\_\_\_ E.

Dependent Resurvey of the E. Bdy. of T. 1 S., R. 26 W.,  
Fifth Principal Meridian, Arkansas  
(Restoring the 1838 survey by John E. Graham)

The cor. of Tps. 1 and 2 S., Rs. 25 and 26 W., is determined at record bearing and distance from the remains of the original bearing trees

A stump hole, bears N. 39° E., 67 lks. dist.

A pine stump, 22 ins. diam., bears S. 59° W., 116 lks. dist., with fragmentary scribe marks visible on opened blaze.

At the corner point

Set an iron post, 28 ins. long, 2½ ins. diam., in a concrete form, 30 ins. long, 9 ins. diam., 24 ins. in the ground, with brass cap mkd.

Dependent Resurvey of  
E. Bdy. of T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas

CHAINS	
	<p style="text-align: center;">T 1 S R 26 W   R 25 W <u>S 36   S 31</u> S 1   S 6 T 2 S 1972</p> <p>from which new bearing trees and a bearing object</p> <p>A pine, 10 ins. diam., bears N. 16° E., 125 lks. dist., mkd. T1S R25W S31 BT.</p> <p>A white oak, 7 ins. diam., bears S. 40½° E., 75 lks. dist., mkd. T2S R25W S6 BT.</p> <p>A white oak, 18 ins. diam., bears S. 53½° W., 94 lks. dist., mkd. T2S R26W S1 BT.</p> <p>A pine, 9 ins. diam., bears N. 41¼° W., 35 lks. dist., mkd. T1S R26W S36 BT.</p> <p>A granite boulder, 3 x 2 x 1 ft. above ground, bears N. 20¼° W., 40 lks. dist., mkd. X B0 on SE face.</p> <p>Cor. falls in fence extending N and S.</p> <p>N. 0°28' E., on the E. bdy. of sec. 36, marking and blazing the true line.</p> <p>Asc. 25 ft. over S slope, along fence, through scattering timber and undergrowth.</p> <p>5.00 Top of ascent, slopes W; desc. 70 ft. over N slope.</p> <p>12.20 Draw, drains W; asc. 80 ft. over broken S slope.</p> <p>26.90 Point of spur, slopes N. 70° E.; desc. 70 ft. over broken N slope.</p> <p>39.30 Road, 20 lks. wide, bears E and W; leave fence S of road; fence turns to east.</p> <p>39.79 Point for the ¼ sec. cor. of sec. 36 only, at propor- tionate dist.; there is no remaining evidence of the original cor.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;">T 1 S   ¼ S 36   R 26 W   1972</p> <p>from which</p> <p>A white oak, 5 ins. diam., bears N. 2 3/4° W., 22 lks. dist., mkd. ¼ S36 BT.</p> <p>A pine, 14 ins. diam., bears S. 14 3/4° W., 130 lks. dist., mkd. ¼ S36 BT</p> <p>Raise a mound of stone, 4 ft. base, 2 ft. high, W of cor.</p> <p>40.60 Creek, 2 lks. wide, course SE; asc. 45 ft. over S slope.</p>

## MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey of  
E. Bdy. of T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas

CHAINS	
47.00	Top of ascent; thence along E slope.
51.40	SE cor. of vacant farmhouse, 40 x 20 ft., bears West, 1.62 chs. dist.; long side bears N and S.
59.85	State Highway No. 270, 40 lks. wide, bears N. $47\frac{1}{2}^{\circ}$ W. and S. $47\frac{1}{2}^{\circ}$ E.
63.00	Desc. 60 ft. over N slope.
79.58	Point for the cor. of secs. 25 and 36 only, monumented by the orig. cor. tree, 12 ins. diam., with faint scribe mks. T1 R26 S25 visible on open blaze on NW and illegible scribe mks. visible on open blaze on SW side, from which the remains of original bearing trees  An elm stump, 18 ins. diam., bears S. $28^{\circ}$ W., 53 lks. dist.; the fallen trunk alongside has a healed blaze. (Record bearing S. $26^{\circ}$ W.)  A post oak stump, 24 ins. diam., bears N. $78^{\circ}$ W., 65 lks. dist., with no marks visible.  And new bearing trees  A white oak, 20 ins. diam., bears S. $22\frac{1}{2}^{\circ}$ W., 340 lks. dist., mkd. T1S R26W S36 BT.  An elm, 15 ins. diam., bears N. $7\frac{1}{4}^{\circ}$ W., 103 lks. dist., mkd. T1S R26W S25 BT.
	Land, rolling hills. Soil, rocky clay. Timber, pine, oak, hickory, and elm; undergrowth, young timber.
	N. $1^{\circ}22'$ E., on the E. bdy. of sec. 25.  Over gently rolling land, in creek bottom, through scattering timber and undergrowth.
0.25	Hackberry Creek, 30 lks. wide, course N. $80^{\circ}$ E.; asc. 40 ft. over S slope.
19.20	Top of ascent; thence over level land.
27.70	Desc. 20 ft. over NW slope.
29.50	Creek, 10 lks. wide, course SW; asc. 20 ft. over S slope.
40.09	The $\frac{1}{4}$ sec. cor. of sec. 25 only, determined from the remains of the original bearing trees  A stump hole, bears N. $62^{\circ}$ W., 63 lks. dist., with an uprooted pine alongside, 14 ins. diam., with healed blaze. (Record bearing N. $58^{\circ}$ W.)  A stump hole, bears S. $45^{\circ}$ W., 27 lks. dist. (Record bearing S. $35^{\circ}$ W.)  At the corner point  Set an iron post, 28 ins. long, $2\frac{1}{2}$ ins. diam., 24 ins. in the ground, with brass cap mkd.

Dependent Resurvey of  
E. Bdy. of T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas

CHAINS													
	<table style="margin-left: auto; margin-right: auto;"> <tr><td>T 1 S</td><td> </td><td></td></tr> <tr><td>1/4 S 25</td><td> </td><td></td></tr> <tr><td>R 26 W</td><td> </td><td></td></tr> </table> <p>1972</p>	T 1 S			1/4 S 25			R 26 W					
T 1 S													
1/4 S 25													
R 26 W													
	from which new bearing trees												
	A pine, 10 ins. diam., bears N. 48° W., 49 lks. dist., mkd. 1/4 S25 BT.												
	A pine, 5 ins. diam., bears S. 21 1/4° W., 39 lks. dist., mkd. 1/4 S25 BT.												
	Raise a mound of stone, 4 ft. base, 2 ft. high, W of cor.												
	From this cor. a local monument, a pine knot, 4 ins. diam., 12 ins. above ground, in a mound of stone, 2 ft. base, 1 ft. high, bears S. 78 3/4° E., 28 lks. dist.												
	—————												
	N. 1°00' E., beginning new measurement.												
	Asc. 55 ft. over SW slope.												
16.00	Top of ascent; thence over rolling W and NW slopes, descending 10 ft. to cor.												
20.50	Draw, drains NW.												
25.40	Creek, 5 lks. wide, course SW.; asc. slightly.												
40.68	Point for the cor. of secs. 24 and 25 only, at propor- tionate distance; there is no remaining evidence of the original cor.												
	Set a brass tablet, 3 1/4 ins. diam., 3 1/2-in. stem, in a concrete form, 6 ins. diam., 30 ins. long, 2 1/2 ins. in the ground, with top mkd.												
	<table style="margin-left: auto; margin-right: auto;"> <tr><td>T 1 S</td><td> </td><td>T 1 S</td></tr> <tr><td>S 24</td><td> </td><td></td></tr> <tr><td>S 25</td><td> </td><td></td></tr> <tr><td>R 26 W</td><td> </td><td>R 25 W</td></tr> </table> <p>1972</p>	T 1 S		T 1 S	S 24			S 25			R 26 W		R 25 W
T 1 S		T 1 S											
S 24													
S 25													
R 26 W		R 25 W											
	from which												
	A pine, 8 ins. diam., bears S. 49 3/4° W., 44 lks. dist., mkd. T1S R26W S25 BT.												
	A pine, 12 ins. diam., bears N. 60 3/4° W., 49 lks. dist., mkd. T1S R26W S24 BT.												
	Raise a mound of stone, 4 ft. base, 2 ft. high, W of cor.												
	Land, rolling hills. Soil, rocky clay. Timber, pine, oak, elm, hickory, and gum; undergrowth, young timber and dogwood.												
	NOTE.— Remainder of east boundary of the township is omitted.												

## MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey of the S. Bdy. of T. 1 S., R. 26 W.,  
Fifth Principal Meridian, Arkansas

CHAINS													
	(Restoring the 1837 survey by Rudolph N. Rowland)												
	From the cor. of Tps. 1 and 2 S., Rs. 25 and 26 W., heretofore described.												
	S. 88°51' W., on the S. bdy. of sec. 36, marking and blazing the true line.												
	Over rolling land, through scattering timber and undergrowth.												
1.40	Desc. 70 ft. over W. slope.												
7.50	Enter river bottom, edge bears N and S.												
19.20	Left bank of Ouachita River, course S. 15° E.												
24.80	Right bank of river; thence over gently rolling land, through timber and undergrowth.												
40.325	Point for the $\frac{1}{4}$ sec. cor. of sec. 36 only, at proportionate dist.; there is no remaining evidence of the original cor.												
	Set an iron post, 28 ins. long, $2\frac{1}{2}$ ins. diam., 24 ins. in the ground, with brass cap mkd.												
	<table style="margin-left: auto; margin-right: auto;"> <tr><td>T</td><td>1</td><td>S</td><td>R</td><td>26</td><td>W</td></tr> <tr><td></td><td></td><td><math>\frac{1}{4}</math></td><td>S</td><td>36</td><td></td></tr> </table>	T	1	S	R	26	W			$\frac{1}{4}$	S	36	
T	1	S	R	26	W								
		$\frac{1}{4}$	S	36									
	1972												
	from which												
	A post oak, 10 ins. diam., bears N. 60 $\frac{1}{4}$ ° E., 75 lks. dist., mkd. $\frac{1}{4}$ S36 BT.												
	A pine, 7 ins. diam., bears N. 73 $\frac{1}{2}$ ° W., 16 lks. dist., mkd. $\frac{1}{4}$ S36 BT.												
73.00	Enter end of a lane extending W along line.												
74.55	Creek, 2 lks. wide, course NW; asc. slightly.												
79.60	Lane turns S; thence along old fence.												
80.65	Point for the cor. of secs. 35 and 36 only, determined longitudinally by proportionate measurement and latitudinally by an old fence bearing E and W. There is no remaining evidence of the original monument.												
	Set an iron post, 28 ins. long, $2\frac{1}{2}$ ins. diam., 24 ins. in the ground, with brass cap mkd.												
	<table style="margin-left: auto; margin-right: auto;"> <tr><td>T</td><td>1</td><td>S</td><td>R</td><td>26</td><td>W</td></tr> <tr><td></td><td></td><td>S</td><td>35</td><td>S</td><td>36</td></tr> </table>	T	1	S	R	26	W			S	35	S	36
T	1	S	R	26	W								
		S	35	S	36								
	1972												
	from which												
	A cedar, 4 ins. diam., bears N. 85 $\frac{1}{2}$ ° E., 91 lks. dist., mkd. T1S R26W S36 BT.												
	A pine, 4 ins. diam., bears N. 30° W., 356 lks. dist., mkd. T1S R26W S35 BT.												

Dependent Resurvey of  
S. Bdy. of T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas

CHAINS	<p>Land, gently rolling. Soil, rocky and sandy clay. Timber, pine, oak, hickory, cedar, and gum; undergrowth, young timber.</p>
	<p>S. 89°55' W., on the S. bdy. of sec. 35.</p> <p>Desc. slightly over gently rolling land, between fields.</p>
4.70	Enter timber and undergrowth, edge bears NE and S. 80° W.; desc. 30 ft.
14.00	Creek, 15 lks. wide, course NE.
17.00	Edge of bottom, bears NE and SW; asc. 110 ft. over SE slope.
31.10	Ridge, bears NE and SW; desc. 65 ft. over NW slope.
40.32	<p>The <math>\frac{1}{4}</math> sec. cor. of sec. 35 only, perpetuated with an unmkd. pine stake, 2 ft. long, 2 ins. sq., set in a mound of stone, 3 ft. base, 1<math>\frac{1}{2}</math> ft. high, at cor. of fences extending E and N, from which a large pine stump hole bears N. 33<math>\frac{1}{2}</math>° W., 15 lks. dist., agreeing with the record position of an original pine bearing tree.</p> <p>At the corner point</p> <p>Set an iron post, 28 ins. long, 2<math>\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;">T 1 S R 26 W <u>        </u>     <math>\frac{1}{4}</math> S 35 <u>        </u> 1972</p> <p>from which new bearing trees</p> <p style="padding-left: 40px;">A red oak, 13 ins. diam., bears N. 69° E., 25 lks. dist., mkd. <math>\frac{1}{4}</math> S35 BT.</p> <p style="padding-left: 40px;">A post oak, 13 ins. diam., bears N. 7<math>\frac{1}{2}</math>° W., 31 lks. dist., mkd. <math>\frac{1}{4}</math> S35 BT.</p> <p>Raise a mound of stone, 3 ft. base, 2 ft. high, N of cor.</p> <p>Reset the pine stake, inverted, alongside the iron post.</p> <hr style="width: 20%; margin: 10px auto;"/> <p>S. 89°37' W., beginning new measurement.</p> <p>Over gently rolling land.</p>
18.50	Fence, bears N and S; thence along old fence row.
38.45	Creek, 3 lks. wide, course N. 30° E.; enter timber, edge bears N. 30° E. and S.
40.16	<p>The cor. of secs. 34 and 35 only, monumented with an unmkd. wooden stake, 2 ins. sq., projecting 12 ins. above ground at cor. of fences extending N, E, and W. This position is harmoniously related to existing original cors., has long been recognized as the cor. by adjacent landowners, and is accepted as the best available evidence of the original corner position.</p> <p>At the corner point</p>

## MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey of  
S. Bdy. of T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas

CHAINS					
	<p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, and in a flat mound of stone to top, 5 ft. diam., with brass cap mkd.</p> <p style="text-align: center;"> <table style="border-collapse: collapse; margin: auto;"> <tr> <td style="border-right: 1px solid black; padding: 0 5px;">T 1 S</td> <td style="padding: 0 5px;">R 26 W</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 0 5px;">S 34</td> <td style="padding: 0 5px;">S 35</td> </tr> </table> </p> <p style="text-align: center;">1972</p> <p>from which</p> <p style="padding-left: 40px;">A water oak, 6 ins. diam., bears N. 53½° E., 79 lks. dist., mkd. T1S R26W S35 BT.</p> <p style="padding-left: 40px;">A water oak, 7 ins. diam., bears N. 75½° W., 22 lks. dist., mkd. T1S R26W S34 BT.</p> <p>Reset the wooden stake, inverted, alongside the iron post.</p> <p>Land, gently rolling. Soil, rocky clay. Timber, pine, oak, hickory, and gum; undergrowth, young timber, vines, and briars.</p>	T 1 S	R 26 W	S 34	S 35
T 1 S	R 26 W				
S 34	S 35				
	<p>NOTE.— Remainder of south boundary and all of west boundary of township is omitted.</p>				
	<p style="text-align: center;">Dependent Resurvey of the Subdivisional Lines, T. 1 S., R. 26 W., Fifth Principal Meridian, Arkansas (Restoring the 1845 survey by B. F. Owen)</p> <hr style="width: 20%; margin: auto;"/> <p>From the cor. of secs. 35 and 36, on the S. bdy. of the Tp., heretofore described.</p> <p>N. 0°26' E., bet. secs. 35 and 36, marking and blazing the true line.</p> <p>Desc. 45 ft. over N slope, through field.</p>				
11.15	Right bank of channel of the Ouachita River, 135 lks. wide, course E.				
12.50	Left bank of first channel; thence over island.				
14.60	Right bank of second channel, 120 lks. wide, course E.				
15.80	Left bank of second channel; asc. 85 ft. over S slope.				
33.45	Farm road, 25 lks. wide, bears E and W.				
40.08	<p>The ¼ sec. cor. of secs. 35 and 36, monumented with a sandstone, 16 x 12 x 12 ins., mkd. ¼ on W face, firmly set 10 ins. in the ground, from which the remains of the original bearing trees</p> <p style="padding-left: 40px;">A dim stump hole, bears S. 73° E., 19 lks. dist.</p> <p style="padding-left: 40px;">A dim stump hole, bears N. 64° W., 9 lks. dist.</p> <p>At the corner point</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p>				

Dependent Resurvey of Subdivisional Lines,  
T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas

CHAINS	
	T 1 S R 26 W $\frac{1}{4}$ S 35   S 36 1972
	from which new bearing trees  A white oak, 9 ins. diam., bears N. $72\frac{1}{2}^{\circ}$ E., 50 lks. dist., mkd. $\frac{1}{4}$ S36 BT.  A white oak, 15 ins. diam., bears N. $59^{\circ}$ W., 36 lks. dist., mkd. $\frac{1}{4}$ S35 BT.  Deposit the mkd. stone alongside the iron post.  <hr style="width: 20%; margin: auto;"/> N. $0^{\circ}44'$ E., beginning new measurement.  Over gently rolling land.  17.00 Desc. 60 ft. over N slope.  28.10 Creek, 3 lks. wide, course NE; thence over level land.  29.10 Fence, bears E and W; asc. 30 ft. over S slope.  39.00 Top of ascent, slopes E; desc. 5 ft. over N slope.  40.26 The cor. of secs. 25, 26, 35, and 36, monumented with an iron bar, 12 x 1 x $\frac{1}{2}$ ins., firmly driven 10 ins. in the ground. This position is harmoniously related to exist- ing original cors., has long been recognized as the cor. by adjacent landowners, and is accepted as the best available evidence of the original cor. position.  At the corner point  Set an iron post, 28 ins. long, $2\frac{1}{2}$ ins. diam., 24 ins. in the ground, with brass cap mkd.  <div style="text-align: center;">             T 1 S R 26 W              S 26   S 25              S 35   S 36              1972           </div> from which  A cedar, 14 ins. diam., bears N. $80^{\circ}$ E., 134 lks. dist., mkd. TLS R26W S25 BT.  A red oak, 17 ins. diam., bears S. $44\frac{1}{2}^{\circ}$ E., 71 lks. dist., mkd. TLS R26W S36 BT.  A white oak, 14 ins. diam., bears S. $61^{\circ}$ W., 37 lks. dist., mkd. TLS R26W S35 BT.  A white oak, 14 ins. diam., bears N. $3\frac{1}{2}^{\circ}$ W., 67 lks. dist., mkd. TLS R26W S26 BT.  NW cor. of pasture fence bears S. $46^{\circ}$ E., 11 lks. dist.  Reset iron bar at S side of iron post.  Raise a mound of stone, 3 ft. base, 2 ft. high, W of cor.  Land, rolling hills. Soil, rocky clay.

## MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey of Subdivisional Lines,  
T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas

CHAINS	Timber, pine, oak, hickory, maple, elm, gum, sycamore, and cedar; undergrowth, young timber.
	From the cor. of secs. 25 and 36, on the E. bdy. of the Tp., heretofore described.
	S. 89°12' W., bet. secs. 25 and 36.
	Asc. 65 ft. over rolling NW slope, through field.
16.95	State Highway No. 270, 40 lks. wide, bears N. 48½° W. and S. 48½° E.; leave field and enter timber and undergrowth; edge bears NE and SW.
37.50	Spur, slopes SW; desc. 20 ft. over W slope.
40.23	The ¼ sec. cor. of secs. 25 and 36, perpetuated by persons unknown with an unmkd. granite stone, 18 x 8 x 7 ins., firmly set 12 ins. in the ground, alongside NE cor. of a fence. This position is harmoniously related to existing original cors., has long been recognized as the cor. by adjacent landowners, and is accepted as the best available evidence of the original cor. position.
	At the corner point
	Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.
	<p style="text-align: center;">T 1 S R 26 W  <math>\frac{1}{4}</math> <math>\frac{S 25}{S 36}</math></p>
	1972
	from which
	A post oak, 8 ins. diam., bears N. 3° E., 49 lks. dist., mkd. ¼ S25 ET.
	An elm, 6 ins. diam., bears S. 53½° E., 32 lks. dist., mkd. ¼ S36 ET.
	Deposit the unmkd. stone alongside the iron post.
	S. 89°26' W., beginning new measurement.
	Asc. 20 ft. over E slope, through scattering timber and undergrowth.
1.95	NE cor. of a house, 40 x 30 ft., bears South, 0.28 chs. dist.; long side bears E and W.
5.20	Top of ascent; thence over rolling land, descending 40 ft.; line follows near secondary road, winding W.
29.70	Creek, 15 lks. wide, course S. 10° E.; asc. 30 ft. over E slope.
38.00	Top of ascent; desc. 10 ft. over NW slope.
40.09	The cor. of secs. 25, 26, 35, and 36.
	Land, rolling hills.
	Soil, rocky clay.
	Timber, pine, oak, hickory, and elm; undergrowth, young timber.

Dependent Resurvey of Subdivisional Lines,  
T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas

CHAINS	
	<p>N. 0°46' E., bet. secs. 25 and 26.</p> <p>Over gently rolling land.</p>
0.25	<p>Secondary road, 25 lks. wide, winding E and W.</p>
0.90	<p>Thence along a fence line, with hedgerow; old clearings E and W.</p>
27.50	<p>Creek, course winding S. 20° E.; enter cleared land.</p>
40.57	<p>Point for the <math>\frac{1}{4}</math> sec. cor. of secs. 25 and 26, falls in State Highway No. 88, 40 lks. wide, bearing N. 89° E. and S. 89° W. This position is harmoniously related to existing original cors., has long been recognized as the cor. by local residents with knowledge prior to construction of the highway, and is accepted as the best available evidence of the original cor. position.</p>
	<p>At the corner point</p>
	<p>Deposit a washed sandstone, 9 x 8 x 6 ins., mkd. X, 14 ins. below surface of highway, from which</p>
	<p>An iron post, 28 ins. long, 2<math>\frac{1}{2}</math> ins. diam., set 24 ins. in the ground, for a reference monument, bears S. 48° E., 73 lks. dist., with brass cap mkd. <math>\frac{1}{4}</math> S25 RM 1972 73 LKS and an arrow pointing to the cor.</p>
	<p>An iron post, 28 ins. long, 2<math>\frac{1}{2}</math> ins. diam., set 24 ins. in the ground, for a reference monument, bears N. 48° W., 73 lks. dist., with brass cap mkd. <math>\frac{1}{4}</math> S26 RM 1972 73 LKS and an arrow pointing to the cor.</p>
	<hr/>
	<p>N. 0°58' E., beginning new measurement.</p>
	<p>Asc. 35 ft. over SW slope.</p>
6.00	<p>Top of ascent; thence over gently rolling land.</p>
19.05	<p>Intersection of roads, bearing N. 74° E., S. 62° W., and North along the sec. line.</p>
34.37	<p>State Highway No. 270, 40 lks. wide, bears N. 33°22' W. and S. 33°22' E.</p>
40.10	<p>Point for the cor. of secs. 23, 24, 25, and 26, falls at the center line of a gravel road, 25 lks. wide, bearing North and South, and in line with property line fences to the east and west. Mr. Charley Ballentine, a resident of the area for many years, furnished a signed statement, attached to and made a part of these field notes, attesting to the cor. position.</p>
	<p>At the corner point</p>
	<p>Deposit a granite stone, 10 x 9 x 6 ins., mkd. X, 19 ins. below surface of road, from which</p>
	<p>A granite boulder, 9 x 6 x 4 ft. above ground, bears N. 34°26' E., 63<math>\frac{1}{2}</math> lks. dist. to a cross chiseled 6 ins. above ground near SW cor., mkd. B + O.</p>
	<p>An elm, 7 ins. diam., bears S. 56 3/4° E., 62 lks. dist., mkd. T1S R26W S25 BT.</p>

## MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey of Subdivisional Lines,  
T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas

CHAINS	
	<p>A pine, 4 ins. diam., bears S. <math>51\frac{1}{2}^{\circ}</math> W., 404 lks. dist., mkd. T1S R26W S26 BT.</p> <p>A mulberry, 4 ins. diam., bears N. <math>62^{\circ}</math> W., 203 lks. dist., mkd. T1S R26W S23 BT.</p> <p>Land, gently rolling hills. Soil, rocky clay. Timber, scattering pine, oak, hickory, and elm; under- growth, young timber.</p>
	<p>From the cor. of secs. 24 and 25, on the E. bdy. of the Tp., heretofore described.</p> <p>S. <math>89^{\circ}33'</math> W., bet. secs. 24 and 25.</p> <p>Over gently rolling upland, through scattering timber and undergrowth.</p>
23.20	Draw, drains S.
25.30	Ridge, bears N and S. $20^{\circ}$ E.; desc. 70 ft. over W slope.
40.27	<p>The <math>\frac{1}{4}</math> sec. cor. of secs. 24 and 25, monumented with a rough-surfaced conglomerate boulder, 4 x 4 x 2 ft. above ground, mkd. with a large X chiseled on SW face, from which an original bearing tree</p> <p>A sawed post oak stump, 20 ins. diam., bears N. <math>52^{\circ}</math> E., 16 lks. dist., with no marks visible.</p> <p>Add the marks <math>\frac{1}{4}</math> at W side of the X, from which new bearing trees</p> <p>A pine, 6 ins. diam., bears N. <math>40\frac{1}{2}^{\circ}</math> E., 130 lks. dist., mkd. <math>\frac{1}{4}</math> S24 BT.</p> <p>A post oak, 6 ins. diam., bears S. <math>70\frac{1}{2}^{\circ}</math> E., 139 lks. dist., mkd. <math>\frac{1}{4}</math> S25 BT.</p> <p>Raise a mound of stone, 4 ft. base, 2 ft. high, N of cor.</p> <p style="text-align: center;">—————</p> <p>S. <math>88^{\circ}44'</math> W., beginning new measurement.</p> <p>Over gently rolling land, through scattering timber and undergrowth.</p>
2.10	SE cor. of a house, 30 x 20 ft., bears North, 1.00 ch. dist.; long side bears N and S.
4.70	Enter road, 25 lks. wide, curving from N to W.
11.12	Bridge over Hackberry Creek, 48 lks. wide, course S.
13.70	Leave road, curving SW from E; enter field, edge bears N and S.
40.47	<p>The cor. of secs. 23, 24, 25, and 26.</p> <p>Land, rolling and gently rolling hills. Soil, rocky clay. Timber, pine, oak, and hickory; undergrowth, young timber and dogwood.</p>

Dependent Resurvey of Subdivisional Lines,  
T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas

CHAINS									
	<p>NOTE.— On each mile of the north boundary of the township, which is the base line of the Fifth Principal Meridian, and on each mile of the west boundary, new quarter-section corners of minimum control for the sections of T. 1 S., R. 26 W., are established. The positions are determined by proportionate measurement as based on the original plat. The descriptive statements are given for two corners.</p> <p>The point for the <math>\frac{1}{4}</math> sec. cor. of sec. 4 only, on the N. bdy. of the Tp., at proportionate dist., based on the original plat, falls in a graded road, 25 lks. wide, bearing N. <math>89^{\circ}08'</math> W. and S. <math>89^{\circ}08'</math> E.</p> <p>At the corner point</p> <p>Deposit a sandstone, <math>1\frac{1}{2} \times 10 \times 6</math> ins., mkd. X, 12 ins. below surface of road, from which</p> <p>An iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., set 24 ins. in the ground, for a reference monument, bears North, 40 lks. dist., with brass cap mkd. RM 1972 40 LKS and an arrow pointing to the cor.</p> <p>An iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., set 24 ins. in the ground, for a reference monument, bears South, 40 lks. dist., with brass cap mkd. <math>\frac{1}{4}</math> S4 RM 1972 40 LKS and an arrow pointing to the cor.</p> <p>From this point the stan. cor. of secs. 32 and 33, T. 1 N., R. 26 W., bears S. <math>89^{\circ}06'</math> E., 1.29 chs. dist., monumented with an iron post, 2 ins. diam., firmly set, projecting <math>\frac{1}{2}</math> ins. above ground, with brass cap properly mkd., from which</p> <p>A pine, 10 ins. diam., bears N. <math>30^{\circ}</math> E., 45 lks. dist., with healed blaze.</p> <p>A mulberry, 12 ins. diam., bears N. <math>45^{\circ}</math> W., 50 lks. dist., with healed blaze.</p>								
	<p>The point for the <math>\frac{1}{4}</math> sec. cor. of sec. 31 only, on the W. bdy. of the Tp., is at midpoint on the W. bdy. of sec. 31.</p> <p>At the corner point</p> <p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <table border="0"> <tr><td> </td><td>T 1 S</td></tr> <tr><td> </td><td><math>\frac{1}{4}</math> S 31</td></tr> <tr><td> </td><td>R 26 W</td></tr> <tr><td colspan="2">1972</td></tr> </table> </div> <p>from which</p> <p>A pine, 5 ins. diam., bears N. <math>37\frac{1}{2}^{\circ}</math> E., 41 lks. dist., mkd. <math>\frac{1}{4}</math> S31 BT.</p> <p>A post oak, 9 ins. diam., bears S. <math>31\frac{1}{4}^{\circ}</math> E., 7 lks. dist., mkd. <math>\frac{1}{4}</math> S31 BT.</p> <p>From this point the <math>\frac{1}{4}</math> sec. cor. of sec. 36, T. 1 S., R. 27 W., bears S. <math>0^{\circ}35'</math> W., 0.36 chs. dist., heretofore described.</p>		T 1 S		$\frac{1}{4}$ S 31		R 26 W	1972	
	T 1 S								
	$\frac{1}{4}$ S 31								
	R 26 W								
1972									

## MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey,  
T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas

CHAINS	<p>NOTE.— The general description for the resurvey follows the same pattern as that in the specimen field notes of the original survey.</p>
	<p>NOTE.— Affidavits to be attached to field notes should be typed on regular field note paper in triplicate, with additional copy made for the person giving testimony.</p>
	<p style="text-align: center;">AFFIDAVIT</p> <p>To whom it may concern: I, Charley Ballentine, do hereby state that I am a lifetime resident in the area adjacent to the corner of sections 23, 24, 25, and 26, T. 1 S., R. 26 W., 5th Principal Meridian, Arkansas, and that I have had definite knowledge of the location of this corner for more than 40 years.</p> <p style="text-align: right;">(Signature) _____</p> <p style="text-align: right;">(Date) _____</p>

SPECIMEN  
FIELD NOTES  
OF THE  
DEPENDENT RESURVEY OF  
THE TENTH STANDARD PARALLEL SOUTH  
ON THE SOUTH BOUNDARY OF TOWNSHIP 40 SOUTH, RANGE 100 WEST,  
AND  
THE EAST BOUNDARY AND SUBDIVISIONAL LINES OF  
TOWNSHIP 41 SOUTH, RANGE 100 WEST  
Of the PRINCIPAL Meridian  
In the State of MONTANA

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EXECUTED BY

John Smith, Cadastral Surveyor

Under special instructions dated March 17, 1972, which provided for the surveys included under Group Number 500, approved March 18, 1972, and assignment instructions dated March 20, 1972.

Survey commenced April 1, 1972

Survey completed May 15, 1972

## MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey of T. 41 S., R. 100 W., Prin. Mer., Montana

## CHAINS

The following field notes describe the dependent resurvey of the north boundary, west boundary, and subdivisional lines of Township 41 South, Range 100 West, Principal Meridian, Montana.

The north boundary (Tenth Standard Parallel South) was surveyed by William A. Smith in 1876. The south, east, and west boundaries, and the subdivisional lines were surveyed by Paul D. Bryson in 1876. The east boundary was dependently resurveyed by Floyd A. White in 1957. The south boundary was dependently resurveyed by Albert L. Green in 1962. The corner of sections 21, 22, 27, and 28 was remonumented by Albert L. Green in 1965.

The resurvey was executed in accordance with the specifications set forth in the Manual of Surveying Instructions, 19\_\_, and the Special Instructions for Group No. 500, Montana, dated March 17, 1972.

Preliminary to the resurvey the lines of the original resurvey were retraced and search was made for all corners and other calls of the record. Identified corners were remonumented in their original positions; lost corners were restored and monumented at proportionate positions based on the original record. The retracement data were thoroughly verified and only the true line field notes are given herein.

The directions of lines were determined by the solar transit method, checked by direct solar observations.

The geographic position of the southeast corner of the township, as scaled from the Geological Survey quadrangle map, "LOOKOUT, MONT.," prepared in 1964, is as follows:

Latitude  $44^{\circ} 35.7' N.$  Longitude  $110^{\circ} 15.3' W.$

The mean magnetic declination is  $17^{\circ} 00' E.$

Dependent Resurvey of the Tenth Standard Parallel South,  
on the South Boundary of T. 40 S., R. 100 W.,  
Principal Meridian, Montana

(Restoring the survey executed by William A. Smith in 1876)

Beginning at the stan. cor. of Tps. 40 S., Rs. 99 and 100 W., monumented with a limestone, 26 x 12 x 8 ins., firmly set 12 ins. in the ground, mkd. SC 40S on N, 99W on E, and 100W on W face, from which the remains of the original bearing trees

A stump hole, bears N.  $43^{\circ} E.$ , 54 lks. dist.

A pine stump, 20 ins. diam., bears N.  $21^{\circ} W.$ , 115 lks. dist., with healed blaze.

At the corner point

Set an iron post, 28 ins. long,  $2\frac{1}{2}$  ins. diam., 24 ins. in the ground, with brass cap mkd.

SC  
T 40 S  
R 100 W | R 99 W  
S 36 | S 31

1972

Dependent Resurvey, 10th Stan. Par. S.,  
S. Bdy., T. 40 S., R. 100 W., Prin. Mer., Montana

CHAINS	
	<p>from which new bearing trees</p> <p>A pine, 10 ins. diam., bears N. 35° E., 62 lks. dist., mkd. T40S R99W S31 SC BT.</p> <p>A white oak, 14 ins. diam., bears N. 65½° W., 116 lks. dist., mkd. T40S R100W S36 SC BT.</p> <p>Deposit the mkd. stone alongside the iron post.</p> <p>Cor. is located near bottom of SE slope, about 3 chs. NW of a small creek, course SW.</p> <p>From this point the closing cor. of Tps. 41 S., Rs. 99 and 100 W., bears S. 89°54' E., 5.63 chs. dist., monu- mented with an iron post, 2½ ins. diam., firmly set, pro- jecting 6 ins. above ground, with brass cap mkd. as de- scribed in the official record of the 1957 resurvey of the W. bdy. of T. 41 S., R. 99 W., from which the 1957 bearing trees</p> <p>A pine, 12 ins. diam., bears S. 44° E., 75 lks. dist., mkd. T41S R99W S6 CC BT on unhealed blaze. (Record bearing, S. 45° E.)</p> <p>A pine, 10 ins. diam., bears S. 57 3/4° W., 29 lks. dist., with marks 100W S1 visible on partly healed blaze.</p> <p>Add the marks 1972 on the brass cap.</p> <p>N. 89°57' W., on the S. bdy. of sec. 36, marking and blazing the true line.</p> <p>Asc. over SE slope, through scattering timber and light undergrowth.</p> <p>6.00 Top of ascent; thence over rolling land.</p> <p>7.50 Fence, barbed wire, bears N. 58° W. and S. 58° E.; enter old logged area, edge bears same as fence; desc. SW slope.</p> <p>12.20 Creek, 5 lks. wide, course S. 25° W.; asc. over SE slope.</p> <p>25.80 Top of ascent; desc. over gradual W slope.</p> <p>34.75 The ¼ sec. cor. of sec. 1 only, T. 41 S., R. 100 W., here- inafter described in the field notes of the dependent re- survey of the subdivisional lines of T. 41 S., R. 100 W.</p> <p>35.60 Road, asphalt, 25 lks. wide, bears N. 55° E. and S. 55° W.; enter scattering timber, edge bears same as road.</p> <p>40.10 Point for the stan. ¼ sec. cor. of sec. 36, at proportion- ate dist.; there is no remaining evidence of the original cor.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 6 ins. in the ground to bedrock, encircled by a mound of stone, 5 ft. base, to top of brass cap, mkd.</p> <p style="text-align: center;">SC T 40 S R 100 W <u>¼ S 36</u> 1972</p> <p>from which</p>

## MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey, 10th Stan. Par. S.,  
S. Bdy., T. 40 S., R. 100 W., Prin. Mer., Montana

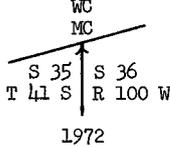
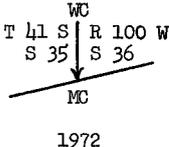
CHAINS										
	<p>A hemlock, 16 ins. diam., bears N. <math>67\frac{3}{4}^{\circ}</math> E., 89 lks. dist., mkd. <math>\frac{1}{4}</math> S36 SC BT.</p> <p>A pine, 10 ins. diam., bears N. <math>22\frac{1}{2}^{\circ}</math> W., 15 lks. dist., mkd. <math>\frac{1}{4}</math> S36 SC BT.</p> <p>Ascend slightly.</p>									
50.10	Spur, slopes S; desc. over SW slope.									
60.20	Draw, drains S; asc. over broken SE slope.									
75.13	Point for the closing cor. of secs. 1 and 2, T. 41 S., R. 100 W., hereinafter described in the field notes of the dependent resurvey of the subdivisional lines of T. 41 S., R. 100 W.									
75.70	Road, unimproved, 15 lks. wide, bears NE and SW.									
80.20	Point for the stan. cor. of secs. 35 and 36, at propor- tionate dist.; there is no remaining evidence of the original cor.									
	<p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <table border="1" style="margin: auto;"> <tr><td></td><td>SC</td><td></td></tr> <tr><td>T 40 S</td><td> </td><td>R 100 W</td></tr> <tr><td>S 35</td><td> </td><td>S 36</td></tr> </table> <p>1972</p> </div> <p>from which</p> <p>A hemlock, 14 ins. diam., bears N. <math>33\frac{1}{2}^{\circ}</math> E., 116 lks. dist., mkd. T40S R100W S36 SC BT.</p> <p>A flat limestone boulder, 6 x 4 ft., projecting 2 ft. above ground, bears N. <math>50\frac{1}{2}^{\circ}</math> W., 85 lks. dist., mkd. X BO at top center.</p> <p>Cor. is located on crest of low ridge bearing NE and SW.</p>		SC		T 40 S		R 100 W	S 35		S 36
	SC									
T 40 S		R 100 W								
S 35		S 36								
	<p>N. <math>89^{\circ}57'</math> W., on the S. bdy. of sec. 35.</p> <p>Desc. over NW slope through heavy young timber.</p>									
5.50	Enter heavy old-growth timber, edge bears NE and SW.									
12.70	NE cor. of log cabin, 20 x 15 ft., bears South, $22\frac{1}{2}$ lks. dist.; long side bears E and W.									
20.10	Lucky Creek, 20 lks. wide, course N. $30^{\circ}$ E.; asc. over broken E slope.									
30.40	Top of ascent; thence over nearly level land through dense undergrowth.									
31.20	East bank of small lake, bears N. $30^{\circ}$ E. and S. $15^{\circ}$ W.									
35.03	True point for the $\frac{1}{4}$ sec. cor. of sec. 2 only, T. 41 S., R. 100 W., falls in lake where it is impracticable to establish a permanent monument.									
35.10	West bank of lake, bears N. $45^{\circ}$ E. and S. $40^{\circ}$ W.; asc. over SE slope through heavy young timber.									
35.53	The witness cor. to the $\frac{1}{4}$ sec. cor. of sec. 2 only,									

Dependent Resurvey, 10th Stan. Par. S.,  
S. Bdy., T. 40 S., R. 100 W., Prin. Mer., Montana

CHAINS	T. 41 S., R. 100 W., hereinafter described in the field notes of the dependent resurvey of the subdivisional lines of T. 41 S., R. 100 W.
40.10	<p>The stan. <math>\frac{1}{4}</math> sec. cor. of sec. 35, monumented with a basalt stone, 12 x 9 x 5 ins., loosely set <math>\frac{1}{4}</math> ins. in the ground, dimly mkd. <math>\frac{1}{4}</math> on N face, from which the remains of an original bearing tree</p> <p>A stump hole, bears N. 20° E., 24 lks. dist., a down pine alongside, 20 ins. diam., with scribe marks S35 SC <math>\frac{1}{4}</math> B visible on opened blaze.</p> <p>At the corner point</p> <p>Set an iron post, 28 ins. long, 2<math>\frac{1}{2}</math> ins. diam., 10 ins. in the ground to solid rock, encircled by a mound of stone, 3 ft. base, to top of brass cap, mkd.</p> <p style="text-align: center;">SC T 40 S R 100 W <u><math>\frac{1}{4}</math> S 35</u> 1972</p> <p>from which</p> <p>A pine, <math>\frac{1}{4}</math> ins. diam., bears N. 30° E., 25 lks. dist., mkd. X BT.</p> <p>A hemlock, <math>\frac{1}{4}</math> ins. diam., bears N. 10° W., 18 lks. dist., mkd. X BT.</p> <p>Deposit the mkd. stone alongside the iron post in the mound of stone.</p>
	<p>NOTE.— The remainder of the field notes of the resurvey of the S. bdy. of T. 40 S., R. 100 W., and the W. bdy. of T. 41 S., R. 100 W., are omitted.</p>
	<p>Dependent Resurvey of the Subdivisional Lines of T. 41 S., R. 100 W., Principal Meridian, Montana</p>
	<p>(Restoring the survey executed by Paul D. Bryson in 1876)</p>
	<p>The cor. of secs. 1, 2, 35, and 36, on the S. bdy. of the Tp., is monumented with an iron post, 2<math>\frac{1}{2}</math> ins. diam., firmly set, projecting 8 ins. above ground, with brass cap mkd. as described in the official record of the 1962 resurvey of the N. bdy. of T. 42 S., R. 100 W., from which the bearing trees mkd. in 1962</p> <p>A white oak, 16 ins. diam., bears N. 35° E., 89 lks. dist., mkd. T41S R100W S36 BT on unhealed blaze.</p> <p>A pine, 12 ins. diam., bears S. 20<math>\frac{1}{2}</math>° E., 75 lks. dist., mkd. T42S R100W S1 BT on unhealed blaze.</p> <p>A pine, 18 ins. diam., bears S. 67° W., 94 lks. dist., mkd. T42S R100W S2 BT on unhealed blaze. (Record bearing, S. 76° W.)</p> <p>A sawed pine stump, 24 ins. diam., bears N. 39° W., 25 lks. dist., with healed blaze.</p>

## MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey, Subdivisional Lines,  
T. 41 S., R. 100 W., Prin. Mer., Montana

CHAINS	
	<p>Add the marks 1972 on the brass cap.</p> <p>Cor. is located on N slope, N. 45° E., 10 lks. dist., from a cor. of fences extending S and W.</p> <p>N. 0°30' W., bet. secs. 35 and 36, marking and blazing the true line.</p> <p>Desc. over N slope, through cleared area.</p>
5.56	<p>Point selected for witness cor. to the meander cor. of secs. 35 and 36, on right bank of the Bighorn River.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;">  <p>WC MC S 35 S 36 T 41 S R 100 W 1972</p> </div> <p>from which</p> <p>A cottonwood, 13 ins. diam., bears S. 40½° E., 27 lks. dist., mkd. X BT.</p> <p>A hemlock, 18 ins. diam., bears S. 29° W., 35 lks. dist., mkd. X BT.</p>
5.80	Present right bank of river, course N. 70° E.
6.10	Point for the meander cor. of secs. 35 and 36, on right bank of river, at proportionate dist., falls in river; there is no remaining evidence of the original cor.
11.40	<p>The meander cor. of secs. 35 and 36, on the eroding left bank of the river, monumented with a washed sandstone boulder, 20 x 15 x 10 ins., firmly set 12 ins. in the ground, mkd. with 1 groove on N and MC on S face, from which an original bearing tree</p> <p>A hemlock stump, 30 ins. diam., bears N. 29° E., 35 lks. dist., with healed blaze.</p> <p>True cor. point not remonumented due to danger of destruction by further erosion of river bank.</p> <hr style="width: 20%; margin: 10px auto;"/> <p>N. 0°58' W., beginning new measurement.</p> <p>Asc. S slope through dense undergrowth.</p>
0.50	<p>Point selected for witness cor. to the meander cor. of secs. 35 and 36, on left bank of Bighorn River.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;">  <p>WC T 41 S R 100 W S 35 S 36 MC 1972</p> </div> <p>from which</p>

Dependent Resurvey, Subdivisional Lines  
T. 41 S., R. 100 W., Prin. Mer., Montana

CHAINS	
	<p>A cottonwood, 12 ins. diam., bears N. <math>75\frac{1}{2}^{\circ}</math> E., 55 lks. dist., mkd. X BT.</p> <p>A cottonwood, 16 ins. diam., bears N. <math>24^{\circ}</math> W., 110 lks. dist., mkd. X BT.</p> <p>Cor. is located at end of a fence extending N. <math>0^{\circ}58'</math> W. Over level cleared land, along fence.</p>
0.80	Abandoned telephone line, bears E and W.
1.00	Road, unimproved, 15 lks. wide, bears E and W.
10.50	Wash, 20 lks. wide, 2 ft. deep, drains NE.
15.50	Enter scattering timber and undergrowth, edge bears E and W; asc. S slope.
27.10	Top of ascent, slopes E; desc. over N slope.
28.75	Point for the $\frac{1}{4}$ sec. cor. of secs. 35 and 36, determined latitudinally by proportionate measurement and longitudi- nally by a fence line extending N and S.
	<p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;">T 41 S R 100 W           <math>\frac{1}{4}</math>           S 35   S 36           1972</p> <p>from which</p> <p>A white oak, 18 ins. diam., bears S. <math>37\frac{1}{2}^{\circ}</math> E., 27 lks. dist., mkd. <math>\frac{1}{4}</math> S36 BT.</p> <p>A pine, 12 ins. diam., bears N. <math>87^{\circ}</math> W., 55 lks. dist., mkd. <math>\frac{1}{4}</math> S35 BT.</p> <p>Cor. is located at S edge of cleared area, edge bears E and W.</p> <p style="text-align: center;">_____</p> <p>N. <math>0^{\circ}21'</math> W., beginning new measurement.</p> <p>Desc. over N slope across cleared area, along fence line extending N and S.</p>
11.05	Fence, barbed wire, bears E and W.
20.05	Point for a witness point on line bet. secs. 35 and 36.
	<p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;">WP T 41 S R 100 W           S 35   S 36           1972</p> <p>Bury a basalt stone, 10 x 8 x 8 ins., mkd. X, at base of iron post.</p> <p>Point is located at cor. of fences extending N, S, and E.</p>

## MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey, Subdivisional Lines  
T. 41 S., R. 100 W., Prin. Mer., Montana

CHAINS	
31.10	Creek, 10 lks. wide, course winding S. 25° E.; asc. across cleared area.
40.10	<p>Point for the cor. of secs. 25, 26, 35, and 36, falls at center line of asphalt-surfaced road, 25 lks. wide, bearing E and W, and in line with fence line to the S. The position was pointed out by local residents, is harmoniously related with other identified original cors. in the area, and is accepted as the best available evidence of the original cor. position.</p> <p>Drive a railroad spike flush with surface of the road, with top mkd. BLM 1972</p> <p>from which</p> <p style="padding-left: 40px;">An iron post, 28 ins. long, 2½ ins. diam., set 24 ins. in the ground, for a reference monument, bears N. 45° E., 73 lks. dist., with brass cap mkd. THIS R100W S25 RM 1972 and an arrow pointing to the cor.</p> <p style="padding-left: 40px;">An iron post, 28 ins. long, 2½ ins. diam., set 24 ins. in the ground, for a reference monument, bears S. 45° W., 85 lks. dist., with brass cap mkd. THIS R100W S35 RM 1972 and an arrow pointing to the cor.</p>
	<p>From the cor. of secs. 25, 30, 31, and 36, on the E. bdy. of the Tp., monumented with an iron post, 2½ ins. diam., firmly set, projecting 8 ins. above ground, with brass cap mkd. as described in the official record of the 1957 resurvey of the W. bdy. of T. 41 S., R. 99 W., from which the remaining bearing trees mkd. in 1957</p> <p style="padding-left: 40px;">A pine, 10 ins. diam., bears S. 37½° E., 57 lks. dist., mkd. THIS R99W S31 BT on unhealed blaze. (Record, 67 lks.)</p> <p style="padding-left: 40px;">A pine, 15 ins. diam., bears S. 87° W., 85 lks. dist., mkd. THIS R100W S36 BT on unhealed blaze.</p> <p>Add the marks 1972 on the brass cap.</p> <p>S. 89°48' W., bet. secs. 25 and 36.</p> <p>Over gently rolling, nearly level land.</p>
9.80	Enter scattering timber and undergrowth; desc. over W slope.
19.95	<p>Point for the E. 1/16 sec. cor. of secs. 25 and 36.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;">E 1/16 <math>\frac{S\ 25}{S\ 36}</math></p> <p style="text-align: center;">1972</p> <p>from which</p> <p style="padding-left: 40px;">A pine, 10 ins. diam., bears N. 20½° E., 75 lks. dist., mkd. E 1/16 S25 BT.</p> <p style="padding-left: 40px;">A white oak, 17 ins. diam., bears S. 75° W., 116 lks. dist., mkd. E 1/16 S36 BT.</p>

Dependent Resurvey, Subdivisional Lines  
T. 41 S., R. 100 W., Prin. Mer., Montana

CHAINS	
	Cor. is located on W slope, 20 lks. N of cor. of old fences extending S and E.
29.10	Fence, barbed wire, bears N and S; enter cleared area.
34.30	Cor. of barbed wire fences extending S and W; thence along fence line.
35.80	Asc. over E slope, across cultivated field.
39.90	Point for the $\frac{1}{4}$ sec. cor. of secs. 25 and 36, at intersection of barbed wire fences extending N, S, E, and W. This is the position of the $\frac{1}{4}$ sec. cor. according to local residents of the area, is harmoniously related to identified original cors., and is accepted as the best available evidence of the original cor. position. No permanent monument established.
	—————
	N. $89^{\circ}55'$ W., beginning new measurement.
	Asc. E slope, along barbed wire fence.
10.50	Cor. of barbed wire fences extending E and S; enter scattering timber and undergrowth.
12.88	Intersect line 1-2 M.S. No. 2332 Gold lode at a point from which cor. No. 2 bears S. $45^{\circ}03'$ E., 7.57 chs. dist., monumented with an aluminum post, 2 ins. diam., firmly set, projecting 2 ins. above ground, with aluminum cap mkd. G-2-2332.
25.77	Intersect line 3-4 M.S. No. 2332 Gold lode at a point from which cor. No. 4 bears N. $45^{\circ}03'$ W., 7.55 chs. dist., monumented with an aluminum post, 2 ins. diam., firmly set, projecting 3 ins. above ground, with aluminum cap mkd. G-4-2332.
30.10	Asphalt-surfaced road, 25 lks. wide, bears N and W.
40.05	The cor. of secs. 25, 26, 35, and 36.
	—————
	N. $0^{\circ}27'$ W., bet. secs. 25 and 26.
	Asc. across cleared area.
11.10	Enter scattering timber and undergrowth, edge bears E and W.
21.73	An original line tree, a pine, 24 ins. diam., in good condition, mkd. with two faint notches each on N and S sides. This now becomes an angle point  from which  An iron post, 28 ins. long, $2\frac{1}{2}$ ins. diam., set 24 ins. in the ground, for a reference monument, bears S. $20^{\circ}30'$ E., 47 lks. dist., with brass cap mkd. AP S25 RM 1972 and an arrow pointing to the cor.  An iron post, 28 ins. long, $2\frac{1}{2}$ ins. diam., set 24 ins. in the ground, for a reference monument, bears N. $47^{\circ}30'$ W., 85 lks. dist., with brass cap mkd. AP S26 RM 1972 and an arrow pointing to the cor.  Line tree is on crest of a low ridge bearing E and W.

## MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey, Subdivisional Lines  
T. 41 S., R. 100 W., Prin. Mer., Montana

CHAINS	
	<p>N. 0°15' W., beginning new measurement.</p> <p>Desc. over steep N slope, through scattering timber and undergrowth.</p>
18.37	<p>Point for the <math>\frac{1}{4}</math> sec. cor. of secs. 25 and 26, at proportionate dist., falls in gully, 15 lks. wide, draining E., where it is impracticable to establish a permanent monument; there is no remaining evidence of the original cor.</p> <p>Asc. over steep S slope, through dense undergrowth.</p>
19.37	<p>Point selected for the witness cor. to the <math>\frac{1}{4}</math> sec. cor. of secs. 25 and 26.</p> <p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <p>WC <math>\frac{1}{4}</math> T 41 S   R 100 W S 26   S 25 ↓ 1972</p> </div>
	<p>Raise a mound of stone, 3 ft. base, 2 ft. high, W of cor.</p> <p>From the witness cor. U.S.C. &amp; G.S. triangulation station "SPRING 1951," bears N. 48°18' W., 2.57 chs. dist., a brass tablet, 3 ins. diam., seated in a concrete monument, 12 ins. sq., projecting 4 ins. above ground.</p>
27.50	<p>Top of ascent; thence over rolling land through scattering small timber.</p>
58.13	<p>Point for the cor. of secs. 23, 24, 25, and 26, at proportionate dist.; there is no remaining evidence of the original cor.</p> <p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <div style="text-align: center;"> <p>T 41 S   R 100 W S 23   S 24 S 26   S 25 ↓ 1972</p> </div>
	<p>from which</p> <ul style="list-style-type: none"> <li>A cedar, 10 ins. diam., bears N. 75<math>\frac{1}{2}</math>° E., 125 lks. dist., mkd. T41S R100W S24 BT.</li> <li>A white oak, 9 ins. diam., bears S. 35<math>\frac{1}{4}</math>° E., 85 lks. dist., mkd. T41S R100W S25 BT.</li> <li>A white oak, 10 ins. diam., bears S. 27° W., 48 lks. dist., mkd. T41S R100W S26 BT.</li> <li>A red oak, 7 ins. diam., bears N. 10° W., 97 lks. dist., mkd. T41S R100W S23 BT.</li> </ul> <p>From this point the cor. of secs. 21, 22, 27, and 28, bears N. 89°51' W., 160.49 chs. dist., monumented with an iron post, <math>2\frac{1}{2}</math> ins. diam., firmly set, projecting 6 ins. above ground, with brass cap mkd. as described in the official record of the 1965 remonumentation, from which the remaining bearing trees mkd. in 1965</p>

Dependent Resurvey, Subdivisional Lines  
T. 41 S., R. 100 W., Prin. Mer., Montana

CHAINS									
	<p>A pine, 14 ins. diam., bears N. <math>55\frac{3}{4}^{\circ}</math> E., 27 lks. dist., mkd. T41S R100W S22 BT on unhealed blaze. (Record, N. <math>45\frac{3}{4}^{\circ}</math> E.)</p> <p>A pine, 18 ins. diam., bears N. <math>87^{\circ}</math> W., 75 lks. dist., mkd. T41S R100W S21 BT on unhealed blaze. (Record, 70 lks.)</p> <p>Add the marks 1972 on the brass cap.</p> <p>The control line was fully retraced, and no evidence of the intervening cors. was found.</p>								
	<p>NOTE.— The tie to and description of the cor. of secs. 21, 22, 27, and 28 is shown here to illustrate the proper form of the field notes when the control line is not resurveyed. When all subdivisional lines are resur- veyed, as in T. 41 S., R. 100 W., the description of lines and corners appears in regular order, and no refer- ence is made to the control corner at this point in the field notes.</p>								
	<p>From the cor. of secs. 19, 24, 25, and 30, on the E. bdy. of the Tp., monumented with an iron post, <math>2\frac{1}{2}</math> ins. diam., firmly set, projecting 6 ins. above ground. The brass cap was erroneously mkd. as a cor. of minimum control for T. 41 S., R. 99 W., in the 1957 resurvey. Add mks. for T. 41 S., R. 100 W.; the cap is now mkd.</p> <table style="margin-left: auto; margin-right: auto;"> <tr><td colspan="2" style="text-align: center;">T 41 S</td></tr> <tr><td style="text-align: center;">R 100 W</td><td style="text-align: center;">R 99 W</td></tr> <tr><td style="text-align: center;">S 24</td><td style="text-align: center;">S 19</td></tr> <tr><td style="text-align: center;">S 25</td><td style="text-align: center;">S 30</td></tr> </table> <p style="text-align: center;">1972 1957</p> <p>from which the only remaining bearing tree mkd. in 1957</p> <p>A pine, 24 ins. diam., bears N. <math>43\frac{3}{2}^{\circ}</math> E., 57 lks. dist., mkd. T41S R99W S19 BT on partly healed blaze.</p> <p>and new bearing trees</p> <p>A pine, 10 ins. diam., bears S. <math>55\frac{3}{4}^{\circ}</math> W., 85 lks. dist., mkd. T41S R100W S25 BT.</p> <p>A pine, 15 ins. diam., bears N. <math>87^{\circ}</math> W., 117 lks. dist., mkd. T41S R100W S24 BT.</p> <p>No suitable bearing tree is available within limits in sec. 30.</p> <p>Cor. is located at cor. of fences extending S and E. N. <math>89^{\circ}57'</math> W., bet. secs. 24 and 25.</p> <p>Asc. over moderate E slope, across cleared area.</p> <p>7.50 Farm road, 15 lks. wide, bears N and S.</p> <p>10.35 Cor. of barbed wire fences extending S and W; thence along fence line.</p> <p>12.50 Crest of ridge, bears N and S; desc. over W slope.</p>	T 41 S		R 100 W	R 99 W	S 24	S 19	S 25	S 30
T 41 S									
R 100 W	R 99 W								
S 24	S 19								
S 25	S 30								

## MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey, Subdivisional Lines  
T. 41 S., R. 100 W., Prin. Mer., Montana

CHAINS	
27.85	Cor. of barbed wire fences extending S and E; leave fence line.
35.10	Enter cultivated area, edge bears N and S.
39.95	Point for the $\frac{1}{4}$ sec. cor. of secs. 24 and 25, at proportionate dist.; there is no remaining evidence of the original cor.  Point falls in cultivated area and was not remonumented, at the request of the owner.
44.95	Leave cultivated area, edge bears N and S; thence through heavy open timber.
57.30	Creek, 5 lks. wide, course N. $10^{\circ}$ E.; asc. E slope through scattering timber and undergrowth.
79.90	The cor. of secs. 23, 24, 25, and 26.
NOTE.— The field notes of the dependent resurvey of the bulk of the subdivision lines in the township follow the same style as shown and are omitted.	
N. $89^{\circ}47'$ W., bet. secs. 6 and 7.	
Over gently rolling land, through scattering timber and undergrowth.	
10.25	Enter cleared area, edge bears N and S.
21.05	Fence, barbed wire, bears N and S.
40.05	Fence, barbed wire, bears N and S.
40.20	Point for the $\frac{1}{4}$ sec. cor. of secs. 6 and 7, at proportionate dist., falls in a gravel-surfaced road, 20 lks. wide, bearing N. $45^{\circ}$ E. and S. $45^{\circ}$ W.; there is no remaining evidence of the original cor.  Set a sandstone, 12 x 10 x 9 ins., mkd. X, 6 ins. below surface of the road  from which
An iron post, 28 ins. long, $2\frac{1}{2}$ ins. diam., set 24 ins. in the ground, for a reference monument, bears N. $45^{\circ}$ W., 57 lks. dist., with brass cap mkd. T4LS R100W S6 RM 1972 and an arrow pointing to the cor.	
An iron post, 28 ins. long, $2\frac{1}{2}$ ins. diam., set 24 ins. in the ground, for a reference monument, bears S. $45^{\circ}$ E., 78 lks. dist., with brass cap mkd. T4LS R100W S7 RM 1972 and an arrow pointing to the cor.	
50.20	Enter scattering timber and undergrowth, edge bears generally N and S; desc. over W slope.
79.50	Intersect the E. bdy. of sec. 1, T. 41 S., R. 101 W.  Point for the closing cor. of secs. 6 and 7.  Set an iron post, 28 ins. long, $2\frac{1}{2}$ ins. diam., 24 ins. in the ground, with brass cap mkd.

Dependent Resurvey, Subdivisional Lines  
T. 41 S., R. 100 W., Prin. Mer., Montana

CHAINS														
	<p style="text-align: center;"> <table border="0" style="margin: auto;"> <tr> <td style="padding-right: 10px;">T 41 S</td> <td style="border-left: 1px solid black; padding-left: 10px;">T 41 S</td> <td></td> </tr> <tr> <td style="padding-right: 10px;">S 1</td> <td style="border-left: 1px solid black; padding-left: 10px;">S 6</td> <td style="padding-left: 10px;">CC</td> </tr> <tr> <td></td> <td style="border-left: 1px solid black; padding-left: 10px;">S 7</td> <td></td> </tr> <tr> <td style="padding-right: 10px;">R 101 W</td> <td style="border-left: 1px solid black; padding-left: 10px;">R 100 W</td> <td></td> </tr> </table> <p style="text-align: center;">1972</p> <p>from which</p> <p style="margin-left: 40px;">A pine, 12 ins. diam., bears N. 35° E., 15 lks. dist., mkd. T41S R100W S6 CC BT.</p> <p style="margin-left: 40px;">A pine, 10 ins. diam., bears S. 77½° E., 27 lks. dist., mkd. T41S R100W S7 CC BT.</p> <p>From this point the original closing cor. of secs. 6 and 7 bears N. 89°47' W., 0.10 chs. dist., monumented with a sandstone, 18 x 15 x 9 ins., firmly set 10 ins. in the ground, mkd. CC on the E, 1 groove on the N, and 5 grooves on the S face. Add the marks AM on E face and bury the stone in place, 6 ins. below surface.</p> <p>From the same point the cor. of secs. 1 and 12, T. 41 S., R. 101 W., heretofore described, bears S. 0°03' E., 1.50 chs. dist.</p> </p>	T 41 S	T 41 S		S 1	S 6	CC		S 7		R 101 W	R 100 W		
T 41 S	T 41 S													
S 1	S 6	CC												
	S 7													
R 101 W	R 100 W													
	<p>The point for the ¼ sec. cor. of sec. 7 only, T. 41 S., R. 100 W., is at midpoint on the W. bdy. of sec. 7.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;"> <table border="0" style="margin: auto;"> <tr> <td style="border-right: 1px solid black; padding-right: 10px;">T 41 S</td> <td></td> </tr> <tr> <td style="border-right: 1px solid black; padding-right: 10px;">¼ S 7</td> <td></td> </tr> <tr> <td style="border-right: 1px solid black; padding-right: 10px;">R 100 W</td> <td></td> </tr> </table> <p style="text-align: center;">1972</p> <p>from which</p> <p style="margin-left: 40px;">A pine, 15 ins. diam., bears S. 78° E., 79 lks. dist., mkd. ¼ S7 BT.</p> <p>No other suitable bearing tree available within limits.</p> <p>From this point the ¼ sec. cor. of sec. 12 only, T. 41 S., R. 101 W., bears S. 0°07' E., 1.35 chs. dist., heretofore described.</p> </p>	T 41 S		¼ S 7		R 100 W								
T 41 S														
¼ S 7														
R 100 W														
	<p>The point for the ¼ sec. cor. of sec. 6 only, T. 41 S., R. 100 W., is at proportionate dist. on the W. bdy. of sec. 6.</p> <p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;"> <table border="0" style="margin: auto;"> <tr> <td style="border-right: 1px solid black; padding-right: 10px;">T 41 S</td> <td></td> </tr> <tr> <td style="border-right: 1px solid black; padding-right: 10px;">¼ S6</td> <td></td> </tr> <tr> <td style="border-right: 1px solid black; padding-right: 10px;">R 100 W</td> <td></td> </tr> </table> <p style="text-align: center;">1972</p> <p>from which</p> <p style="margin-left: 40px;">A pine, 12 ins. diam., bears N. 88° E., 45 lks. dist., mkd. ¼ S6 BT.</p> </p>	T 41 S		¼ S6		R 100 W								
T 41 S														
¼ S6														
R 100 W														

MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey, Subdivisional Lines  
T. 41 S., R. 100 W., Prin. Mer., Montana

CHAINS	
	<p>A white oak, 10 ins. diam., bears S. 78° E., 77 lks. dist., mkd. ¼ S6 BT.</p> <p>From this point the ¼ sec. cor. of sec. 1 only, T. 41 S., R. 101 W., bears S. 0°07' E., 1.27 chs. dist., heretofore described.</p>
	<p>From the cor. of secs. 5, 6, 7, and 8.</p>
	<p>N. 0°10' W., bet. secs. 5 and 6.</p>
	<p>Over gently rolling land, through scattering timber and undergrowth.</p>
10.50	<p>Fence, barbed wire, bears E and W; enter cleared area, edge bears same as fence.</p>
40.05	<p>The ¼ sec. cor. of secs. 5 and 6, at intersection of barbed wire fences extending E, W, and N. This position is harmoniously related with identified existing original cors. in the area, has long been recognized by owners of the adjacent lands as the cor., and is accepted as the best available evidence of the original cor. position.</p>
	<p>At the corner point</p>
	<p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p>
	<p style="text-align: center;">T 41 S R 100 W ¼ S 6   S 5 1972</p>
	<p>No cor. accessories established, at the request of adjoining landowners.</p>
	<p>N. 0°03' E., beginning new measurement.</p>
	<p>Over gently rolling land, across cleared area, along a barbed wire fence.</p>
19.90	<p>Cor. of barbed wire fences extending E, W, and S; enter scattering timber and undergrowth.</p>
27.90	<p>Desc. NE slope.</p>
38.57	<p>Point for the closing cor. of secs. 5 and 6, on the N. bdy. of the Tp., at proportionate dist.; there is no remaining evidence of the original cor.</p>
	<p>Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd.</p>
	<p style="text-align: center;">T 40 S R 100 W S 31 S 6   S 5 T 41 S R 100 W CC 1972</p>
	<p>from which</p>

Dependent Resurvey, Subdivisional Lines  
T. 41 S., R. 100 W., Prin. Mer., Montana

CHAINS	
	<p>A pine, 8 ins. diam., bears S. 35° E., 37 lks. dist., mkd. T41S R100W S5 CC BT.</p> <p>A pine, 12 ins. diam., bears S. 76° W., 48 lks. dist., mkd. T41S R100W S6 CC BT.</p> <p>Cor. is located at S edge of unimproved road, 15 lks. wide, bears E and W.</p> <p>From this point the stan. cor. of secs. 31 and 32, T. 40 S., R. 100 W., bears S. 89°57' W., 4.85 chs. dist., heretofore described.</p>
	<p>The point for the <math>\frac{1}{4}</math> sec. cor. of sec. 5 only, T. 41 S., R. 100 W., is at midpoint on the N. bdy. of sec. 5.</p> <p>Set an iron post, 28 ins. long, 2<math>\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;"> <math>\frac{1}{4}</math> S 5        T 41 S R 100 W        1972     </p> <p>from which</p> <p>A pine, 10 ins. diam., bears S. 37<math>\frac{1}{2}</math>° E., 55 lks. dist., mkd. <math>\frac{1}{4}</math> S5 BT.</p> <p>A pine, 12 ins. diam., bears S. 78° W., 105 lks. dist., mkd. <math>\frac{1}{4}</math> S5 BT.</p> <p>Cor. is located at S edge of unimproved road, 15 lks. wide, bears E and W.</p> <p>From this point the stan. <math>\frac{1}{4}</math> sec. cor. of sec. 32, T. 40 S., R. 100 W., bears S. 89°57' W., 4.95 chs. dist., heretofore described.</p>
	<p>The point for the <math>\frac{1}{4}</math> sec. cor. of sec. 6 only, T. 41 S., R. 100 W., is at proportionate dist. on the N. bdy. of sec. 6.</p> <p>Set an iron post, 28 ins. long, 2<math>\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;"> <math>\frac{1}{4}</math> S 6        T 41 S R 100 W        1972     </p> <p>from which</p> <p>A pine, 14 ins. diam., bears S. 60° E., 20 lks. dist., mkd. <math>\frac{1}{4}</math> S6 BT.</p> <p>A pine, 15 ins. diam., bears S. 37<math>\frac{1}{2}</math>° W., 89 lks. dist., mkd. <math>\frac{1}{4}</math> S6 BT.</p> <p>Cor. is located at SW side of curve in unimproved field road, 15 lks. wide, bears N and E.</p> <p>From this point the stan. <math>\frac{1}{4}</math> sec. cor. of sec. 31, T. 40 S., R. 100 W., bears S. 89°57' W., 4.70 chs. dist., heretofore described.</p>

## MANUAL OF SURVEYING INSTRUCTIONS

Dependent Resurvey, Subdivisional Lines  
T. 41 S., R. 100 W., Prin. Mer., Montana

CHAINS	
	<p>The point for the E. 1/16 sec. cor. of sec. 6 only, T. 41 S., R. 100 W., is at midpoint bet. the closing cor. of secs. 5 and 6 and the <math>\frac{1}{4}</math> sec. cor. of sec. 6 only, on the N. bdy. of sec. 6.</p> <p>Set an iron post, 28 ins. long, <math>2\frac{1}{2}</math> ins. diam., 24 ins. in the ground, with brass cap mkd.</p> <p style="text-align: center;"><u>E 1/16 S 6</u> 1972</p> <p>Raise a mound of stone, 3 ft. base, 2 ft. high, S of cor.</p> <p>Cor. is located at S edge of unimproved road, 15 lks. wide, bears E and W.</p> <p>From this point the stan. cor. of secs. 31 and 32, T. 40 S., R. 100 W., bears N. <math>89^{\circ}57'</math> E., 15.25 chs. dist., heretofore described.</p>
	<p style="text-align: center;">GENERAL DESCRIPTION</p> <p>The land encompassed in this survey is located about eight miles north of the town of Nugget. The northwest part of section 2, north part of section 3, and northeast part of section 4 are drained by Lucky Creek, a turbulent stream that rises in a small lake in the NW<math>\frac{1}{4}</math> of section 3. The remainder of the township is drained by the Bighorn River, its tributary, Flat Creek, and small tributaries of each, the drainage being generally to the east and southeast. Elevation ranges from about 3,450 feet above sea level where the Bighorn River enters section 36 to 5,275 feet above sea level on the divide between Lucky Creek and Flat Creek drainage.</p> <p>Access is by way of U.S. Highway No. 87, which crosses the center of the township in a north-south direction, an asphalt road that leaves the highway in section 33 and extends into section 25 to the recently closed Gold Lode Mine, an asphalt road extending into the north part of section 1 from the northeast, and numerous unimproved or lightly gravelled roads.</p> <p>There are scattering stands of timber, including pine, white and red oak, hemlock, cedar, and cottonwood, the predominate species being pine. The remainder of the township is naturally open or has been cleared. The undergrowth consists of young timber, sagebrush, and ceanothus (snow brush). There is a good cover of native grasses in uncultivated areas.</p> <p>The principal use of the area is livestock grazing. Public land areas are used for recreation by rockhounds, hunters, hikers, campers, and picnickers.</p> <p>The only improvements noted were buildings at the Gold Lode Mine in section 25, a few small cabins, fencing, and a small farm that extends into section 25 from the east.</p> <p>The only mineral noted was on the line between sections 25 and 36, near the Gold Lode Mine.</p> <p>The mean of a considerable number of observations of the magnetic declination throughout the township is <math>17^{\circ}00'</math> E., with a range of <math>1^{\circ}10'</math> in local attraction.</p>

SPECIMEN  
FIELD NOTES

MINERAL SURVEY NO. 20220 A AND B

COLORADO

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FIELD NOTES

OF THE SURVEY OF THE MINING CLAIM OF  
THE GOLD MINING COMPANY

KNOWN AS THE JIM DANDY, PRINCE, AND  
PROTECTOR LODES AND DUMP MILLSITE

Cottonwood Mining District, Chaffee County

Pueblo Land District

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Sections 7, 8, 17, and 18, Township 16 South, Range 80 West, of the  
Sixth Principal Meridian

Surveyed by H.B. SANDS, Mineral Surveyor, under order dated  
April 9, 1972

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Survey commenced May 10, 1972; completed May 14, 1972.

Address of claimant's agent,  
John Jones, 561 Foster Building, Denver, Colorado

Dates of amended locations: Protector lode, June 16, 1971;  
Prince lode, August 10, 1971.

Dates of locations: Jim Dandy lode, July 26, 1932;  
Dump Millsite, August 10, 1971.

Form 9180-22  
(April 1965)  
(formerly 4-693a)

## Mineral Survey No. 20220 A and B

FEET	
	<p>This survey was made with a transit No. , with horizontal limb 5.65 ins. diam., having two double opposite verniers, and full vertical circle 5 ins. diam., having one double vernier; the verniers read to one minute of arc; the eyepiece is equipped with a colored shade set in the dust shutter for making direct observations on the sun. The instrument was in good condition at the time of the survey, and all adjustments were in good order.</p> <p>All azimuths in this record were determined by the method of deflection angles referred to the meridian determined by the following observation:</p> <p>May 10, 1972, at Cor. No. 1 of the Jim Dandy lode, in latitude <math>38^{\circ}45'</math> N., and longitude <math>106^{\circ}20'</math> W., elevation 9,500 ft. above sea level, and temperature <math>50^{\circ}</math> F., make a series of six altitude observations on the sun for azimuth at approximately equal time intervals, three each with the telescope in direct and reversed positions, observing opposite limbs of the sun, and reading the horizontal angle from a reference point about 600 ft. southward SE. to the sun.</p> <p>Mean time of observation, 105th meridian standard time = <math>8^{\text{h}}15^{\text{m}}</math> a.m.  Declination of sun at mean time of observation = <math>17^{\circ}45'27.4''</math> N.  Mean observed vertical angle to sun's center = <math>37^{\circ}59'30''</math>  Mean horizontal angle from reference point to sun's center = <math>74^{\circ}10'</math> S-E.  True bearing to reference point = S. <math>8^{\circ}20'</math> E.</p> <p>The lines were measured with a steel tape 300 ft. in length, graduated every foot for 100 ft., and the remainder at intervals of 10 ft.; and a steel tape 10 ft. in length, graduated to feet, tenths, and hundredths; both tapes were compared with a standard tape at the time of beginning the survey, and found to be correct.</p> <p>All lines and connections of this survey were run by direct methods where the lines are accessible; the inaccessible lines were run by traverse methods, as shown by the calculation sheets herewith submitted.</p> <p>The magnetic declination observed at each corner of the survey gave a uniform value of <math>15^{\circ}30'</math> E.</p>
	Mineral Survey No. 20220 A
	JIM DANDY LODE
	<p>At Cor. No. 1 of the Jim Dandy lode, identical with Cor. No. 1 of the Prince lode of this survey.</p> <p>Set a granite stone, 26 x 10 x 8 ins., 14 ins. in the ground to bedrock, surrounded by a mound of stone to top, mkd. JD-1-PRI-1-20220A; from which</p> <p>The cor. of secs. 7, 8, 17, and 18, T. 16 S., R. 80 W., 6th Prin. Mer., bears S. <math>55^{\circ}40'</math> W., 212.5 ft. dist.; monumented with an iron post, 2 ins. diam., 12 ins. above ground, firmly set, with brass cap properly mkd., and with a mound of stone, 3 ft. base, 2 ft. high, W of cor.</p>

(This form bound at top)

Form 9180-22  
(April 1965)  
(formerly 4-693a)

## Mineral Survey No. 20220 A

FEET	
	<p>Cor. No. 1, M.S. No. 19557 Alley lode, bears N. 55°19' W., 360.0 ft. dist.</p> <p>Cor. No. 1, M.S. No. 19142 I.X.L. lode, claimant herein, bears S. 49°48' W., 642.7 ft. dist.</p> <p>Cor. No. 3, M.S. No. 18837 C.O.D. lode, bears N. 58°45' E., 208.47 ft. dist.</p> <p>A yellow pine, 14 ins. diam., bears N. 10°00' E., 38.3 ft. dist., mkd. JD-1-20220A BT.</p> <p>A distant peak, known as Barren Mt., bears N. 55°57' W.</p> <p style="text-align: center;">Thence N. 28°50' W.</p>
170.28	Intersect line 3-4, M.S. No. 19142 I.X.L. lode, at a point from which Cor. No. 3 bears N. 61°27' E., 871.43 ft. dist.
301.30	Lode line; discovery point bears N. 50°23' E., 496.0 ft. dist.
370.28	Intersect line 4-1, M.S. No. 19557 Alley lode, at a point from which Cor. No. 4 bears N. 44°30' E., 1,332.42 ft. dist.
456.67	Intersect line 4-1 Protector lode of this survey.
535.90	<p>Cor. No. 2, identical with Cor. No. 2 of the Prince lode of this survey.</p> <p>Set an iron post, 3 ft. long, 2 ins. diam., 24 ins. in the ground, and in a mound of stone, 3 ft. base, to top, with brass cap mkd. JD-2-PRI-2-20220A; from which</p> <p style="padding-left: 40px;">A granite rock in place, 46 x 34 ins., 26 ins. above ground, bears S. 24°00' E., 10.5 ft. dist., mkd. X BO-JD-2-20220A.</p> <p style="text-align: center;">Thence N. 50°23' E.</p>
679.32	Intersect line 3-4 Protector lode of this survey.
1,150.19	Intersect line 4-1, M.S. No. 20062 Copper lode, at a point from which Cor. No. 4 bears S. 59°25' E., 94.5 ft. dist.
1,230.73	Intersect line 1-2, M.S. No. 12071 Major lode, at a point from which Cor. No. 2 bears S. 11°00' E., 101.3 ft. dist.
1,291.67	Intersect line 3-4, M.S. No. 19557 Alley lode, at a point from which Cor. No. 4 bears S. 45°30' E., 26.31 ft. dist.
1,500.00	<p>Cor. No. 3.</p> <p>On line 3-4, M.S. No. 20062 Copper lode.</p> <p>On granite bedrock outcrop, even with the general surface, point for Cor. No. 3, mkd. X JD-3-20220A; from which</p> <p style="padding-left: 40px;">Cor. No. 4, M.S. No. 20062 Copper lode, bears S. 34°45' W., 330.0 ft. dist.; identical with Cor. No. 2, M.S. No. 12071 Major lode.</p> <p style="padding-left: 40px;">A silver spruce, 16 ins. diam., bears N. 40°00' E., 47.5 ft. dist., mkd. JD-3-20220A BT.</p> <p style="text-align: center;">Thence S. 28°50' E.</p>

(This form bound at top)

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## Mineral Survey No. 20220 A

FEET	
234.60	Lode line; discovery point bears S. 50°23' W., 1,004.0 ft. dist.
241.90	Intersect line 2-3, M.S. No. 12071 Major lode, at a point from which Cor. No. 2 bears S. 79°00' W., 310.46 ft. dist.
404.50	Intersect line 1-2, M.S. No. 19910 Golden lode, claimant herein, at a point from which Cor. No. 1 bears S. 47°12' W., 620.0 ft. dist.
535.90	Cor. No. 4.  This cor. falls on a rock slide where a permanent monument cannot be established; from this point Cor. No. 1, M.S. No. 19910 Golden lode, bears S. 59°26' W., 601.9 ft. dist.  Thence S. 50°23' W.
99.66	A point on top of a granite boulder, 48 x 26 ins., 36 ins. above ground, for witness Cor. No. 4, mkd. X-WC-JD-4-20220A.
612.92	Intersect Cor. No. 3, M.S. No. 19142 I.X.L. lode, established on line 6-1, M.S. No. 19910 Golden lode, at a point from which Cor. No. 1 bears N. 28°33' W., 96.46 ft. dist.
1,500.00	Cor. No. 1, and place of beginning.
PRINCE LODE	
	Beginning at Cor. No. 1 of the Prince lode, identical with Cor. No. 1 of the Jim Dandy lode of this survey.  Thence N. 28°50' W.
170.28	Intersect line 3-4, M.S. No. 19142 I.X.L. lode, at a point from which Cor. No. 4 bears S. 61°27' W., 628.57 ft. dist.
267.95	Lode line; discovery point bears S. 42°25' W., 849.0 ft. dist.
370.28	Intersect line 4-1, M.S. No. 19557 Alley lode, at a point from which Cor. No. 1 bears S. 44°30' W., 167.58 ft. dist.
456.67	Intersect line 4-1 Protector lode of this survey.
535.90	Cor. No. 2, identical with Cor. No. 2 of the Jim Dandy lode of this survey.  Thence S. 41°58' W.
215.30	Intersect line 1-2, M.S. No. 19557 Alley lode, at a point from which Cor. No. 1 bears S. 45°30' E., 149.14 ft. dist.
356.	Center of road, 16 ft. wide, bears N. 15° W. and S. 15° E.
598.76	Intersect line 1-2, M.S. No. 4923 Idella lode, at a point from which Cor. No. 1 bears N. 24°48' E., 399.35 ft. dist.
756.32	Intersect line 4-1 Protector lode of this survey.
891.	Left bank of Chalk Creek, 18 ft. wide, course S. 42° E.
930.	Center of road, 16 ft. wide, bears N. 40° W. and S. 40° E.
1,504.00	Cor. No. 3.

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Mineral Survey No. 20220 A

FEET	
	<p>Set a schist rock, 28 x 10 x 6 ins., 18 ins. in the ground, mkd. PRI-3-20220A; from which</p> <p>A silver spruce, 14 ins. diam., bears N. 10°00' E., 15.0 ft. dist., mkd. PRI-3-20220A BT.</p> <p>A yellow pine, 26 ins. diam., bears S. 45°00' E., 22.5 ft. dist., mkd. PRI-3-20220A BT.</p> <p>A cor. of the location bears N. 28°50' W., 12.5 ft. dist.</p> <p style="text-align: center;">Thence S. 28°50' E.</p>
255.45	Lode line; discovery point bears N. 42°25' E., 651.0 ft. dist.
331.80	Intersect line 1-2, M.S. No. 4923 Idella lode, at a point from which Cor. No. 1 bears N. 24°48' E., 1,461.0 ft. dist.
507.30	<p>Cor. No. 4.</p> <p>Set a brass tablet, 3¼ ins. diam., 3½-in. stem, in a concrete post, 24 ins. long, 6 ins. sq., 16 ins. in the ground, with top mkd. PRI-4-20220A; from which</p> <p>Cor. No. 2, M.S. No. 4923 Idella lode, bears N. 38°50' W., 157.72 ft. dist.</p> <p>A point on granite bedrock outcrop, even with the general surface, bears S. 26°00' E., 20.0 ft. dist., mkd. X BO-PRI-4-20220A.</p> <p>A cor. of the location bears S. 28°50' E., 16.1 ft. dist.</p> <p style="text-align: center;">Thence N. 43°00' E.</p>
220.00	Cor. No. 2 Dump Millsite of this survey.
480.	Creek, 2 ft. wide, course N.
665.	Center of road, 16 ft. wide, bears N. 55° W. and S. 55° E.
772.	Right bank of Chalk Creek, 16 ft. wide, course S. 47° E.
880.00	Cor. No. 1 Dump Millsite of this survey.
1,084.80	Intersect line 1-2, M.S. No. 19142 I.X.L. lode, at a point from which Cor. No. 1 bears S. 61°27' W., 240.5 ft. dist.
1,108.	Center of road, 16 ft. wide, bears N. 42° W. and S. 42° E.
1,237.60	Intersect the line bet. secs. 17 and 18 at a point from which cor. of secs. 7, 8, 17, and 18 bears North, 68.3 ft. dist., heretofore described. Enter patented land.
1,331.00	Intersect the line bet. secs. 8 and 17 at a point from which cor. of secs. 7, 8, 17, and 18 bears N. 89°59' W., 63.7 ft. dist. Leave patented land.
1,494.90	Cor. No. 1, and place of beginning.
	<p>PROTECTOR LODE</p> <p>Beginning at Cor. No. 1 of the Protector lode.</p> <p>A point on top of a granite rock in place, 56 x 14 ins.</p>

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## Mineral Survey No. 20220 A

FEET	
	<p>18 ins. above ground, mkd. X PRO-1-20220A; from which</p> <p>The cor. of secs. 7, 8, 17, and 18, bears N. 88°16' E., 640.1 ft. dist., heretofore described.</p> <p>Cor. No. 1 of the Jim Dandy and the Prince lodes of this survey, bears N. 80°19' E., 827.1 ft. dist.</p> <p>Thence N. 42°11' W.</p>
245.44	Intersect line 3-4, M.S. No. 4923 Idella lode, at a point from which Cor. No. 4 bears N. 24°48' E., 518.26 ft. dist.
300.00	Lode line; discovery point bears N. 47°49' E., 73.0 ft. dist.
310.	Left bank of Chalk Creek, 20 ft. wide, course S. 2° E.
600.00	<p>Cor. No. 2.</p> <p>Set an iron post, 3 ft. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd. PRO-2-20220A; from which</p> <p>Cor. No. 4, M.S. No. 4923 Idella lode, bears N. 65°29' E., 500.6 ft. dist.</p> <p>Cor. No. 2, M.S. No. 20100 Silver lode, claimant herein, bears N. 39°44' E., 381.6 ft. dist.</p> <p>A yellow pine, 12 ins. diam., bears N. 20°00' W., 35.0 ft. dist., mkd. PRO-2-20220A BT.</p> <p>A yellow pine, 14 ins. diam., bears S. 51°00' W., 22.0 ft. dist., mkd. PRO-2-20220A BT.</p> <p>Thence N. 47°49' E.</p>
70.	Right bank of Chalk Creek, 19 ft. wide, course S. 30° E.
557.88	Intersect line 1-2, M.S. No. 20100 Silver lode, at a point from which Cor. No. 2 bears S. 64°25' W., 187.91 ft. dist.
625.	Center of road, 16 ft. wide, bears N. 22° W. and S. 22° E.
1,390.00	A point 5 ft. above the base of a granite cliff, 120 ft. high, facing S. 10° E., for witness Cor. No. 3, mkd. X WC-PRO-3-20220A.
1,500.00	<p>Cor. No. 3.</p> <p>This cor. falls at an inaccessible point on the cliff, described above, where a monument cannot be established.</p> <p>Thence S. 42°11' E.</p>
40.	Base of cliff, bears N. 82° E. and S. 80° W.
280.77	Intersect line 1-2, M.S. No. 20100 Silver lode, at a point from which Cor. No. 2 bears S. 64°25' W., 1,170.98 ft. dist.
300.00	Lode line; discovery point bears S. 47°49' W., 1,427.0 ft. dist.
342.02	Intersect line 2-3, M.S. No. 19557 Alley lode, at a point from which Cor. No. 2 bears S. 44°30' W., 903.05 ft. dist.
553.30	Intersect line 2-3 Jim Dandy lode of this survey.

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## Mineral Survey No. 20220 A

600.00	<p>Cor. No. 4.</p> <p>Set a granite stone, 25 x 10 x 9 ins., 16 ins. in the ground, mkd. PRO-4-20220A; from which</p> <p style="padding-left: 40px;">Cor. No. 4, M.S. No. 19557 Alley lode, bears N. 48°28' E., 613.35 ft. dist.</p> <p>No local bearing objects or bearing trees available.</p> <p style="padding-left: 40px;">Thence S. 47°49' W.</p>
696.94	Intersect the common line 1-2 Jim Dandy and Prince lodes of this survey.
889.61	Intersect line 1-2, M.S. No. 19557 Alley lode, at a point from which Cor. No. 2 bears N. 45°30' W., 206.06 ft. dist.
1,054.	Center of road, 16 ft. wide, bears N. 15° W. and S. 15° E.
1,312.10	Intersect line 1-2, M.S. No. 4923 Idella lode, at a point from which Cor. No. 1 bears N. 24°48' E., 440.63 ft. dist.
1,431.05	Intersect line 2-3 Prince lode of this survey.
1,500.00	Cor. No. 1, and place of beginning.
Mineral Survey No. 20220 B	
DUMP MILLSITE	
At Cor. No. 1 of the Dump Millsite, on line 4-1 Prince lode of this survey.	
Set a brass tablet, 3¼ ins. diam., 3½-in. stem, in a concrete post, 24 ins. long, 6 ins. sq., 16 ins. in the ground, surrounded by a mound of stone, 3 ft. base, to top, mkd. DMS-1-20220B; from which	
<p style="padding-left: 40px;">The cor. of secs. 7, 8, 17, and 18, bears N. 36°28' E., 410.3 ft. dist., heretofore described.</p> <p style="padding-left: 40px;">Thence S. 43°00' W.</p>	
92.	Left bank of Chalk Creek, 16 ft. wide, course S. 47° E.
215.	Center of road, 16 ft. wide, bears N. 55° W. and S. 55° E.
400.	Creek, 2 ft. wide, course N.
660.00	Cor. No. 2, on line 4-1 Prince lode of this survey.
A yellow pine, 18 ins. diam., mkd. DMS-2-20220B; from which	
<p style="padding-left: 40px;">A yellow pine, 18 ins. diam., bears S. 80°00' E., 17.5 ft. dist., mkd. DMS-2-20220B BT.</p> <p style="padding-left: 40px;">Thence S. 47°00' E.</p>	
220.	Creek, 2 ft. wide, course N. 50° E.
330.00	Cor. No. 3.
Set a granite stone, 24 x 14 x 8 ins., 12 ins. in the ground to bedrock, surrounded by a mound of stone, 3 ft. base, to top, mkd. DMS-3-20220B.	

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## MANUAL OF SURVEYING INSTRUCTIONS

## Mineral Survey No. 20220 B

FEET	
	No local bearing objects or bearing trees available. Thence N. 43°00' E.
390.	Center of road, 16 ft. wide, bears N. 40° W. and S. 40° E.
425.	Right bank of Chalk Creek, 23 ft. wide, course S. 35° E.
660.00	Cor. No. 4.  Set a granite stone, 26 x 10 x 8 ins., 14 ins. in the ground to bedrock, surrounded by a mound of stone to top, mkd. DMS-4-20220B; from which  A yellow pine, 16 ins. diam., bears N. 15°00' E., 20.5 ft. dist., mkd. DMS-4-20220B BT.  Thence N. 47°00' W.
330.00	Cor. No. 1, and place of beginning.  The Dump Millsite contains 5.00 acres.

## Mineral Survey No. 20220 A and B

AREAS	Acres
Total area, Jim Dandy lode -----	18.129
Area in conflict with -----	
Tract A, hereinafter described -----	0.450
M.S. No. 12071 Major lode -----	1.095
M.S. No. 19142 I. X. L. lode -----	1.708
M.S. No. 19557 Alley lode -----	2.815
M.S. No. 19557 Alley lode, exclusive of its conflict with M.S. No. 12071 Major lode -----	2.767
M.S. No. 19910 Golden lode -----	1.572
M.S. No. 19910 Golden lode, exclusive of its conflict with Tract A -----	1.122
M.S. No. 20062 Copper lode -----	0.357
M.S. No. 20062 Copper lode, exclusive of its conflict with: (1) M.S. No. 12071 Major lode -----	0.082
(2) M.S. No. 19557 Alley lode -----	0.246
(3) M.S. Nos. 12071 and 19557 Major and Alley lodes -----	0.030
Total area, Prince lode -----	17.008
Area in conflict with -----	
NW ¼ NW ¼ sec. 17 -----	0.050
M.S. No. 4923 Idella lode -----	3.258
M.S. No. 19142 I. X. L. lode -----	3.744
M.S. No. 19142 I. X. L. lode, exclusive of its conflict with NW ¼ NW ¼ sec. 17 -----	3.694
M.S. No. 19557 Alley lode -----	0.675
Total area, Protector lode -----	20.661
Area in conflict with -----	
M.S. No. 4923 Idella lode -----	3.826
M.S. No. 19557 Alley lode -----	4.776
M.S. No. 20100 Silver lode -----	3.036
Jim Dandy lode of this survey -----	0.981
Jim Dandy lode of this survey, exclusive of its conflict with M.S. No. 19557 Alley lode -----	0.000
Prince lode of this survey -----	0.650
Prince lode of this survey, exclusive of its conflict with (1) M.S. No. 4923 Idella lode -----	0.628
(2) M.S. No. 19557 Alley lode -----	0.342
(3) M.S. No. 4923 and 19557 Idella and Alley lodes -----	0.320
Total area, Dump Millsite -----	5.000

## Mineral Survey No. 20220 A and B

TRACT A	
<p>That portion of M.S. No. 19910 Golden lode in conflict with Jim Dandy lode of this survey, excluded by said Golden lode in favor of a location now abandoned, is bounded and described as follows:</p> <p>Beginning at Cor. No. 4 Jim Dandy lode —            Thence N. 28°50' W., 131.4 ft., to line 1-2 Golden lode;            Thence S. 47°12' W., 275.6 ft., to a point on same line;            Thence N. 79°00' E., 237.6 ft., to line 4-1 Jim Dandy lode;            Thence N. 50°23' E., 42.0 ft., to place of beginning.</p> <p>Tract A contains 0.450 acres.</p>	
LOCATION	
<p>This survey is located in the SE <math>\frac{1}{4}</math> sec. 7, SW <math>\frac{1}{4}</math> sec. 8, NW <math>\frac{1}{4}</math> sec. 17, and NE <math>\frac{1}{4}</math> sec. 18, of T. 16 S., R. 80 W., Sixth Principal Meridian.</p> <p>The survey of the Jim Dandy and Protector lodes and the Dump Millsite is identical with the respective location or amended location as marked on the ground. The survey of the Prince lode is wholly within the amended location as marked on the ground; Cors. Nos. 1 and 2 are identical with corners of the location; Cors. Nos. 3 and 4 differ to the extent previously shown.</p>	
EXPENDITURES	
<p>The improvements and the value of the labor and improvements made upon or for the benefit of each of the lode locations embraced in said mining claim by the claimant or its grantors are as follows:</p>	
No. 1	<p>The discovery cut of the Jim Dandy lode, the face of which being the discovery point, is on the lode line 496 ft. from a point on line 1-2, 301.3 ft. from Cor. No. 1; 6 ft. wide, 15 ft. face, runs N. 50°23' E., 30 ft. to face and portal of tunnel, 5 x 7 ft. in size, running N. 50° E., 23 ft. to breast; at breast is a winze, 5 x 5 ft., 20 ft. deep; tunnel and winze timbered.</p> <p>Value of cut, tunnel, and winze, \$380.</p>
No. 2	<p>A tunnel, 5 x 7 ft. in size, the portal of which bears N. 70°57' E., 373.5 ft. from Cor. No. 2 Jim Dandy lode, and runs N. 51°03' E., 148 ft., thence N. 31°45' E., 17.5 ft., thence N. 50°31' E., 49 ft. to breast; partly caved.</p> <p>Value, \$2,300.</p>
No. 3	<p>A trench, the west end of which bears N. 38°12' E., 395 ft. from Cor. No. 1 Jim Dandy lode; 4 ft. wide, 8 ft. deep, running N. 48° E., 40 ft.</p> <p>Value, \$125.</p>
No. 1	<p>The discovery cut of the Prince lode, the face of which being the discovery point, is on the lode line 849 ft., S. 42°25' W. from the center of line 1-2; 6 ft. wide, 13 ft. face; running N. 42°25' E., 20 ft. to face.</p> <p>Value, \$100.</p>
No. 2	<p>A shaft, the center of which bears N. 20°42' E., 450 ft. from Cor. No. 4 Prince lode; 4 x 7 ft., 3 ft. deep.</p> <p>Value, \$130.</p>
No. 1	<p>The discovery shaft of the Protector lode, the center of which being the discovery point, is on the center line 73 ft. from the center of line 1-2; 6 x 8 ft., 18 ft. deep, partly timbered.</p>

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Value, \$200.

An interest in a common improvement described as follows:

A tunnel, 6 x 7 ft. in size, the portal of which bears S. 34°00' W., 668 ft. from Cor. No. 1 Prince lode; running N. 3°30' E., 230 ft. to Sta. 1; thence N. 23°30' E., 280 ft. to pt. A and 350 ft. to Sta. 2; thence N. 7°45' E., 19 ft. to pt. B, 100 ft. to pt. C, and 210 ft. to breast at date of survey. At pt. A, a drift, 5 x 7 ft. in size, runs N. 74°30' E., 55.6 ft. to breast. At pt. B, a drift, 5 x 7 ft. in size, runs N. 58° E., 70.8 ft. to breast and foot of raise, 5 x 5 ft., 16 ft. high. At pt. C is the beginning of a stope, 70 ft. long, 4 ft. wide, and averaging 30 ft. in height.

Value of tunnel, drifts, raise, and stope, \$14,200.

Value of one-eighth interest, \$1,775.

This improvement is in course of construction for the development of the three lodes of this survey and M.S. No. 19142 I. X. L. lode, M.S. No. 19910 Golden lode, M.S. No. 20100 Silver lode, and the Lead King and Daisy lodes, unsurveyed, which are all the contiguous lode claims owned in common within the range of benefit of said tunnel.

The surface rises rapidly to the north and east from the portal of the tunnel, and the extension in its present course, with necessary laterals, affords the most practical and economical means of developing each of the stated lodes at depth.

Five hundred dollars or over has been expended in this improvement in such a manner as tends to the development of each lode of this survey subsequent to its location and to the time since which common ownership and contiguity have prevailed; therefore an undivided one-eighth interest in its value is hereby credited to each of said lodes and a like interest apportioned to each of the other stated lodes of the common group.

The first 165 ft. of this tunnel, valued at \$2,400 was credited to M.S. No. 19142 I. X. L. lode.

An undivided one-half interest in the first 290 ft., valued at \$2,200, was credited to M.S. No. 19910 Golden lode.

An undivided one-fifth interest in the first 510 ft., valued at \$1,520, was credited to M.S. No. 20100 Silver lode.

Except as above stated, no portion of or interest in this improvement has been credited heretofore as patent expenditure to any lode claim.

OTHER IMPROVEMENTS

A cut, 6 ft. wide, the face of which bears S. 17°42' W., 402 ft. from Cor. No. 2 Prince lode, runs East, 20 ft., to 12 ft. face.

A shaft, 4 x 6 ft., 10 ft. deep, the center of which bears N. 37°17' E., 318 ft. from Cor. No. 1 Jim Dandy lode.

Claimant of each unknown.

A plank ore bin, 14 x 20 ft., 3 ft. deep, the north cor. of which bears S. 3°00' W., 210 ft. from Cor. No. 1 Dump Millsite; the long sides bear N. 20° W.

Claimant herein.

A frame compressor house and shop, the NE cor. of which bears S. 25°00' E., 80 ft. from Cor. No. 1 Dump Millsite; 16 x 30 ft. in size; the long sides bear N. 85° W.

Claimant herein.

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A frame bunkhouse, the NE cor. of which bears S. 50°00' W., 690 ft. from Cor. No. 1 Prince lode; 20 x 50 ft. in size; the long sides bear N. 86° W.  
Claimant herein.

A bridge, the east end of which bears S. 3°00' W., 153 ft. from Cor. No. 1 Dump Millsite; of logs and planks, 10 ft. wide and 30 ft. long, bearing N. 50° E.  
Claimant herein.

OTHER CORNER DESCRIPTIONS AND SUPPLEMENTAL DATA

M.S. No. 4923 Idella lode: Cors. Nos. 1, 3, and 4 are monumented with granite stones, firmly set and properly mkd.; Cor. No. 2 is lost. Line 3-4 was found to be approximately correct as approved; line 4-1 was found to be S. 65°05' E., 299.4 ft., instead of S. 65°12' E., 300 ft., as approved; line 1-2 shown as approved. From Cor. No. 1 the cor. of secs. 7, 8, 17, and 18, bears S. 31°56' E., 596.9 ft., instead of S. 33°47' E., 605.0 ft., as approved

M.S. No. 12071 Major lode: Cor. No. 2 is monumented with a pine post, firmly set and properly mkd.; no other cors. could be found. All lines shown as approved. Owing to the absence of Cor. No. 1, the apparent error in the connecting line to the cor. of secs. 7, 8, 17, and 18, could not be verified.

M.S. No. 18837 C. O. D. lode: Cor. No. 3 is monumented with a granite stone, firmly set and properly mkd.

M.S. No. 19142 I. X. L. lode: Cors. Nos. 2, 3, and 4 are monumented with pine posts, firmly set and properly mkd.; Cor. No. 1 could not be found. Lines 2-3 and 3-4 are correct as approved; lines 1-2 and 4-1 are shown as approved.

M.S. No. 19557 Alley lode: Cor. No. 1 is monumented with a pine post and Cor. No. 4 with a granite stone, both firmly set and properly mkd.; Cors. Nos. 2 and 3 are lost. Line 4-1 was found to be S. 44°30' W., 1500.0 ft., instead of S. 44°20' W., 1,500.0 ft., as approved; lines 1-2 and 3-4 are shown at right angles to line 4-1, and each 300 ft. long as approved; this makes line 2-3, N. 44°30' E., instead of N. 44°20' E., as approved, and lines 1-2 and 4-3 each N. 45°30' W., instead of N. 45°40' W., as approved. From Cor. No. 4 of the Alley lode, Cor. No. 2, M.S. No. 12071 Major lode bears S. 21°10' W., 128.7 ft., instead of S. 20°35' W., 136.0 ft., as approved.

M.S. No. 19910 Golden lode: Cors. Nos. 1, 2, and 6 are monumented with granite stones, firmly set and properly mkd. Lines 1-2 and 6-1 are correct as approved.

M.S. No. 20062 Copper lode: Cors. Nos. 1, 2, and 3 are monumented with pine posts, firmly set and properly mkd. Cor. No. 4 is identical with Cor. No. 2, M.S. No. 12071 Major lode, described above. All lines are correct as approved.

M.S. No. 20100 Silver lode: Cors. Nos. 1 and 2 are monumented with granite stones, firmly set and properly mkd. Line 1-2 is correct as approved.

MEMORANDUM

Here explain any allowable disagreement with the location certificate, and show the cause.

FIELD ASSISTANTS

Name	Capacity
_____	_____
_____	_____

MANUAL OF SURVEYING INSTRUCTIONS

CERTIFICATE OF SURVEYOR

Name of Mineral Surveyor	Date
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I HEREBY CERTIFY That in pursuance of an order received from the \_\_\_\_\_, at \_\_\_\_\_, dated \_\_\_\_\_, 19\_\_\_\_, I have carefully executed the survey of the claim of \_\_\_\_\_, known as the (*lode, placer, or mill site*) \_\_\_\_\_, situated in \_\_\_\_\_, Township \_\_\_\_\_, Range \_\_\_\_\_ Meridian, in the State of \_\_\_\_\_.

This survey, designated as number \_\_\_\_\_, has been executed by me and under my direction and has been made in strict conformity with said order, the Manual of Instructions for the Survey of Public Lands of the United States, and in specific manner described in the foregoing field notes.

I FURTHER CERTIFY That the labor expended and improvements made upon and for the benefit of the (*lode or placer*) \_\_\_\_\_ location(s) embraced in the said mining claim by claimant(s) or grantors are fully stated in my report. The character, extent, location, and itemized value are specified in full detail. No portion of, or interest in, said labor and improvements so credited to this claim has been included in the estimate of expenditures upon any other claim.

(Location)	(Signature of Mineral Surveyor)
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CERTIFICATE OF APPROVAL

Office
Location
Date

The foregoing field notes of mineral survey number \_\_\_\_\_, in \_\_\_\_\_,  surveyed  unsurveyed Township \_\_\_\_\_, Range \_\_\_\_\_, Meridian, in the State of \_\_\_\_\_, executed by \_\_\_\_\_, Mineral Surveyor, under order dated \_\_\_\_\_, 19\_\_\_\_, having been critically examined and the necessary corrections made prior to their certification by the surveyor, the field notes and the survey therein described are hereby approved.

(Authorized Signature)	(Title)
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# MINERAL SURVEY No. 20220 A & B COLORADO

CLAIM OF  
**THE GOLD MINING COMPANY**

KNOWN AS THE  
**JIM DANDY, PRINCE AND  
PROTECTOR LODES AND  
DUMP MILL SITE**

SITUATE IN  
Secs. 7, 8, 17, & 18, T. 16 S., R. 80 W., 6th P. M.  
CHAFFEE COUNTY  
Cottonwood Mining District  
Pueblo Land District  
Lat. 38°45'N., Long. 106°20'W., at Cor. No. 1, Jim Dandy



Feet  
Magnetic Declination, 15°30' East.

Surveyed, May 10 to May 14, 1945,  
By H. B. Sands, Mineral Surveyor.

UNITED STATES DEPARTMENT OF THE INTERIOR  
BUREAU OF LAND MANAGEMENT

Public Survey Office

Denver, Colorado,

I hereby certify that this plat of Mineral Survey  
No. 20220 A & B, Colorado, is strictly conformable  
to the field notes of said survey which have been  
examined and approved.

Office Cadastral Engineer

