# *Manual of*

# SURVEYING INSTRUCTIONS

# 1947

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

UNITED STATES DEPARTMENT OF THE INTERIOR
J. A. Krug, Secretary

BUREAU OF LAND MANAGEMENT
Fred W. Johnson, Director

# *Manual of* INSTRUCTIONS FOR THE SURVEY OF THE PUBLIC LANDS OF THE UNITED STATES 1947

PREPARED AND PUBLISHED BY THE
BUREAU OF LAND MANAGEMENT



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THE *Superintendent of Documents, United States Government Printing Office, Washington 25, D. C., has on hand for sale to the public, at the cost of printing, the following publications of the Bureau of Land Management:*

Manual of Instructions for the Survey of the Public Lands of the United States, edition of 1947.

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

Ephemeris of the Sun, Polaris and Other Selected Stars, with companion data and tables, published annually in advance (a supplement to the Manual of Surveying Instructions).

Restoration of Lost or Obliterated Corners and Subdivision of Sections (a supplement to the Manual of Surveying Instructions, for the guidance of county and other local surveyors).

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

Map of the United States showing the Principal Meridians and Base Lines, and the areas governed by each.

## FIELD NOTES AND PLATS

Copies of the approved field notes and plats of the public-land township surveys, and of the mineral-patent, and the private-land-claim patent-surveys, may be procured from the Bureau of Land Management, Washington 25, D. C., also from the regional and public survey offices, or the appropriate State office, as noted in Secs. 9 and 10 herein. A charge is usually made for making copies of records furnished to the public. Opportunity is afforded for the examination of the records as required by the public, and for making copies or extracts therefrom.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

WASHINGTON, *August 5, 1947.*

The Manual of Instructions for the Survey of the Public Lands of the United States is issued for the guidance of all employees who exercise a technical responsibility in the execution of cadastral surveys or resurveys, including the preparation of the field notes and plats thereof, in any manner relating to the public domain. The Manual of 1947 will supersede all previous instructions or regulations on the technical subjects contained therein.

FRED W. JOHNSON,
*Director.*

## PENALTY FOR THE DESTRUCTION OF MONUMENTS

Section 57 of the Criminal Code of 1909 (35 Stat. 1088, 1099; 18 U. S. C. sec. 111), provides a penalty for the unauthorized alteration or removal of any Government survey-monument or marked trees, as follows:

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

## TEXTUAL AND TYPOGRAPHICAL ERRORS

All readers of this Manual are requested to report any errors which may be found herein, addressing the Bureau of Land Management, Washington 25, D. C.

## 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 will include section number. |
| U. S. | United States Reports. Decisions of the Supreme Court of the United States. The early reports include in the title the name of the authorized court reporter. |
| 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. |
| I. D. | Ditto, Vol. 53, and later. |
| C F R | Code of Federal Regulations of the United States of America.<br>Title 43—Public Lands: Interior.<br>This will include the Cumulative Supplement. |

Section numbers, cited herein without other designation, refer to sections in this Manual.

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# THE GENERAL PLAN



## THE MANUAL

**1.** The Manual of Surveying Instructions exemplifies the plan of the cadastral survey of the public lands of the United States. There have been six previous Manuals, each in turn demonstrating improvements in methods, and the newer conditions to be dealt with.

Various regions of the United States have been surveyed under amended or different instructions in periods ranging from 1785 to the present time. The earliest rules were issued in manuscript, and in printed circulars. Regulations more in detail, improving the plan in both accuracy and uniformity, were issued in the Manuals of 1855, 1881, 1890, 1894, 1902, and 1930. This volume will be known as the Manual of 1947.

Surveying 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.

The term "cadastral survey" is applied to the establishment of the land boundaries and subdivisions by the running and marking of the lines that are required by the 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 the approval of the directing authority.

The Manual presents the detail of the plan and methods from the point where the subjects are ordinarily concluded in the text books on surveying. The application to large scale areas requires a thorough understanding of the stellar and solar methods for making the observations by which 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 its angular value will be referred to the true north at that place. The latter subjects are therefore explained and examples given with specific relation to the approved surveying practice. The use, care, and adjustments of the General Land Office solar transit are fully treated because of the great value of this instrument and the necessity for its selection, outclassing as it does all other designs at all suited to the making of the rectangular surveys on cardinal courses.

For many reasons there is much need for extended treatment of the subjects of subdivision of sections, restoration of lost or obliterated corners, resurveys, surveys of many special kinds, and mineral surveys. By their growing importance these subjects indicate much change in the present character of the work, wherein the need is stressed for thoroughness in the identification and perpetuation of the surveys already created, properly to mark the boundaries of the public land remaining undisposed of.

The Manual is for the guidance of the employees of the Bureau of Land Management. To all others this surveying practice should be regarded as advisory, with no attempt to interpret State law respecting the survey of private property.

## THE PUBLIC DOMAIN

**2.** The survey of the public lands has been inseparably associated with the many questions of title relating to the lands which were turned over to the Federal Government by the Colonial States, also in similar relation to those larger areas that were acquired later by purchase from, or treaty with the native Indians, or with the foreign powers that had previously exercised the sovereignty. The term "public lands" has been applied broadly to this area insofar as the lands have been subject to administration, survey, and transfer of title under the public-land laws of the United States, wherein the jurisdiction is now vested in the Director of the Bureau of Land Management, under the direction of the Secretary of the Interior.

Beginning with the territory northwest of the Ohio River, the public land surveys have been extended, or are now being continued within the 29 States and the Territory of Alaska that has constituted the public domain, and does now constitute the public domain after excluding all valid prior grants of title, and until the transfer of the title by the United States. Supplemental to the establishment of the surveys, the plan includes the necessary retracements for the maintenance or restoration of the monuments where these are becoming or have become obliterated, but this jurisdiction extends only so far as the title is held by the United States.

The title to the vacant lands, and therefore the direction over the surveys, within their own boundaries, was retained by the Colonial States, the other New England and Atlantic Coast States (excepting Florida), and later by the States of West Virginia, Kentucky, Tennessee, and Texas, in which areas the United States public land laws have not been applicable.

## ADMINISTRATION, OR DISPOSAL OF THE TITLE

**3.** After the admission of the States into the Union the United States continued to hold title to the unappropriated lands and to administer its public-land laws with reference thereto. It is expressly provided, as one of the conditions set forth in the various enabling acts, that the title to unappropriated lands within the State shall remain in the United States. The lands in the territories not appropriated by competent authority before they were acquired are in the first instance the exclusive property of the United States, to be administered, or for disposal to such persons, at such times, in such modes, and by such titles as the Government may deem most advantageous to the public. Congress alone has the power, derived from article IV, section 3, of the Constitution, of disposing of the public domain and making all needful rules and regulations in respect thereto.

It comes within the province of the Director to consider and 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; it is a well-settled principle of law that 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

**4.** The beds of navigable bodies of water are not public domain and are not subject to survey and disposal by the United States. The sovereignty is in the individual States. Under the laws of the United States the navigable waters have always been and shall forever remain

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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 the same as navigable water (R. S. sec. 2476).

Tide lands which are covered by the normal daily overflow are not subject to survey as public land. Sections 530, 531, 532.

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 dates of statehood. The opinion of the Supreme Court of the United States establishes the guiding principle, as follows:

> 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. *United States* v. *Holt State Bank*, 270 U. S. 49, 56 (1926).

## SWAMP AND OVERFLOWED LANDS

**5.** In 17 of the 29 States (exceptions—Arkansas, Idaho, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, South Dakota, Utah, Washington, and Wyoming), 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. Section 534.

The Act of March 2, 1849 (9 Stat. 352), granted to the State of Louisiana all the swamp and overflowed lands within the limits of the State for the purpose of aiding in the reclamation of said lands; the Act of September 28, 1850 (9 Stat. 519), extended the grant to the other public-land States then in the Union. The grant was also extended to the States of Minnesota and Oregon by the Act of March 12, 1860 (12 Stat. 3). These various swamp-land grants were carried over into R. S. sec. 2479 (43 U. S. C. sec. 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. sec. 991), by which all right, title, and interest to the remaining unappropriated swamp and overflowed lands reverted to the United States.

The provisions of the grants apply to the elevations situated below the uplands, wherein the lands are of such a character that without the construction of levees or drainage canals the areas would be wet and unfit for agriculture. The grants apply to all swamp and overflowed lands within the States which were unappropriated at the dates of the granting acts, and whose character *at that time* would bring them within the provisions of the grant. Section 535.

## LAWS RELATING TO SURVEYS

**6.** The principal early laws are found (1) in "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; and, (2) in 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). Manual Appendix I.

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 then made applicable as the surveys progressed westward until the general plan became perfected.

The adoption of the rectangular system marked the important transition from the surveying practice that prevailed in the greater part of the Colonial States, where the land grants were defined by irregular metes-and-bounds, each depending more or less on the description of the adjoining tract, known by name or survey number, and mostly without common geographic location other than by reference to some well-known natural object.

There follows below a reference to portions of the Revised Statutes and United States Code devoted especially to the surveying practice, with appropriate modification to reflect current organization of the Bureau of Land Management:

Duties of director

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

Power of director to make regulations.

The Director, under the direction of the Secretary of the Interior, is authorized to enforce and carry into execution every part of the public land laws not otherwise specially provided for (R. S. sec. 2478; 43 U. S. C. sec. 1201).

Rules of survey.

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

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

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

Fourth. The cadastral engineers, 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 cadastral engineers shall carefully note, in their respective field books, the names of the corner trees marked and the numbers so made.

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

Sixth. All lines shall be plainly marked upon trees, and measured with chains, containing two perches of sixteen and 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.[2]

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

Eighth. These field books shall be returned to the regional office and from them a description of the whole lands surveyed shall be made out and transmitted to the officers who may superintend the sales. There shall also be made a fair plat of the townships and fractional parts of townships contained in the lands, describing the subdivisions thereof, and the marks of the corners. This

[1] Authority for the establishment of section lines at intervals of 1 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 by the General Land Office before and after the adoption of the Revised Statutes.

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

plat shall be recorded in books to be kept for that purpose; and a copy thereof shall be kept open at the public survey office for public information, and other copies shall be sent to the places of the sale and to the Bureau of Land Management. (R. S. sec. 2395; Mar. 3, 1925, 43 Stat. 1144; 43 U. S. C. sec. 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 Director 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 Director, shall be established as the proper boundary lines of the sections or subdivisions for which they were intended, and the length of such lines as returned shall be held and considered as the true length thereof. And the boundary lines which have not been actually run and marked shall be ascertained by running straight lines from the established corners to the opposite corresponding corners; but in those portions of the fractional townships, where no such opposite corresponding corners have been or can be fixed, the boundary lines shall be ascertained by running from the established corners due north and south or east and west lines, as the case may be, to the water course, Indian boundary line or other external boundary of such fractional township.

Third. Each section or subdivision of section, the contents whereof have been returned by the Director, 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. sec. 2396; Mar. 3, 1925, 43 Stat. 1144; 43 U. S. C. sec. 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. sec. 2397; 43 U. S. C. sec. 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 be common to both. (R. S. sec. 2476; 43 U. S. C. sec. 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. sec. 2406; 43 U. S. C. sec. 766).

Survey of private land claims.

The Director 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. sec. 2223; Mar. 3, 1925, 43 Stat. 1144; 43 U. S. C. sec. 52).

Penalty for interrupting surveys.

Whoever in any manner, by threats or force, shall interrupt, hinder, or prevent 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, Bureau of Land Management, shall be fined not more than $3,000, and be imprisoned not more than three years. (Act of Mar. 4, 1909, sec. 58, 35 Stat. 1099; 18 U. S. C. sec. 112).

Protection of engineer by marshal of district.

Whenever the President is satisfied that forcible opposition has been offered, or is likely to be offered, to any cadastral engineer in the discharge of his duties in surveying the public lands, it may be lawful for the President to order the marshal of the State or district, by himself or deputy, to attend such engineer with sufficient force to protect such officer in the execution of his duty, and to remove force should any be offered (R. S. sec. 2413; Mar. 3, 1925, 43 Stat. 1144; 43 U.S.C. sec. 774).

## LEGISLATION SUBSEQUENT TO THE REVISED STATUTES

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

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 (35 Stat. 1088, 1099; 18 U. S. C. sec. 111), provides a penalty for the unauthorized alteration or removal of any Government survey-monument or marked trees, as follows:

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

The Act of March 3, 1909 (35 Stat. 845) as amended June 25, 1910 (36 Stat. 884; 43 U. S. C. sec. 772), provides as follows:

Resurvey of public lands.

"That the Secretary of the Interior may, in his discretion, cause to be made, as he may deem wise under the rectangular system now provided by law, such resurveys or retracements of the surveys of public lands as, after full investigation, he may deem essential to properly mark the boundaries of the public lands remaining undisposed of: *Provided*, That no such resurvey or retracement shall be so executed as to impair the bona fide rights or claims of any claimant, entryman, or owner of lands affected by such resurvey or retracement."

The Interior Department appropriation Act of 1911 (June 25, 1910, 36 Stat. 703, 740), provided, under "Surveying the Public Lands":

Selection of surveyors.

"The surveys and resurveys to be made by such competent surveyors as the Secretary of the Interior may select, * * *." This provision of law brought to a close the practice of letting contracts for the making of the public-land surveys.

The Act of September 21, 1918 (40 Stat. 965; 43 U. S. C. sec. 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 cost of the resurvey. The regulations under that act are contained in 43 C. F. R., secs. 281.10 to 281.16.

The Act of May 28, 1926 (44 Stat. 672; 43 U. S. C. secs. 25, 25a, 25b), provides as follows:

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

"That whenever the last United States land office in any State has been or hereafter may be abolished the Secretary of the Interior be, and he is hereby, authorized to transfer to the State within which such United States land office was or is situated such transcripts, documents, and records of the office aforesaid as may not be required for use of the United States and which the State may desire to preserve.

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

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

Provision for safekeeping required.

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

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 new Bureau; the office of the United States Supervisor of Surveys, together with the field surveying service (known as the cadastral engineering service), was abolished and the functions transferred to the Secretary of the Interior.

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 new Bureau of Land Management, the Branch of Engineering and Construction has been created in the headquarters office. In so far as the work of surveying the public lands is concerned, that branch develops programs of required surveys and resurveys and has technical supervision, through the regional administrators, over the administration of such programs by the field organization. The chief of the branch acts as consultant to the Director in the formulation of policies, programs, standards, and procedures of cadastral engineering.

The field activities of the bureau have been grouped in seven regions as outlined in section 9.

## GENERAL RULES

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

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

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

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

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

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

Sixth. That lost or obliterated corners of the approved surveys must be restored to their original locations whenever it is possible to do so. Actions or decisions by surveyors, Federal, State, or local, which may involve the possibility of changes in the established boundaries of patented lands, are subject to review by the State courts upon suit advancing that issue.

These 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" (R. S. 2395; Mar. 3, 1925, 43 Stat. 1144; 43 U. S. C. sec. 751).

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|---|---|---|---|---|---|
| 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 |

In this rectangular plan the township boundaries are to be due north and south or due east and west; these are the cardinal lines of the four principal geographic directions. The boundaries running north and south are termed "range lines"; with few exceptions the range lines are run on cardinal; and have been, or were intended to be on cardinal. The east and west boundaries are called merely "township lines"; these were intended to be on true parallels.

At certain intervals, in the normal order, the township lines are run as standard parallels; the remainder by "random and true line" between established township corners, departing not over 21′ of angle from the cardinal; the locations are controlled primarily by the *measurements* along the range lines. The early methods differed considerably, and frequently resulted in there being established two sets of corners along the township boundaries.

The range lines converge; this becomes manifest in the measurement of the township lines. The convergency is taken up at intervals by the running of standard parallels, on which the measurements are again made full. On the latter "correction lines", as these were first named, there are offsets in the range lines and two sets of corners; "standard corners" for the lines to the north; "closing corners" for the lines to the south. The fractional measurement along a range line when intersecting a standard parallel is placed in the north half-mile, with a lotting in the sections according to that measured length. The usual interval between the standard parallels has been 24 miles, but there were many exceptions in the older surveys.

The range lines are great circles of the earth and, if extended, would intersect at the north pole. The standard parallels and township lines are small circles of the earth, always equidistant, or intended to be, and are parallel to the equator. These features are best illustrated by the cardinal lines on a globe. The solar transit gives the orientation instrumentally, for running these lines. Other methods must be employed for running the parallels of latitude if an instrument without the solar unit is employed.

In order to make the sections "square miles", as nearly as may be, in the usual plan, the meridional lines are run, and for a long time have been run, from south to north and parallel to the east boundary of the township, or intended to be parallel, for a distance of 5 miles counting 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, and within the 21-minute limit.

This produces the rectangular sections; of these 25 contain 640 acres each, within the allowable limit. The sections along the north and west boundaries are subdivided on a plan for certain lottings to absorb the excess or deficiency in the measurements, and the convergency. This is illustrated in the diagram of the normal township. These sections provide a maximum number of aliquot parts, i. e.—160-, 80-, and 40-acre units, or regular subdivisions of a section; the remainder by lottings as shown, whose contents are computed according to the field measurements.

The above completes an outline of the rectangular system. It should be emphasized that errors of the approved surveys cannot be corrected after the title has passed. The technique of making the observations, and the running and measurement of the lines, has of course greatly improved with the modern instruments and practice. Methods are provided, as will be explained in detail in chapter III, by which the discrepancies or inaccuracies of the older surveys are not extended into the new surveys.

## THE REGIONAL AND PUBLIC SURVEY OFFICES

**9.** The direction of the public land surveys is conducted through the regional offices of the Bureau of Land Management, by the regional Branch of Engineering and Construction under the administrative supervision of the regional administrator. The authority over field operations exercised by regional Branch is limited by the regulations and instructions issued by the Director to the regional administrator. One or more public survey offices may be located within each region; each is under the administrative supervision of the regional administrator.

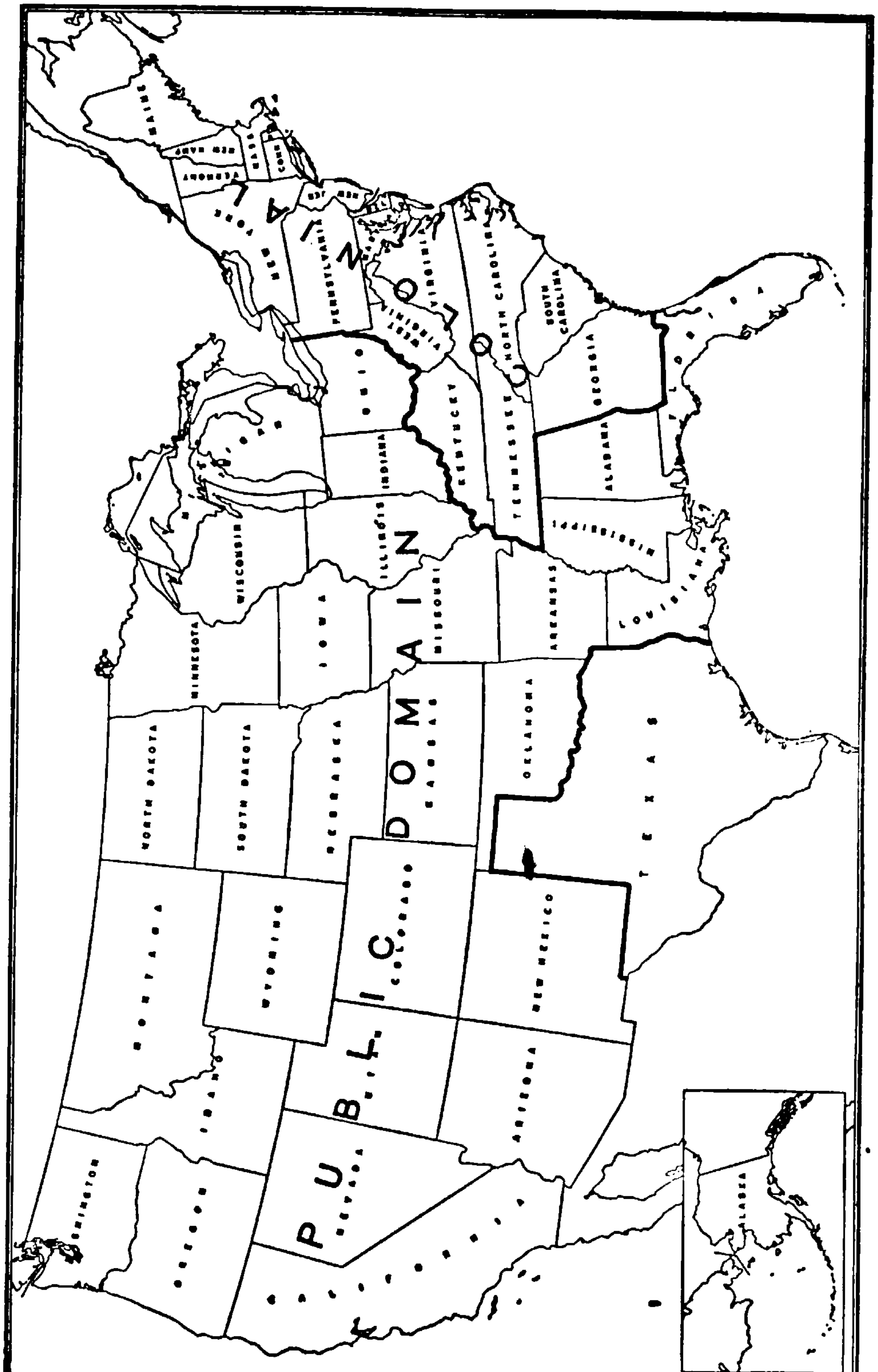
Many changes in the arrangement of surveying districts have been required from time to time, principally to accord with the enlargement of the public domain, to keep up with the progress of settlement, and to take care of major surveying activities of the period, which are now centered in the western states and Alaska. Within this active area, the original records pertaining to the survey and resurvey of the public lands, the mineral-patent surveys, and the private land claims and grants, are filed in the regional field office or public survey office of the state in which the lands are situated. The public survey offices are usually under the administrative charge of an office cadastral engineer.

The field regions of the Bureau of Land Management are as follows:

1. Washington, Oregon, and Idaho, with headquarters at Portland, Oregon.
2. California and Nevada, with headquarters at San Francisco, California.
3. Montana, Wyoming, North Dakota, South Dakota, Nebraska, Kansas, Iowa, and Missouri, with headquarters at Billings, Montana.
4. Utah and Colorado, with headquarters at Salt Lake City, Utah.
5. Arizona, New Mexico, Texas, Oklahoma, Arkansas, and Louisiana, with headquarters at Albuquerque, New Mexico.
6. All the remaining states with headquarters at Washington, D. C.
7. Alaska, with headquarters at Anchorage.

## THE STATE OFFICES

**10.** The original records have been transferred to the States where the public land surveys have been completed, excepting Oklahoma. In most respects duplicate copies are on file in Washington. The




The States created out of the Public Domain.

Director of the Bureau of Land Management exercises all administrative authority in questions relating to the remarking of the boundaries of the remaining public land, where resurvey is required, and in the extension of the surveys to include parcels of public land in any manner heretofore omitted from the official surveys.

The 29 States have been created out of the public domain; their boundary descriptions [3] are given in the enabling acts as cited below, the references being to the United States Statutes at Large, by volume and page.

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

*Arizona.*—Included in the lands ceded by Mexico in 1848 and the Gadsden purchase in 1853; admitted into the Union February 14, 1912 (36 Stat. 557; 37 Stat. 1728); public survey office at Phoenix.

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

*California.*—Ceded by Mexico in 1848 and admitted into the Union September 9, 1850 (9 Stat. 452); public survey office at Glendale; regional office at San Francisco.

*Colorado.*—Acquired largely under the Louisiana Purchase in 1803, but including additional land, title to which was quieted through treaty with Spain in 1819, with other lands annexed with Texas in 1845, and lands ceded by Mexico in 1848; admitted into the Union August 1, 1876 (18 Stat. 474; 19 Stat. 665); public survey office at Denver.

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

*Idaho.*—Acquired with the Oregon Territory, title to which was established in 1846, and admitted into the Union July 3, 1890 (26 Stat. 215); public survey office at Boise.

*Illinois.*—Included in the territory of the original 13 States and admitted into the Union December 3, 1818 (3 Stat. 536); records transferred to the Auditor 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 transferred to the Auditor of State at Indianapolis.

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[3] For an extended treatment of the boundary subjects, the territorial acquisitions, treaties with the foreign sovereignties, etc., see H. Doc. No. 113, 71st Cong., 1st sess., entitled "Boundaries, Areas, Geographic Centers, and Altitudes of the United States and the Several States," by Edward M. Douglas, Geological Survey Bulletin 817, U. S. Department of the Interior: Superintendent of Documents, Government Printing Office, Washington, D. C.

See also the wall map of the United States: Superintendent of Documents, Government Printing Office, Washington, D. C.

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

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

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

*Minnesota.*—Included in the territory of the original 13 States, and with lands acquired under the Louisiana Purchase in 1803; admitted into the Union May 11, 1858 (11 Stat. 285); records transferred to the Secretary of State at St. Paul.

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

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

*Montana.*—Acquired under the Louisiana Purchase in 1803 and with the Oregon Territory, title to which was established in 1846; admitted into the Union November 8, 1889 (25 Stat. 676, 26 Stat. 1551); public survey office at Helena; regional office at Billings.

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

*Nevada.*—Ceded by Mexico in 1848 and admitted into the Union October 13, 1864 (13 Stat. 30, 749); public survey office at Reno.

*New Mexico.*—Included with lands annexed with Texas in 1845, with lands ceded by Mexico in 1848, and the Gadsden Purchase in 1853; admitted into the Union January 6, 1912 (36 Stat. 557, 37 Stat. 1723); public survey office at Santa Fe; regional office at Albuquerque.

*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 transferred to the State Engineer 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 filed with the Bureau of Land Management at Washington, D. C.

*Ohio.*—Included in the territory of the original 13 States and admitted into the Union April 30, 1802 (2 Stat. 173); records transferred to 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); regional office 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 transferred to the Commissioner of School and Public Lands at Pierre. The plats of the mineral patent surveys of South Dakota are filed in the public survey office in Denver, Colo., 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); regional office 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); public survey office at Olympia.

*Wisconsin.*—Included in the territory of the original 13 States and admitted into the Union May 29, 1848 (9 Stat. 233); records transferred to the Commissioners of Public Lands at Madison.

*Wyoming.*—Included with lands acquired under the Louisiana Purchase in 1803, with lands annexed with Texas in 1845, with lands included in the Oregon Territory, title to which was established in 1846, and with lands ceded by Mexico in 1848; admitted into the Union July 10, 1890 (26 Stat. 222); public survey office at Cheyenne.

*Territory of Alaska.*—Ceded by Russia in 1867; public survey office at Juneau; regional office at Anchorage.

## The Manual Supplements

### Standard Field Tables

**11.** There was published in 1910 by the General Land Office, as a pocket field book, a compendium of tables and formulas entitled "Standard Field Tables." The volume embraces the data useful to engineers engaged on cadastral surveys, especially in subdividing the public lands. The Standard Field Tables are issued as a supplement to the Manual. The contents of the sixth edition (1942) are as follows:

1. Units of linear measure, units of area, expansion of steel tapes, and conversion tables, chains to feet and feet to chains.
2. Reduction in latitude to south boundary of township, and corrections for convergency within a township.
3. Traverse table, for the correction of random lines.
4. Traverse tables.
5. Correction of error in stadia wire interval.
6. Stadia coefficients, vertical rod.
7. Natural sines and cosines.
8. Natural tangents and cotangents.
9. Logarithmic sines, cosines, tangents, and cotangents.
10. Logarithms of numbers.
11. Convergency of meridians, and differences of latitude and longitude.
12. Azimuths of the tangent to the parallel.
13. Offsets from the tangent to the parallel.
14. Azimuths of the secant.
15. Offsets from the secant to the parallel.
16. Lengths of arcs of the earth's surface.
17. Apparent time of sunrise and sunset.
18. Conversion tables, dgrees to time, and time to degrees.
19. Sidereal conversions, and reductions to the local mean time of upper culmination of Polaris, including the meridian passage of the equatorial stars.
20. Mean refractions in zenith distance.
21. Coefficients to apply to mean refractions for variations in barometer and temperature.
22. Coefficients for computing errors in azimuth due to small errors in declination or latitude.
23. Mean refractions in polar distance.
24. Trigonometric formulas for the solution of plane triangles.
25. Trigonometric formulas for the solution of stadia measurements, observations for time, latitude and azimuth, and problems in convergency.
26. The arpent and vara units.
27. Conversions: Chains and links to feet.
28. Conversions: Feet to chains and links.

## Ephemeris of the Sun, Polaris, and Other Selected Stars, With Companion Data and Tables

12. The astronomical data for the stellar and solar observations by which to determine the true meridian, as practiced by the cadastral engineers and conforming to the Manual methods and examples, are published annually in advance, in a supplement that bears the above title. The methods are primarily for the operation of the General Land Office solar transit, comparing its orientation with observations on the sun, Polaris, and the brighter stars by which to make the needed instrumental adjustments and tests. This includes also a determination for the direction of any line that is to be run without the use of the solar unit, and for the verification of all lines as required.

In this practice the data for the *sun* are required in terms of the daily *apparent positions* for the Greenwich meridian; for all *stellar positions* in terms of the Greenwich meridian, *mean time* and *mean time intervals*.

The Ephemeris of the sun and Polaris, in this form, was first published by the General Land Office in 1910. The data has since been extended to include the following contents:

### Astronomical Data

The daily positions of the sun and Polaris.
A list of the selected stars and star chart.
The semi-monthly positions of 28 bright stars.
Azimuths of Polaris at all hour angles.
Azimuths of Polaris at elongation.
Latitudes by an altitude observation of Polaris at any hour angle.
Explanations for finding the stellar positions, and use of the equations for the reduction of observations.

### Tables

Refractions in zenith distance, and the sun's parallax.
Conversion of time to arc.
Conversion of arc to time.
Sidereal conversions: sidereal into mean solar interval;
mean solar into sidereal interval;
Greenwich meridian to longitude of station.
Natural sines, cosines, and tangents, 4-place, for finding the vertical and horizontal angles of a star.

#### Example

A supplemental explanation on preparing for the observations, and graph of the natural trigonometric sines, cosines, and tangents, for use in finding the vertical and horizontal angles of a star.

### Restoration of Lost or Obliterated Corners and Subdivision of Sections

**13.** A third supplement to the Manual bears the above title; it is addressed primarily to county and local surveyors and others who may have occasion to retrace the lines of the public land surveys, and to subdivide the sections. The subject matter under that title first appeared in the decisions of the Department of the Interior, 1 L. D. 339; 2d edition, 1 L. D. 671 (1883); there have been several revisions and extensions, the latest in 1939.

In the general plan for the public land surveys it is provided that "all subdividing of surveyed lands into lots less than 160 acres may be done by county and local surveyors at the expense of the claimants" (R. S. sec. 2406; 43 U. S. C. sec. 766); this to be according to the rules for the subdividing of sections as heretofore shown, and as represented upon the official plat.

After the title to the lands passes into private ownership, the property comes under the jurisdiction of the State law, which is controlling in regard to the principles, or rules for surveying, and the procedure that is to be followed in the retracement, identification, and remarking of the boundaries; the interpretations are to be found in the opinions and decrees of the State courts.

On many occasions and in varying situations, there is an overlapping of the surveying work that is required, though the distinction in jurisdiction is clear; this is brought to the attention of all through the medium of this supplement.

The subjects are treated in four parts, as follows:

*Foreword.*—A statement concerning the jurisdiction, the original records, and the general rules.

*Restoration of lost or obliterated corners.*—The specific rules that are applicable after the evidence has been fully developed.

*Subdivision of sections.*—The rules when all necessary corners on the section boundaries are in position.

*Retracements.*—Explanation of the technique found by experienced surveyors to be the most generally successful in the recovery of the evidence of the early public land surveys.

A limited amount of additional material has been added in response to frequent inquiries on the subject of meander lines and riparian rights, though the points are not strictly within the scope of the main title.

# Chapter II

# INSTRUMENTS AND METHODS

## OUTLINE

**14.** The methods that are outlined in this chapter may be termed the specifications for the ascertainment of the length and direction of lines. A common standard is intended for all surveying districts. There is provided ample freedom of choice of methods best suited to the job in hand. The regional engineers and all reviewing officers will be guided by these specifications.

In active field operations, the tests and various observations may be made at such times as will least interfere with the progress of the survey. In most cases ample instrumental tests are made prior to the organization of the field party; after that, the chief of party is required to continue the necessary observations and tests to insure that the instruments are being maintained in good adjustment.

As to the field notes, let it be recognized that county and other surveyors most concerned with the retracement and identification of the lines, and the public generally, including the legal and engineering professions, manifestly are entitled to a complete record of the survey, one that describes all essential field operations and is admissible as evidence in formal court proceedings, bearing official approval.

The examples are explicit as to the entries that are required in the field tablets, and as to the summarized results which are to be carried to the transcribed field notes.

Basic examples are given in the text for the methods most frequently employed, in order to clarify these fundamentals. Additional examples are given in the Manual appendix for reference purposes, segregated from the text so as to simplify the showing of the requirements.

## MEASUREMENTS

**15.** In land surveying, the distance between two points, or length of line, means the horizontal distance. On sloping ground, the tape may be held horizontally, or supported in that position, using a plummet at the end which is higher than the surface, for the projection of the tape length to the ground.

Where the ground is uneven, or sloping sharply, the measurement may be made more accurately along the slope, the tape being held taut at proper tension, both ends at or near the surface, which will give the distance on the slope between those points; the latter value is then reduced (mathematically) to the equivalent true horizontal distance. In this method, the slope measurement multiplied by the cosine of the vertical angle of that interval of the slope equals the true horizontal distance between those points.

The law prescribes the chain as the unit of linear measure for the survey of the public lands, and all returns of measurements are to be made in true horizontal distances, in miles, chains, and links.

| *Units of linear measure* | *Units of area* |
|---|---|
| 1 chain = 100 links. | 1 acre = 10 square chains. |
| = 66 feet. | = 43,560 square feet. |
| 1 mile = 80 chains. | 1 square mile = 640 acres. |
| = 5,280 feet. | |

The chain, arpent, and vara units.
The link chain, and the long steel-ribbon tape.
Manual Appendix II.

**16.** Each engineer will be provided with a standard and an assortment of 1-, 2-, 5-, or 8-chain steel tapes. The standard tape will be employed for comparison with the field tapes, in order that errors in the latter may be noted and corrected. An affirmative statement is required in the transcribed field notes to the effect that the party chief has tested the tape in the required manner.

It is essential to the record of a survey to state briefly at the beginning of the field notes, with every set of returns, the general manner of making the measurements in that survey. The usual plan is the steel tape measurement. It is required that the data be entered in the regulation field tablets with all necessary completeness. The field tablets will show all necessary offsets, triangulations, or stadia measurements. Where the length of an interval of the line has not been duly determined, or verified, by steel tape measurement, the detail of the triangulation or stadia measurement will be carried to the transcribed field notes. Such detail may be omitted from the transcribed notes where a triangulation or stadia measurement has been made as a check against error in the steel tape distance. Likewise, where a triangulation has been verified by a stadia measurement, or vice versa, only the one that is regarded as giving the best value will be carried to the transcribed field notes.

The field notes thus exhibit the manner of making all measurements. The record should be such that another engineer retracing any line can substantially duplicate the procedure adopted in the survey.

The following paragraph is illustrative of the record to be made in the field notes:

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

Additional examples, specimen field notes, Manual Appendix VIII.

## The Long Steel Tape

**17.** The approved method of measurement involves the use of steel ribbon tapes from 2 to 8 chains in length; in its use the tape is properly alined and stretched; the measurements are made on the slope at any convenient distance up to the length of the tape as limited by the changes in slope. The vertical angles of moderate slopes are determined by clinometer; the very steep or sharp slopes are determined with the transit. The slope distances are then reduced to true horizontal, the entire operation being suitably recorded. It is not considered necessary to exhibit in the transcribed field notes any but the true horizontal distances, omitting details, except where precise measurements are made of various bases for special use.

As the slope measurements are to be reduced to true horizontal equivalents, the slope angles must be carefully determined, either by clinometer or transit. The order of entry in the field tablet is first, the measurement on the slope; second, the vertical angle; third, the correction for the slope; fourth, the horizontal distance. Plus distances are entered (fifth) for the items of topography that are intermediate between the points of line measurement. An entry is made (sixth) for the difference in elevation for each interval as measured;



700004°—47——3

this is expressed in the foot unit, in order to conform with the conventional practice in topographic surveying. Example, section 20.

Where the elevation above sea level is known (or has been ascertained approximately) for the point of beginning, the value is placed at the top of the column. The plus or minus differences are then applied, giving the elevation above sea level for each measured point, and showing at once the crossing of any desired contour.

The reductions are supplied with whatever accuracy may be required for the class of survey (sec. 234), and to keep within the allowable tolerance. The linear tolerance may be as little as 2.0 links (1.32 feet), or up to a maximum of 12.5 links (8.25 feet) per mile, depending upon the class of survey, and as tested both by the basic standards of length and direction of lines, and by the error of closure. The smaller limit is attainable by the methods prescribed, depending upon the exercise of care in all detail.

**18.** The following is an example of both field-tablet and transcribed record for the use of the long steel tape and clinometer; reductions by the use of the traverse tables (table 4, Standard Field Tables):

| Field record | | | | | Transcribed field notes | |
|---|---|---|---|---|---|---|
| Distance on slope | Mean vertical angle | True horizontal distance | Intermediate measurement | Difference in elevation | | |
| *Chains* | | *Chains* | *Chains* | *Chains* | *Chains* | North, bet. secs. 19 and 24. Desc. 155 ft. over NW. slope, through scattering timber and dense undergrowth. |
| 4.50 | −12¼° | 4.398 | | −0.95 | | |
| 2.20 | −17½° | 2.098 | | −.66 | | |
| 6.70 | | 6.496 | 3.80 | −.75 | 10.30 | Dry gulch, course W.; asc. 295 ft. over SW. slope. |
| | | | | +.75 | | |
| 8.00 | +8¼° | 7.917 | | +1.15 | | |
| 14.70 | | 14.413 | | | | |
| 6.20 | +19¾° | 5.835 | | +2.10 | | |
| 20.90 | | 20.248 | | | | |
| 3.30 | +7¾° | 3.270 | | +.44 | | |
| 24.20 | | 23.518 | 0.00 | | 23.50 | Spur, slopes W.; desc. 185 ft. to ¼ sec. cor., over NW. slope. |
| | | | 1.20 | | 24.70 | Road, bears E. and W. |
| | | | 1.90 | | 25.40 | Leave undergrowth. |
| 8.00 | −6½° | 7.949 | | −0.91 | | |
| 32.20 | | 31.467 | 1.15 | | 32.60 | Enter heavy timber, bears NW. and SE. |
| 3.70 | −10¼° | 3.641 | | −.66 | | |
| 35.90 | | 35.108 | | | | |
| 5.00 | −14 ° | 4.851 | | −1.21 | | |
| 40.90 | | 39.959 | | | | |
| .04 | 0 ° | .04 | | | | |
| 40.94 | | 40.00 | | | | |
| 40.00 | | 40.00 | | | 40.00 | Point for the ¼ sec. cor of secs. 19 and 24. Set an iron post, etc. |

**19.** A simplification of the reduction of measurements on the slope is obtained by the use of two diagrams constructed on cross-section paper, as follows: The first with the vertical lines representing intervals of 20 links measurement on the slope to 2, 5, or 8 chains to suit the length of tape used; the horizontal lines representing the correction in links to be made from the measurement on the slope to obtain the true horizontal distance; slanting lines are drawn to represent various degrees of slope scaled to the proper points for the correction for the full length of the tape. The second diagram is constructed with the vertical lines representing similarly the measurement on the slope in the *chain* unit; the horizontal lines in this diagram representing the difference in elevation in *feet,* at intervals of 5 feet; slanting lines are drawn to represent various degrees of slope scaled to the proper points for the differences of elevation for the full length of the tape (figs. 1 and 2).

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

| Field record | | | | | | Distance | Transcribed field notes |
|---|---|---|---|---|---|---|---|
| Measurement on slope | Vertical angle | Correction for slope | Horizontal distance | Plus distance | Difference in elevation | | |
| *Chains* | *Degrees* | *Chains* | *Chains* | *Chains* | *Feet* | *Chains* | North, bet. secs. 19 and 24. Desc. 155 ft. over NW. slope, through scattering timber and dense undergrowth. |
| 4.50 | −12¼ | 0.10 | 4.40 | | −60 | | |
| 2.20 | −17½ | .10 | 2.10 | | −45 | | |
| 6.70 | | .20 | 6.50 | 3.80 | −50 | 10.30 | Dry gulch, course W.; asc. 295 ft. over SW. slope. |
| | | | | | +50 | | |
| 8.00 | +8¼ | .08 | 7.92 | | +75 | | |
| 14.70 | | .28 | 14.42 | | | | |
| 6.20 | +19¾ | .37 | 5.83 | | +140 | | |
| 20.90 | | .65 | 20.25 | | | | |
| 3.30 | +7¾ | .03 | 3.27 | | +30 | | |
| 24.20 | | .68 | 23.52 | 0.00 | | 23.50 | Spur, slopes W.; desc. 185 ft. to ¼ sec. cor., over NW. slope. |
| | | | | 1.20 | | 24.70 | Road, bears E. and W. |
| | | | | 1.90 | | 25.40 | Leave undergrowth. |
| 8.00 | −6¼ | .05 | 7.95 | | −60 | | |
| 32.20 | | .73 | 31.47 | 1.15 | | 32.60 | Enter heavy timber, bears NW. and SE. |
| 3.70 | −10¼ | .06 | 3.64 | | −45 | | |
| 35.90 | | .79 | 35.11 | | | | |
| 5.00 | −14 | .15 | 4.85 | | −80 | | |
| 40.90 | | .94 | 39.96 | | | | |
| .04 | 0 | .00 | .04 | | | | |
| 40.94 | | .94 | 40.00 | | | 40.00 | Point for the ¼ sec. cor. of secs. 19 and 24. Set an iron post, etc. |

**21.** By skillful use of the long steel tape on the slope, with correct determinations of the vertical angle, and proper reductions from the

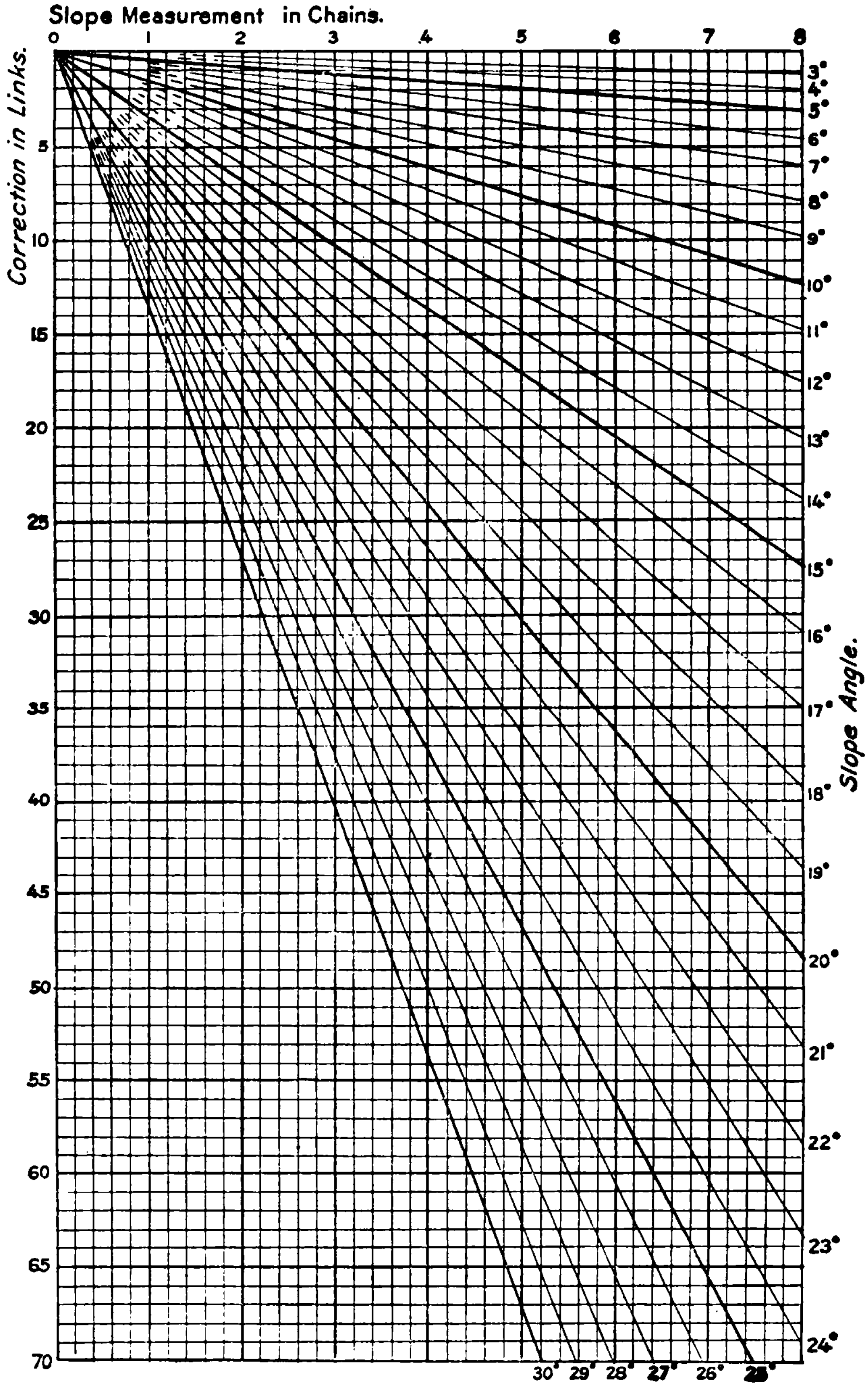



Fig. I.

Reduction from the slope to the horizontal.

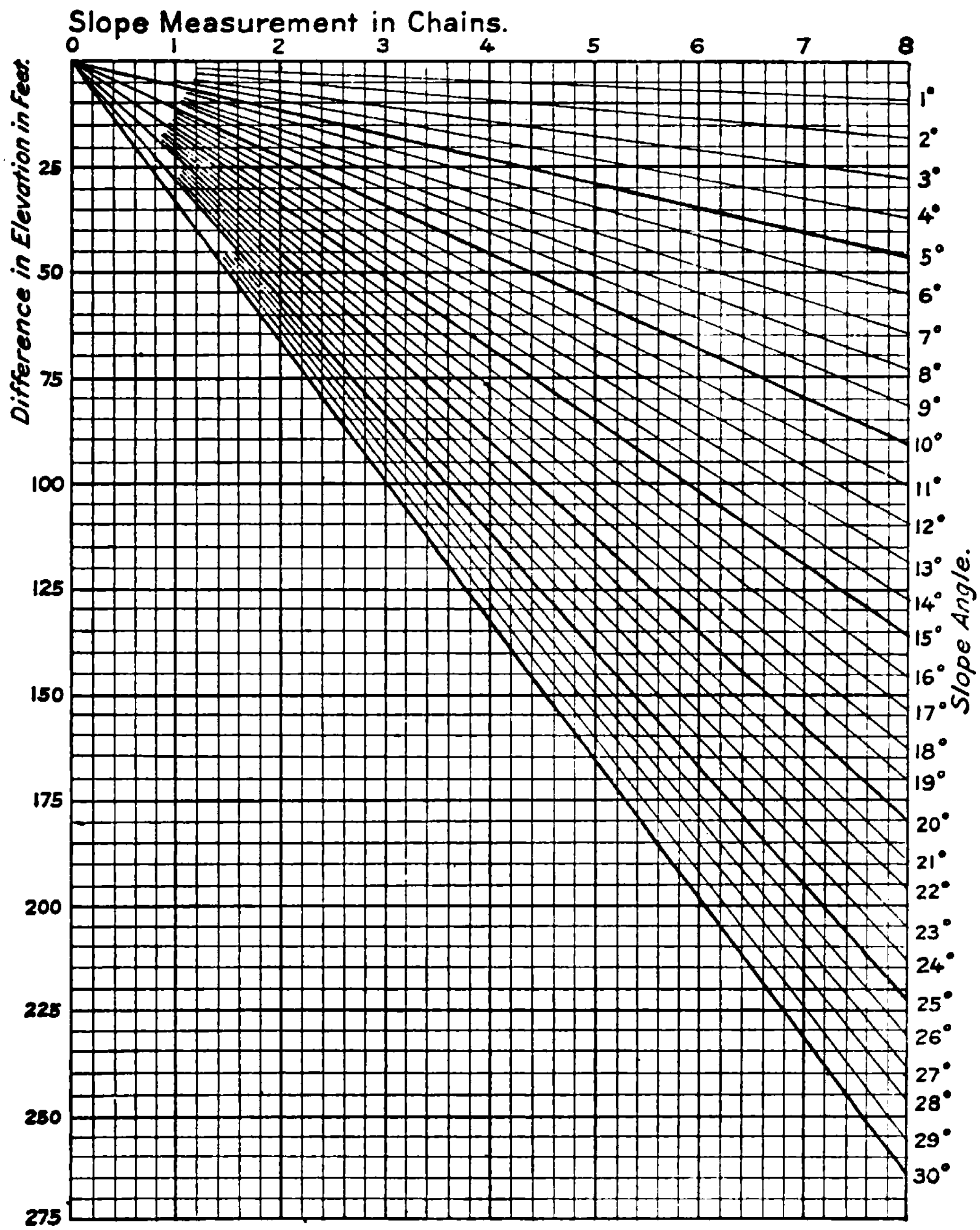



Fig. 2.

**Reduction for difference of elevation.**

slope to the true horizontal distance, the engineer obtains one of the most rapid and reliable methods of measurement. It is essential to make all reductions for distance as the work progresses, but the additional information regarding the amount of the ascents and descents is readily obtainable from the record at the convenience of the engineer.

## Stadia Measurements

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

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

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

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

**24.** Notation used in stadia measurements:

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

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

"$r$": Vertical rod reading.

"$v$": Observed vertical angle.

"$K$": The wire interval or ratio.

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

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

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

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

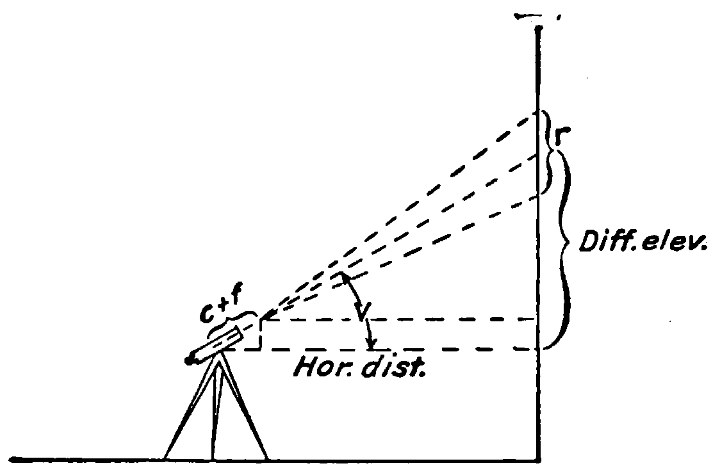



Fig. 3.

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

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

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

| Field record | | | | Transcribed field notes |
|---|---|---|---|---|
| Measurement of base by steel tape and clinometer | | | Vertical rod reading | |
| Mean vertical angle | Distance on slope | True horizontal distance | | |
| | *Chains* | *Chains* | *Feet* | June 11, 1945, I make the following test of the stadia wire interval: |
| $-4\frac{1}{2}°$ | 3.90 | 3.888 | 6.992 | Horizontal length of base = 14.066 chs. |
| $-1\frac{1}{4}°$ | 8.00 | 7.998 | 6.998 | Mean of 10 rod readings = 6.9985 ft. |
| $+7\frac{1}{2}°$ | 2.20 | 2.180 | 7.002 | Vertical angle of of test = −0°40′ |
| | | | 6.995 | $K$ = 132.551 |
| Total base | | = 14.066 | 7.003 | Reduced error in 10 chs. = 4.1 lks. |
| Focal constant | | = .012 | 7.004 | |
| | | | 6.997 | All corrections to be added to the distances given by the stadia. |
| Stadia base | | = 14.054 chs. | 6.995 | |
| " " | | = 927.564 ft. | 7.001 | |
| | | | 6.998 | |
| Mean rod reading | | = | 6.9985 | |
| Coefficient for 0°40′ | | = 0.9999; | | |
| 0.0001×6.9985 | | = | .0007 | |
| $r \cos^2 v$ | | = | 6.9978 | |
| $K = \frac{927.564}{6.9978} = 132.551$ | | | | |
| Measured base | | | = 14.066 chs. | |
| 6.9985 } = mean rod reading. 6.9985 | | | | |
| 13.997 = equivalent 1:66. | | | | |
| 13.997 ×0.9999 = 13.996 } $(c+f)$ = .012 | | | 14.008 chs. | |
| Error in 14.008 chs. by stadia | | | = 0.058 chs. | |
| Error in 10.00 chs. by stadia | | | = 0.041 chs. | |

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

Emphasis is placed upon the necessity for the above tests for accurate stadia work, and attention is directed to the probability that successive tests will show slightly increasing or decreasing values of the wire interval; this is with reference to the usual spider-web cross wires. The platinum cross wires should give a nearly constant ratio. It is not considered necessary to record in the transcribed field notes any but the basic elements of stadia observations, omitting the details of the reductions.

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

| Field record | Transcribed field notes | |
|---|---|---|
| | *Chains* | N. 0°02′ W., bet. secs. 15 and 16.<br>Descend gradually over mountainous land. |
| | 12.60 | Rim of canyon, bears NW. and SE.; precipitous descent of 170 ft.<br>Stadia to left bank of creek: 3.194 and 3.212 ft., −26°44′.<br>Stadia to right bank of creek: 3.448 and 3.432 ft., −24°10′.<br>Stadia to right rim of canyon: 4.914 and 4.895 ft., +4°58′. |
| 3.194<br>3.212<br>6.406×0.7976=5.109<br>Error+ .021<br>$(c+f)\cos v$+ .011<br>12.60 +5.14 chs.<br>6.406×0.4018=2.574 chs.<br>Diff. elev. =170 ft. | 17.74 | Left bank of creek, 62 lks. wide, course NW. |
| 3.448<br>3.432<br>6.880×0.8324=5.727<br>Error+ .024<br>$(c+f)\cos v$+ .011<br>12.60 +5.76 chs.<br>5.14 chs.<br>Width of creek =0.62 chs. | 18.36 | Right bank of creek; precipitous ascent of 225 ft. to rim of canyon. |
| 4.914<br>4.895<br>9.809×0.9925=9.735<br>Error+ .040<br>$(c+f)\cos v$ .012<br>12.60 +9.79 chs.<br>9.809×0.0863=0.847 chs.<br>= 56 ft.<br>+170 ft.<br>Diff. elev. =226 ft. | 22.39 | Rim of canyon, bears NW. and SE.; asc. gradually. |

**30.** Attention is directed to the fact that in making the above reductions in the chain unit, wire ratio 1:132, the process is at once resolved into taking the sum of the two rod readings in feet multiplied by the proper coefficient for vertical angle, to which product are applied the corrections for the error in the wire interval and for the horizontal value of the focal constant. As two rod readings should always be taken, one as a check upon the other, the entire operation becomes very simple. It should also be noted that in computing the difference of elevation no correction has been made for the height of the instrument above the ground, nor for the mean height of the rod reading; these corrections are compensating and ordinarily may be neglected. Therefore, in ordinary work in computing differences of elevation by the stadia method it is permissible to neglect the height of the instrument above the ground, the mean height of the rod reading, the error in the wire interval, and the term '$(c+f)\sin v$.'' These factors should be applied for close results.

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

Stadia-wire ratio 1:100; example of test.

Stadia-wire ratio 1:100; form of field-note record.

Manual Appendix II.

**32.** Most of the Bureau of Land Management surveying instruments are equipped with fixed stadia wires of the ratio 1:132, which has been found well adapted to all practical purposes for which used, and permits the use of standard double-target stadia and level rods graduated to feet.

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

The detail will be incorporated in the field notes as provided in sections 16, 35, 253, and 254.

**33.** A number of the models B and C General Land Office solar transits have been equipped with *vertical* stadia wires (ratio 1:132), for reading a rod that is held horizontally. More extensive field tests will be required before the advantages in land-surveying practice, if any, may be demonstrated. As the reduction to horizontal distance is by the factor "$\cos v$" (instead of "$\cos^2 v$" as where using the vertical rod), it is evident that the horizontal stadia rod should give more exact results on steep vertical angles. Identification and description of the instrument models: Manual Appendix II, section 78.

If the sighting conditions are favorable, the stadia determination may be checked (approximately) by using the 10 ft. rod horizontally as a subtense bar, repeating the horizontal angle to secure a 10-second value. (The improved accuracy in the sighting is possible with the double cross-wires of this reticle, sec. 112.)

**34.** With the horizontal rod, the equations that are given in sec. 24 will take the forms as follows (both results in the chain unit if the wire interval is 1:132, and if two rod readings are added as suggested in usual practice):

$$\text{Hor. dist.} = (Kr + c + f)\cos v$$
$$\text{Diff. elev.} = (Kr + c + f)\sin v$$

## Triangulations

**35.** In making triangulations across water or over precipitous slopes, judgment is required in the selection of the measured base, so as to adopt the best possible geometric proportions of the sides and angles of the triangle. A complete record of the measurement of the base, the determination of the angles, the location and direction of the sides, and other essential details of the problem will be required in the field notes, together with a small diagram to represent the triangulation. The method of triangulation at all times must be sufficiently refined to produce reliable results. When necessary to determine the value of an angle with a precision of less than the least reading of the vernier, the method of repetitions will be employed.

In the longer and more important triangulations all of the stations should be occupied (if possible), and the several angles should be *repeated* and checked to a satisfactory closure; the latter limit may be kept within 0′20″ by careful use of the one minute transit. If the triangulation is verified by stadia or steel tape measurement, or by double triangulation (two base lines), a simple statement to that effect may be entered in the transcribed field notes, omitting much or all of the detail; but if there has been no such verification, and in all cases where the triangulation (or a stadia measurement) has been made that passes over one or more regular corner positions, omitting the monumentation, the detail must necessarily be set out in the transcribed field notes for its indispensable value in subsequent retracement or resurvey.

In line practice the chainmen are frequently sent through for steel tape measurement over *extremely difficult terrain*, but with the length of the interval verified by triangulation (or stadia). This is done to secure the most exact determination of the length of the line, duly checked, and to note the intervening topographic data. Where there has been such verification of the length of line it will be unnecessary, in most cases, to carry the detail to the transcribed field notes, the entry being made that best expresses the plan of the survey and the correct value for the length of line.

**36.** In its simplest form the method of repeating an angle consists in sighting upon a station, A, with the vernier of the horizontal circle set at zero; the angle is then turned to the second station, B; the *lower clamp* is now loosened and the telescope again set upon station A with the lower tangent motion *without disturbing the angle first turned,* after which the *upper clamp* is loosened and the angle turned a second time to station B. The angle is thus "repeated" two, three, or more times, and finally the multiple angle is read, which, when

36

divided by the repeating factor, gives a value for the angle much closer than the least reading of the instrument. For example, assume an instrument reading to single minutes of arc, and that a certain angle has been repeated five times with a resulting reading of 124°32′; this gives a value of 24°54′24″ for the angle, which if skillfully done is unquestionably closer than a single reading. In surveys which may require even greater precision both verniers are read and the angle is repeated as nearly as practicable to one complete turn of 360°, when both verniers are again read. The observer then reverses the telescope, and duplicates the process by turning the angle in the opposite direction, to eliminate instrumental errors, and finally takes a mean of the resulting four readings, which is divided by the proper factor. It is occasionally necessary in public-land surveying to repeat angles by the latter method, but the former is of more general use and will be found dependable and quickly executed in most cases.

A somewhat different form of repetition is employed on a transit traverse that is run by deflection angles and calculated courses. If it is an ordinary traverse, with 10 to 20 or 30 turning points per mile, where care is required to avoid accumulative errors, the best practice calls for the several steps as follows: (1) at the forward station "B", when occupied, sight to the back station "A", plates set at zero; transit the telescope and turn to the next station "C", reading the angle, the value being called the first reading; (2) release the lower clamp, turn on the lower center to the back station "A", and make another sighting, using the lower tangent motion (being careful not to disturb the angle first turned); (3) again transit the telescope, loosen the plate clamp and turn to station "C", reading the angle, the value being called the double reading; (4) divide the latter by two for the accepted value of the deflection angle. The plan eliminates an error of collimation, and gives a much better value than by single deflection. For longer sights, and where greater accuracy may be desired, the double turning may be extended to 4, 6, 8, or 10, always an even number, reading the first or single value, and the last or sum of the turns, the latter to be divided by the number of the repetitions.

Basically, the repetition of angles has a two-fold purpose, only one of which has been explained above, i. e.—to obtain an angular value better than a single vernier reading. The vernier of the one-minute transit reads directly to one-minute or 60″. When needed, the value may be estimated to the nearest 30″. By careful repetition a value down to $\pm 10''$ may be ascertained. Authorities agree quite generally that an increase in the number of the repetitions does not add materially to the accuracy or certainty of the result. The limit is usually placed at six repetitions for the larger angles; ten for small deflection angles. There is a convenience in the multiple of *six* repetitions, as the division of an angle by six is very simple, with minimum chance of error, thus: divide the degrees by six; the fractional remainder in the degrees becomes the *first figure of the minutes* (as, for instance, $5\times 60\div 6=5\times 10$; or $5°$ divided by $6=50'$). Then divide the minutes by six to obtain the second figure of the minutes; the fractional remainder is the first figure of the seconds; etc.

The second purpose of a repetition, *when needed*, is to insure the elimination of the residual instrumental errors of *adjustment, graduation, setting of the plate verniers, and eccentricity of the line of the graduations with respect to the centers.* This is accomplished through the technique of the execution of the repetition. It is almost never required in the normal execution of the land survey, as the limit of tolerance of the land survey is usually well above whatever can be gained by this technique. However, for this greater accuracy, when desired or demanded by the surveying problem that is involved, three sets of six repetitions should be made; one with the initial plate setting at or near 0°, one with the initial plate setting at or near 120°, one at or near 240°. In this plan, read and record the angles for both the A and B verniers. Run this through with the telescope in the direct position. After dividing the accumulated angles by six, there will be three values for the A vernier, three for the B vernier. The whole run is then made with the telescope in the reversed position, turning the angles in the *opposite* direction. This will give twelve indicated values for the angle, each calculated to $05''$; the mean of the whole should have an accuracy of $\pm 05''$, excepting that the sighting or pointing, or optical performance, of the one-minute transit is not designed to insure that accuracy. Improved sighting or pointing may be secured with the reticle that is described in section 112.

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

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

**(a) Field record**

*Angles*

50°35′
93 20
36 05

180°00′

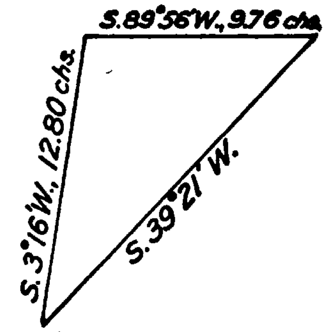
Hor. meas. of base by one chain tape = 12.80 chs.

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

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

**Transcribed field notes**

| *Chains* | |
|---|---|
| | S. 89°56′ W., on random line bet. secs. 19 and 30. |
| 40.00 | Set temp. ¼ sec. cor. |
| 72.20 | Top of precipitous bluff; vertical angle to flag on random line = −32°47′; auxiliary flag bears S. 39°21′ W.; from flag on random line the auxiliary flag bears S. 3°16′ W., 12.80 chs. dist.; all bearings checked by direct reading of the solar, and all angles checked by deflection: |




| | | |
|---|---|---|
| Dist. on random line | | =72.20 chs |
| Dist. by triangulation | | = 9.76 |
| | | 81.96 |
| Dist. by return meas. | | = 2.84 |
| | | 79.12 |

| | |
|---|---|
| 79.12 | Fall 14 lks. to the left of the cor. of secs. 19, 24, 25 and 30 on the W. bdy. of the Tp. |
| | Thence |
| | S. 89° 58′ E., on a true line bet. secs. 19 and 30. |
| | Ascend gradually in valley. |
| 1.75 | Base of bad-land bluff, bears N. and S.; precipitous ascent of about 400 ft. |
| 6.92 | Top of bad-land bluff, bears N. and S.; thence over level prairie. |

**(b) Field record**

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

| | |
|---|---|
| | 9.827 |
| | 9.839 |
| | 19.666 |
| Error = | +.082 |
| $(c+f)$ = | +.012 |
| Base = | 19.76 |

*Angles*

79°11′
33 03
67 46

180°00′

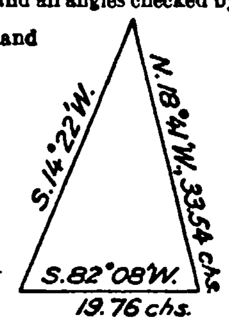
$$\text{Dist.} = 19.76 \frac{\sin 67°46'}{\sin 33°03'}$$

| | |
|---|---|
| log 19.76 | = 1.295787 |
| " sin 67°46′ | = 9.966447 |
| | 1.262234 |
| " sin 33°03′ | = 9.736692 |
| " 33.54 | = 1.525542 |
| Dist. by tri. | =33.54 chs. |

**Transcribed field notes**

At the meander cor. at 57.30 chs. bet secs. 16 and 17, a flag on Indian Island bears N. 18°41′ W.; a point on a rock in the lake bears S. 82°08′ W., stadia base to this point: 9.827 and 9.839 ft., level, measured base impracticable; from point on island, flag on rock in lake bears S. 14°22′ W.; all bearings checked by direct reading of the solar, and all angles checked by deflection:

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




At the above point for an auxiliary meander cor. in sec. 8 on Indian Island from which the meander cor. at 57.30 chs. bet. secs. 16 and 17, bears S. 18°41′ E., 33.54 chs. dist.; I
Set a limestone, 28 x 10 x 6 ins., 21 ins. in the ground, mkd. S 8 on N., and A M C on S. face; from which
A spruce, 14 ins. diam., bears N. 42½° E., 69 lks. dist., mkd. T 67 N R 43 W S 8 A M C B T.
A fir-balsam, 9 ins. diam., bears N. 14¼° W., 38 lks. dist., mkd. T 67 N R 43 W S 8 A M C B T.

**(c) Field record**

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

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

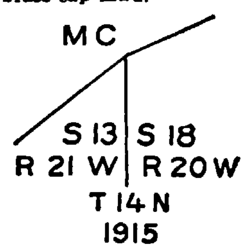
$$\text{" } C = \frac{240^\circ 19'}{3} = \frac{80^\circ 06' 20'' (-09'')}{180^\circ 00' 20'' (-20'')}$$

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

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

**Transcribed field notes**

| Chains | |
|---|---|
| | 5th Guide Meridian West, through T. 14 N., between Rs. 20 and 21 W. |
| | North, bet. secs. 13 and 18. |
| | Descend 225 ft. over NW. slope, through heavy timber and dense undergrowth. |
| 27.80 | Point for the meander cor. of secs. 13 and 18 on the south shore of Grand Lake, which bears N. 62° E. and S. 48° W. |
| | Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd. |



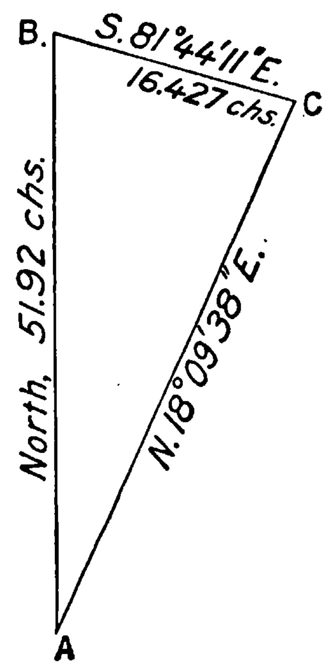

from which

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

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

To make a triangulation across the lake I designate the above meander cor. point *A* and set a flag *B* at point for meander cor. on north shore of lake, also a flag *C* on the north shore which from point *A* bears N. 18°09′38″ E.; the base *B C* bears S. 81°44′11″ E., 16.427 chs. dist.; longer base impracticable; the angle subtended at point *C*=80°06′11″; all angles by three repetitions with error of 0′20″ balanced to 180°.

Distance across lake=51.92 chs.




79.72 Point for the meander cor. of secs. 13 and 18 on the north shore of lake which bears S. 82° E. and N. 75° W.

**39.** In practical field work triangulations are made principally to overcome the physical difficulties of measurement. Under the conditions generally presented a right-angled triangle is likely to be less desirable than an oblique triangle, as the latter may be selected to fit the best location for the base line. A stadia base may sometimes be superior to a measured base as, for example, in extremely rough mountainous regions where possibly no obstruction would interfere with a good stadia determination even though a steel tape measurement of the same base might be almost impossible, or involve great delay and expense. Under some conditions a double triangulation by using two base lines may be highly desirable, one result as a check upon the other, whereby the mean of the two would give a better value; there should be a choice of the best method to suit the conditions in each situation; this must be left to the judgment of the engineer.

## INSTRUMENTS AND REQUIREMENTS AS TO ADJUSTMENT

**40.** The direction of all lines of the public-land surveys will be determined with reference to the true meridian as defined by the axis of the earth's rotation. On the plan, it is intended that the direction of all lines be stated in terms of angular measure referred to the true north or south at the point of record. No departure from this rule is authorized.

Beginning with the Manual of 1890 the use of the magnetic needle was prohibited except in subdividing and meandering, and then only in localities free from local attraction. The Manual of 1894 required that all surveys of the public lands of the United States, embracing all classes of lines, be made with reference to the true meridian, independently of the magnetic needle; this prohibition against the use of the compass was even more pronounced in the Manual of 1902. In 1919, by partial publication of the Manual of 1930, the use of the needle compass as a means of determining the direction of lines of the public-land surveys was unqualifiedly prohibited.

A field note record of the magnetic declination has always been required in each survey, the value at the southeast corner of the township to be shown on the plat. The principal purpose of this record is for its use in various 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. Its accuracy in azimuth depends first upon the care that is taken in recording the magnetic declination, including its daily variation, and the differences from one locality to another; and second, in correcting the value to the date when used. Section 236, item 19.

The use and test of the magnetic compass. Manual Appendix II.

**41.** On the plan of the rectangular surveys as outlined in sections 6 and 8, it has been required that the direction of all lines be stated in terms of angular measure referred to the true north or south at the point of record. These determinations are made many years in advance of a geodetic control. Since the beginning of the public-land surveys the direction of the lines have been based upon the observations made within the area of the survey, at the time of the survey, by methods as provided in the several Manuals of Surveying Instructions. Until 1890 this included the use of the needle compass, common to the older land-surveying practice, though all needed restrictions were intended. By the later methods, beginning from 1910, the instrument that is found to be best suited to the public-land surveys is the solar transit.

The performance that is required of the General Land Office solar transit is for uniform orientation, within the usual hours of observation, holding to within 1′30″ of the true meridian. This instrument is a light mountain engineer's transit, designed for minimum weight, small dimensions, and compactness, all of which are of extreme practical importance. All verniers read to single minutes, and when needed may be estimated to the nearest 30″. The dimensions depend upon standard instrumental designs of American manufacture. All are provided with stadia wires; a prismatic eye-piece for reading high vertical angles; a reflector for the illumination of the cross wires for the stellar observations (when made after the twilight period); and, a movable neutral-tint glass-shade mounted with the dust cap of the eye piece for making the direct observations upon the sun. A small number of the latest new instruments have been provided with a solar circle in the reticle of the main telescope, spaced on a radius of 15′45″. A description of the solar unit is given in section 78; the solar circle, in section 112.

Adjustments of the General Land Office solar transit; Manual Appendix II, sections 41 and 79.

**42.** Each field party will be supplied with one or more General Land Office solar transits of approved construction and condition, the model selected will be one suited to the type of country in the area of the survey. There will be included in the transcribed field-note record a description of the instruments employed, and an outline of the methods that were used. For positive identification the description should give the firm name of the maker, and the maker's serial number for that instrument.

The regional engineer maintains a record of each instrument, its condition, adjustments, and service, and as a rule will require that all instruments be thoroughly tested, preferably at headquarters prior to departure for the field, by the engineer who is to use the instrument. Then, at an early date after the field observations and tests have been made, which are attended to during the early stages of the survey, the chief of party will prepare a memorandum (in the weekly service report) for record information in the office, indicating satisfactory working condition of the instrument, to be followed by subsequent report in case of the substitution of another instrument for any reason.

**43.** The *transcribed* field-note record regarding the instrumental tests should state the time and locality, and that (after the adjustments have been duly completed) the instrument was in satisfactory condition. Complete data will be entered in the field tablets, from which an abstract will be prepared for the principal initial field observations and record of the orientation of the solar unit that is to be carried forward to the transcribed field notes. This does not need to be elaborate in detail, but it must include the essential facts, the purpose being to supply the record qualification that the instrument was in good order, and the data from which the basic observations may be duly verified. The latitude and longitude of the station, and the date or dates, are needed, the time of each recorded observation, and the declination of the sun, or of any star in the equatorial belt, basic to the use of the tables in the Ephemeris or for any of the equations. This is exemplified in the many examples that follow.

**44.** When the strictly transit methods are employed without the use of the solar unit, the fact will be stated. Transit methods are required in every survey that calls for an accuracy much closer than the tolerance of 1′30″ which is permitted in solar orientation. Frequently, in the extensive open spaces where there may be little or no forest cover or tall undergrowth to interfere, transit methods may be preferred to solar orientation, the latter not being used at all or else just incidentally. The basic data for the observations will be carried forward to the transcribed field notes. Most frequently the azimuth determinations will be by observation on Polaris, or by altitude observation on the sun, by one of the approved methods, and usually a check determination. An altitude observation upon one or more of the bright stars within the equatorial belt may be made supplemental to, or substituted for the altitude observation upon the sun. This is particularly useful for verification of the line of the survey at points remote from the camp meridian. By the Manual methods the stellar observations may be made during daylight or twilight in a clear sky. Subsequent observations for the verification of the line of the survey as carried forward will be duly recorded in the field tablets. A suitable memorandum will be included in the descriptive statement called for in sec. 42.

**45.** The field tests of the solar unit are carried along continually. This is done by comparing the orientation of the solar with a carefully determined azimuth line that is based upon a Polaris observation, or by altitude observation on the sun. Various combinations of these methods are employed, and frequently coupled with one or more observations upon a bright star, or stars, within the equatorial belt. The record should be complete in the field tablets. As a rule, the instruments are carefully checked and tested prior to departure for the field, and then verified again at earliest opportunity on the survey, followed subsequently by tests of one method or another almost daily, and on the camp meridian at frequent intervals.

A closing statement in the transcribed field-note record should be made to show appropriate attention to the above Manual requirements, all of them bearing upon the maintenance of the transit and solar adjustments.

**46.** Before closing the subject of the entries that are required in the field-note tablets and those that are to be carried forward to the transcribed field notes, the term instrumental "index error" should be defined, and the practice stated as to the field note record where it involves this term.

An index error or index correction is the angular difference between a vernier reading just as it is set and the true value as it would read had the vernier been adjusted to exact position.

A warning is not inappropriate. The residual errors of adjustment that are mentioned below may be much larger than might be assumed. The only safe practice is to be thorough in making the complete tests, and to be on constant alert for possible changes in the value of each correction.

In transit operation, the index correction applies especially to the residual error in the setting of the vernier of the vertical circle. This includes also the residuals in the adjustment for sighting in the true horizontal plane, both positions of the telescope, direct and reversed; it includes in addition any needed further correction that may be traceable to eccentricity in the mounting of the vertical circle. These are fully treated in the transit adjustments, Manual Appendix II, section 41.

The index corrections of the solar unit apply particularly to the residual errors in setting the verniers of the latitude and declination arcs. With both arcs, this includes also any additional differences that may be determined by the tests away from the zero positions, the latter being traceable to errors in the mounting of these arcs. The index error of the latitude arc may be further defined, and more simply treated as the difference between the *instrumental latitude*, noon observation solar unit, and the true latitude of the station.

A third index error may be employed with the solar unit (during the preliminary stages of the tests of the adjustments) to represent the angular difference between the vertical plane of the polar axis, when the solar telescope is set and clamped in the latitude of the station, and the vertical plane of the transit telescope.

The tests for the residual errors are fully explained in the adjustments of the solar unit, Manual Appendix II, section 79.

It is generally regarded as better practice to carry an index correction, if small, rather than to disturb a vernier setting that is good in other respects. The exact settings are difficult to make, frequently do not hold as well as might be desired, and other factors may be the cause of slight changes in the value of the correction. There is much difference on detail of the adjustments between instruments of the same model, otherwise exactly alike. The adding or subtracting of an index error is to be regarded as just another step in careful instrumental work, that is taken to ascertain the most dependable values for observed vertical angle, and for the setting of the arcs. The values of the corrections will be applied in the field-tablet record. The steps for making these corrections will not be carried to the transcribed field notes. This is the practice in order to avoid confusion.

## General Statement, Time, Latitude, Longitude, and Azimuth

**47.** When considering the following treatment of field methods of determination of time, latitude, and azimuth, the engineer should bear in mind that a small error, either in assumed latitude or azimuth, produces only a slight effect in time, and when all are unknown the order of sequence in their determination should be that of time, latitude, and azimuth.

The longitudes that are shown upon the large wall map of the United States, and those of the public-land States, published by the Bureau of Land Management,[1] refer to the zero meridian of the Royal Observatory at Greenwich, England. The map values for longitude may be accepted for use in making any of the calculations incident to the observations for time, latitude, and azimuth that are required with the Manual practice. More exact longitudes may be secured from the topographic maps of the United States Geological Survey, where those maps are available. Precision in both latitude and longitude may be secured wherever geodetic stations are available, established either by the Geological Survey or by the United States Coast and Geodetic Survey. To a large extent the cadastral survey has been carried for-

[1] Superintendent of Documents: U. S. Government Printing Office, Washington, D. C.

ward much in advance of the topographic and geodetic surveys. Section 133.

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.

The methods that are set out for a well-balanced observing program are good for results within $\pm 6$ seconds of time; $\pm 15''$ in latitude and azimuth; when estimated vernier readings are made to the nearest $30''$; due care to be given to all necessary refinements in the observing, and in the reductions; these limits are with reference to the one-minute graduation of the General Land Office solar transit, ordinarily supplied to the field parties.

The college courses in applied field astronomy, or engineering astronomy, are extremely helpful to an understanding of and familiarity with the methods herein set out, which are of course designed especially for the Bureau of Land Management surveying practice. The necessary definition of terms are not given in most cases. The theory of the methods relating to the observations, and the derivation of the many formulae, are 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 begin by doing the recording for an experienced observer, and then to assist in making the reductions, checking and verifying the whole.

The methods are applied principally in observations upon the sun and the north star, Polaris, and 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 primarily for the convenience of the cadastral engineers in the field, and to encourage a general use of improved methods, consistent at all times with the engineer's understanding of the principles involved.

The bright stars in the equatorial belt may be employed to secure additional 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 a higher accuracy is required.

All references to tables and formulas, or to the daily functions of the sun or Polaris, and to the other stars that follow herein, are the same as those shown in the supplements to the Manual. Conventional notations in the demonstrations that follow, agree with those shown in the Standard Field Tables and the Ephemeris.

With reference to the subject of records of observations as the same should appear in the transcribed field notes, it is necessary to state all of the basic data, but usually unnecessary to include the process of reduction. The field notes should be complete in every respect; it is the purpose to insist upon this requirement without involving that which is unessential to the record. It is unwarranted to make the results by analytical reduction appear to be more accurate than justified by the refinements of the observation upon which a determination is based. It is good practice not to discard the various small elements, fractions or decimal parts of the calculated value until the result is ascertained, the insignificant figures may then be discarded. The reduced value in azimuth is usually reported in the nearest even minute.

## ANALYTICAL NOTATION, DECLINATION AND REFRACTION

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

**49.** *v:* Observed vertical angle; in altitude observations on the sun, the reductions to the sun's center both vertically and horizontally, as well as instrumental errors, are compensated by taking direct and reversed observations on the opposite limbs of the sun. The mean observed vertical angle to the sun's center will be designated $v$ in the notation. In single observations the vertical reduction to the sun's center $=16'$; a refinement is had by referring to the Ephemeris for the value of the sun's semi-diameter for the date of observation.

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

### $\zeta$

**51.** $\zeta$: Zeta: true zenith distance of the sun's center, and to any star:

$$\zeta=90°-h.$$

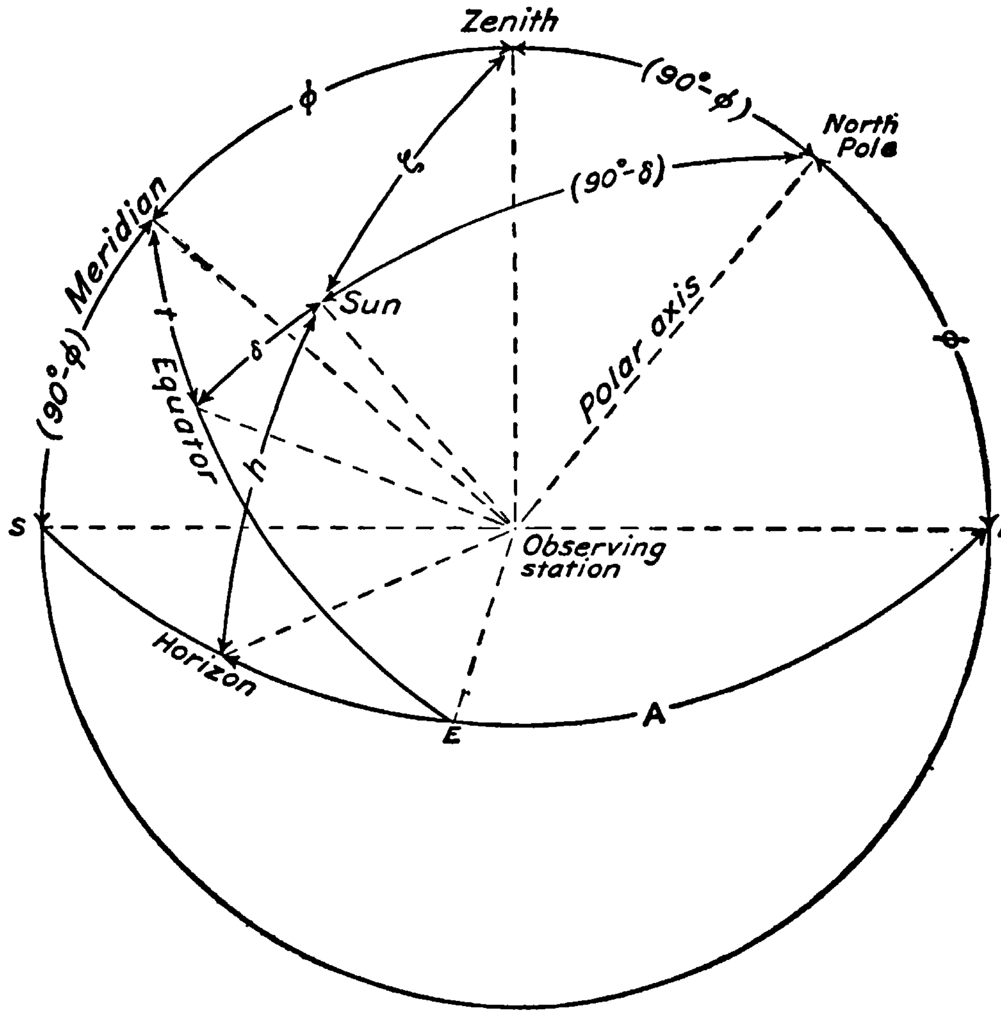



Fig. 4.

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

Examples of the relative use of $v$, refraction, parallax, $h$ and $\zeta$.

| Field record | | | | | Transcribed field notes |
|---|---|---|---|---|---|
| Telescope | Watch time | Horizontal angle | Vertical angle | Sun's limbs | |
| Dir. | $3^h56^m58^s$ | 65° 0′ 0″ | 25° 20′ 0″ | | Mar. 18, 1910, I make an altitude observation upon the sun for time and azimuth, making two observations, one each with the telescope in direct and reversed positions, observing opposite limbs of the sun. |
| Rev. | 3 58 48 | 64 45 0 | 25 31 0 | | |
| Mean | $3^h57^m53^s$ | 64° 52′ 30″ | 25° 25′ 30″ | | Mean watch time of observation, 3h 57m 53s p. m. |
| | | $v$= | 25° 25′ 30″ | | Mean horizontal angle from flag S. to sun SW., 64° 52′ 30″. |
| | | Refraction= | − 2′ 0″ | | Mean observed vertical angle 25° 25′30″. |
| | | Parallax= | +0′ 8″ | | |
| | | $h$= | 25° 23′ 38″ | | |
| | | $\zeta$= | 64° 36′ 22″ | | |
| | | | 90° 0′ 0″ | | |

Example of vertical reduction to the sun's center.

| Field record | | Transcribed field notes |
|---|---|---|
| Sun's lower limb | =25°20′ 0″ | Mar. 18, 1910, I make an altitude observation upon the sun for time, observing the sun's lower limb only; failing to observe the sun's upper limb in the reversa of the transit on account of clouds. |
| Reduction to sun's center | = +16′ 6″ | Watch time of observation, 3h 56m 58s p. m. |
| Sun's center, $v$ | =2 °36′ 6″ | Observed vertical angle to sun's lower limb, 25°20′0″, corrected to the sun's center=25°36′6″. |
| $v$ | =25°36′ 6″ | |
| Refraction | = − 2′ 0″ | |
| Parallax | = + 0′ 8″ | |
| $h$ | =25°34′14″ | |
| $\zeta$ | =64°25′46″ | |
| | 90° 0′ 0″ | |

$\phi$

**52.** $\phi$: Phi: Latitude of the station of observation.

$\lambda$

**53.** $\lambda$: Lambda: Longitude of the station of observation.

$\delta$

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

Examples of computation of the sun's declination.

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

Declination of the sun at Greenwich apparent noon Mar. 18, 1910 = 1°11′ 3″ S.

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

For longitude = $5^h\ 8^m$

For time, p. m. = +3 42

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

Hourly difference in declination = +59″.28

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

8.83×59.28=523″ = 8′43″ N.

True declination of the sun 1° 2′20″ S.

51

(*b*) It is desired to prepare, by computation, a table of hourly declinations of the sun, corrected for refraction in polar distance, for use with the solar unit, for a date March 14, 1945, for a station in latitude 33°10′ N., and longitude 116°45′ W. ($7^h\ 47^m$).

Declination of the sun at Greenwich apparent noon, March 14, 1945: 2°33′36″.4 S.

Difference in time from Greenwich apparent noon to 7 a. m., app. time; longitude 116°45′ W.

For longitude $= 7^h\ 47^m$

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

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

Hourly difference in declinations = +59″.17.

Difference in declination from Greenwich apparent noon to 7 a. m., apparent time; longitude 116°45′ W.; 2.78×59.17=164″.5= 2′44″.5 N.

Declination of the sun, 7 a. m., apparent time= 2°30′51″.9 S.

| Apparent time | True declination | Refraction | Declination setting |
|---|---|---|---|
| 7 a. m. | 2°30′52″ S. | 2′41″ N. | 2°28′11″ S. |
| 7½ | 2 30 22 | 1 48 | 2 28 34 |
| 8 | 2 29 53 | 1 22 | 2 28 31 |
| 9 | 2 28 54 | 0 58 | 2 27 56 |
| 10 | 2 27 54 | 0 47 | 2 27 07 |
| 11 a. m. | 2 26 55 | 0 43 | 2 26 12 |
| Noon | 2 25 56 | 0 41 | 2 25 15 |
| 1 p. m. | 2 24 57 | 0 43 | 2 24 14 |
| 2 | 2 23 58 | 0 47 | 2 23 11 |
| 3 | 2 22 59 | 0 58 | 2 22 01 |
| 4 | 2 21 59 | 1 22 | 2 20 37 |
| 4½ | 2 21 29 | 1 48 | 2 19 41 |
| 5 p. m. | 2 21 00 | 2 41 | 2 18 19 |

(*c*) It is desired to prepare, by computation, a table of hourly declinations of the sun, corrected for refraction in polar distance, for use with the solar unit, for a date August 12, 1945, for a station in latitude 47°10′ N., and longitude 111°00′ W. ($7^h\ 24^m$).

Declination of the sun at Greenwich apparent noon, Aug. 12, 1945: 15°0′27.3″ N.

Difference in time from Greenwich apparent noon to 6 a. m., app. time; longitude 111°00′ W.

For longitude= $7^h\ 24^m$

For time a. m., 12h−6h 0m= $-6\ \ 0$

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

Hourly difference in declination = −45.05″.

Difference in declination from Greenwich apparent noon to 6 a. m., apparent time; longitude 111°00′ W.; 1.4 × 45.05=63″= 1′ 3″ S.=

Declination of the sun, 6 a. m., apparent time= 14°59′24.3″ N.

| Apparent time | True declination | Refraction | Declination setting |
|---|---|---|---|
| 6 a. m | 14°59′24″ N. | 3′29″ N. | 15° 2′53″ N. |
| 6½ | 14 59 01 | 2 22 | 15 1 23 |
| 7 | 14 58 39 | 1 46 | 15 0 25 |
| 8 | 14 57 54 | 1 9 | 14 59 3 |
| 9 | 14 57 9 | 0 52 | 14 58 1 |
| 10 | 14 56 24 | 0 42 | 14 57 6 |
| 11 a. m | 14 55 39 | 0 39 | 14 56 18 |
| Noon | 14 54 54 | 0 37 | 14 55 31 |
| 1 p. m | 14 54 9 | 0 39 | 14 54 48 |
| 2 | 14 53 24 | 0 42 | 14 54 6 |
| 3 | 14 52 39 | 0 52 | 14 53 31 |
| 4 | 14 51 53 | 1 9 | 14 53 2 |
| 5 | 14 51 8 | 1 46 | 14 52 54 |
| 5½ | 14 50 46 | 2 22 | 14 53 8 |
| 6 p. m | 14 50 23 | 3 29 | 14 53 52 |

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

The horizontal lines may be used to represent each hour of the day; the vertical lines may represent intervals of 1′ in declination. It is convenient to use the right-hand side of the sheet to represent N., the left-hand side to represent S.; N. declinations increase numerically to the right-hand side of the sheet, S. declinations increase numerically to the left-hand. The vertical lines are numbered to suit the range of declination for the date.

Two points are marked on the diagram to agree with the true declination of the sun; the first point is marked with the argument of declination agreeing with the declination of the sun taken from the Ephemeris for Greenwich apparent noon, with the argument of time agreeing with the apparent time at the longitude 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 straight line of true declination at the point corresponding to the time of observation.

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 a linear interpolation.

The following diagrams have been prepared to illustrate the method:

**Diagram of the Sun's Declinations**

Date, Mar. 20, 1912.
Station: Lat. = 37°30′ N.
Long. = $7^h30^m$ W.

*Declination*

Greenwich noon = 0°11′14″ S. = $4^h30^m$ a. m.
Diff. $10^h$, +593″ = 09 53 N.

0°01′21″ S. = $2^h30^m$ p. m.

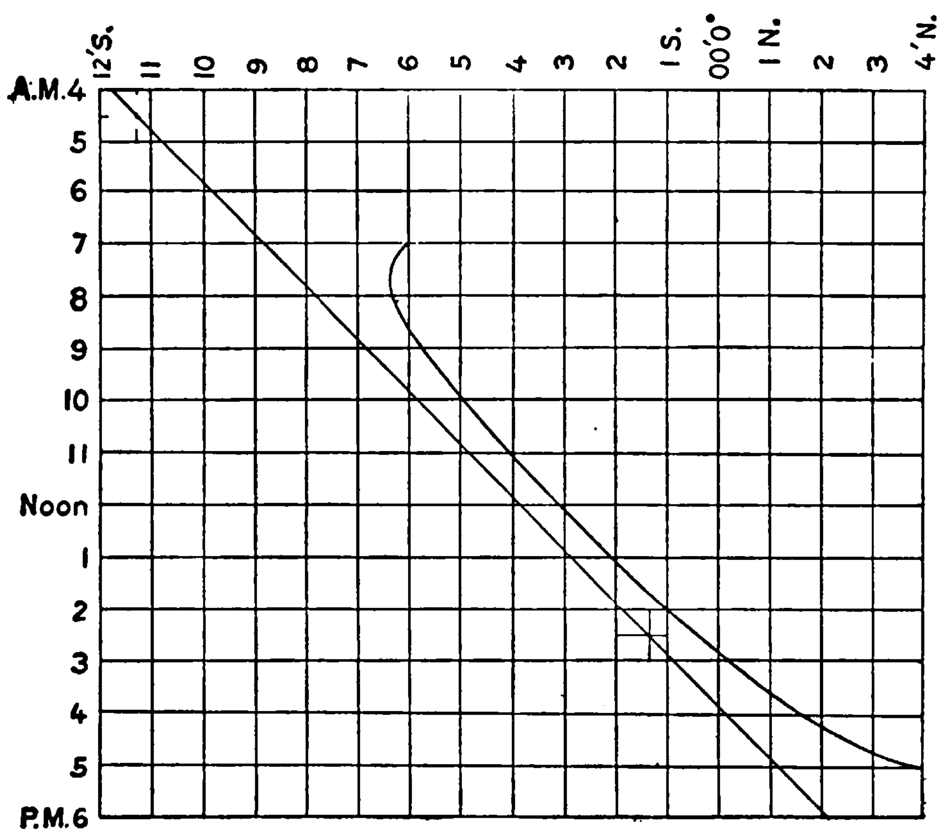



Fig. 5.

**Diagram of the Sun's Declinations**

Date, Sept. 23, 1913.
Station: Lat. $=47°30'$ N.
Long. $=6^h18^m$ W.
Greenwich noon $=0°03'55''$ N. $=5^h42^m$ a. m.
Diff. $10^h$, $-585''=$ 9 45 S.

$0°05'50''$S. $=3^h42^m$ p. m.

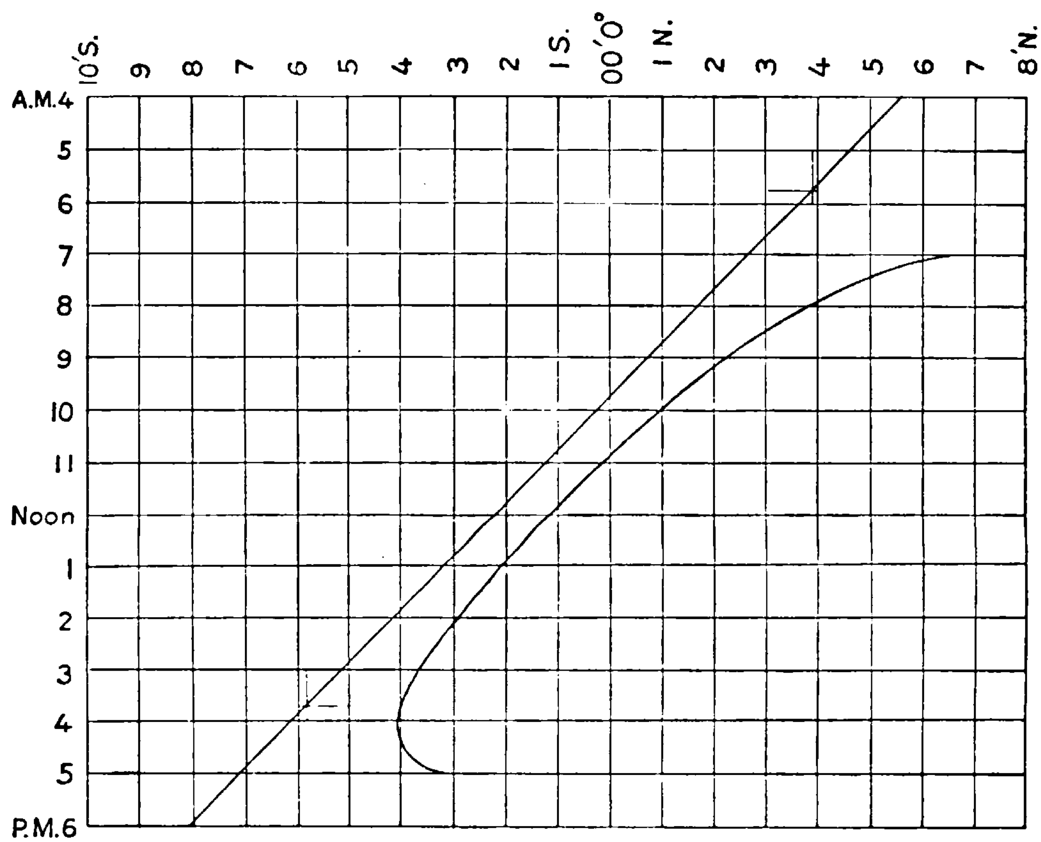



Fig. 6.

## Azimuth

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

In the first of the foregoing examples of the relative use of $v$, $h$ and $\zeta$, is shown the record of certain observed horizontal angles from a fixed reference point to the sun's limbs. Now, for the purpose of clearly stating the use of the notation A, the reduction of that observation gives the following result:

*Sun's azimuth*

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

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

In the Polaris observation for azimuth a greater refinement is secured by *repeating* the horizontal angle. On this plan, read and record the angle first turned; loosen the lower clamp and set back to the observing mark (using the lower tangent motion); then turn the angle a second time for the second sighting. Leave the plate clamp set. Reverse, and set back to the observing mark. Make two more observations on the same plan. This has repeated the horizontal angle *four* times. Record the last reading, and divide that value by 4. The quotient is the desired horizontal angle for the mean of the observation (sec. 36). The time is recorded for each position. When making the daylight observation, an assistant should give the observer the *setting angles*, multiplying the first reading by 2, 3, and 4.

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

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

| Field record | | Transcribed field notes |
|---|---|---|
| Vertical angle to sun's lower limb | $=25°20'00''$ | Mar. 18, 1910, I make an altitude observation upon the sun for azimuth, observing the sun's lower and right limbs only; failing to observe the sun's upper and left limbs in the reversal of the transit on account of clouds: |
| Sun's semi-diameter for reduction to center | $=+16'06''$ | Apparent time of observation, 3h 42m p. m. |
| Sun's center, $s$ | $=25°36'06''$ | Observed vertical angle to sun's lower limb, 25°20'00'', corrected to the sun's center=25°36'06''. |
| Hor. angle from flag S. to sun's right limb, SW. | $=65°00'00''$ | Observed horizontal angle to sun's right limb from flag S. to sun SW., 65°00'00'', corrected to the sun's center=64°42'06''. |
| Reduction to sun's center, $\frac{16'.1}{\cos 25°36'}=17'.9$ | $=-17'54''$ | |
| Hor. angle from flag S. to sun's center, SW. | $=64°42'06''$ | |

When using the new General Land Office solar transits which have been provided with the solar circle (sec. 41), all observations are complete, each one in itself, as though taken precisely on the sun's center. References and example: sections 100, 112.

## Tables

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

Tabulated refraction $=6'45''=6'.75$; elevation above sea level $=10{,}000$ feet, for which elevation the coefficient is 0.70; temperature at the time of observation $=82°$ F., for which temperature the coefficient is 0.94; true refraction $=0.70\times0.94\times6'.75=4'.44=4'26''$.

# TIME

**57.** There are two normal time rates, mean solar time as used in civilian life, sidereal time as employed by astronomers. Solar time itself is divided into three distinct classes—apparent time, local mean time, standard time.

Apparent time is based upon the *real sun*, the 24-hour period of which counts from the sun's meridian passage of one day—i. e., apparent noon, to the next meridian passage. This rate is irregular. The sun dial is designed to read apparent time.

Mean solar time is based upon a fictitious or imaginary sun whose solar day is mathematically uniform. The mean time clock and the ordinary watch are designed to be rated for a 24-hour period that conforms to the mean sun.

The *equation of time* is counted in the mean time rate. It 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.

Local mean time is identical with mean solar time on the meridian at the station where that time is being employed. It is correct on that meridian only. Stations that are 1° apart in longitude differ by 4 minutes in local mean time; one hour for 15° difference in longitude. (Table 18, Standard Field Tables.)

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 of longitude. This is the time that has been adopted in the United States for general use. The 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.

The watch correction in local mean time may require an adjustment for longitude to the meridian where it is to be employed in making the Polaris observation. The most general correction is the conversion from standard time to local mean time in the meridian of the station of the Polaris observation; this is brought out in the explanations and examples that follow. The less frequent, but equally important adjustment is one that should be made when a time observation is made at some station other than in the meridian where the resulting watch correction is to be employed in a Polaris observation. This adjustment amounts to 23 seconds across one township at Cape Sable, Fla.; 60 seconds at Point Barrow, Alaska; it is 30 seconds across one township in latitude 46°. Table 11, Standard Field Tables. For example, a Polaris observation is to be made at a station in latitude 46°; 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 correction that is $0^m\ 0^s$ at the point of the time observation will be $0^m\ 5^s$ *slow* of local mean time in the meridian 1 mile east thereof; or, the same amount *fast* for the meridian a 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 the party camp-site.

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 366¼ sidereal 24-hour periods in the solar year of 365¼ days.

Sidereal time is not employed 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 (or 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.

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.

The sidereal time rate is necessarily employed when using the equations for time and altitudes of the equatorial stars, and for azimuths and altitudes of Polaris at various hour angles. The plan of the conversion from the mean time rate to the sidereal time rate, or from the latter to the former, for use in the equations, is explained in the Manual text for the several types of stellar observations. A simple table for the conversion from the one rate to the other is included in the Ephemeris, also in the Standard Field Tables, table 19.

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 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.

The conversion from standard time to local mean time, or conversely, is the correction that is applied for the longitude of the station, with respect to the meridian of the standard time that is referred to. Standard time and local mean time are identical on the 75th, 90th, 105th, and 120th meridians. The exact local mean time at any station of the survey may be determined by stellar observation

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(in the equatorial belt) at meridian passage, or by altitude observation southeasterly or southwesterly, Manual methods.

The meridian passage of the sun denotes the apparent noon. An altitude observation of the sun, southeasterly or southwesterly, gives a determination of the apparent time, a. m. or p. m. The difference between the apparent time and the local mean time is termed the equation of time; it varies plus or minus through the year, from day to day, only a few minutes most of the time, up to a maximum of about 16 minutes early in November. A watch may be set to read the correct apparent time for the day, or to read the approximate apparent time for a period of several days, but this will need changing from week to week as a watch cannot be adjusted to an apparent time rate because of the irregularities of the latter.

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 extremely 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; for this reason, 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 engineers like to use a wrist watch set to apparent time.

The record entry therefore should 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.

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

In observations upon Polaris at elongation precision in local mean time is unnecessary, but in hour angle observations upon Polaris it will be noted that at upper or lower culmination, in latitude 40° for example, Polaris varies 1′ in azimuth in about 3.0 minutes of time;

this interval of time slowly increases toward elongation and in the latter position more than 30 minutes of time are required for a change of 1′ in azimuth.

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

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

| | |
|---|---|
| Watch time of observation | $=6^h26^m40^s$ p. m. |
| Watch slow of 75th meridian standard time by comparison with a standard clock | $=\ +1^m22^s$ |
| Correction for longitude of station (77°01′37″.5 W.= $5^h08^m06.5^s$) | $=\ -8^m06^s$ |
| Local mean time of observation | $=6^h19^m56^s$ p. m. |

The broadcasting by radio of the standard time at frequent intervals has now become so general, and is done with such care, that this has become extremely useful for converting from *standard* watch time to *local mean time*, for use in the *stellar observations*. Applying the equation of time, by simple addition or subtraction, then transforms from local mean time into apparent time for use in the solar observations. The precise radio time signals that are broadcast at regular periods, from Naval Air Stations, controlled from the United States Naval Observatory are by special codes on short wave length. The codes will be furnished on request.

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

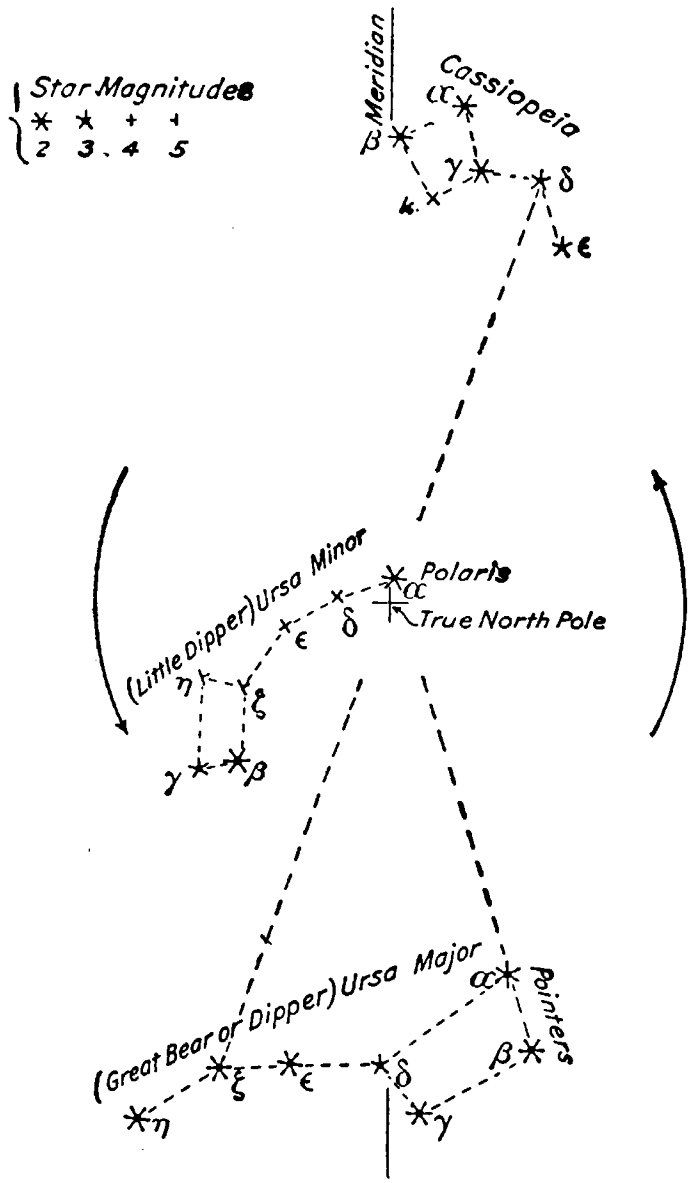
Example of conversion of apparent time into local mean time; longitude 77°01′37″.5 W. (data in sec. 51):

| | | |
|---|---|---|
| Mar. 18, 1910, apparent time of altitude observation upon sun | | $=3^h42^m11^s$ p. m. |
| Equation of time, Greenwich apparent noon | $+8^m23.4^s$ | |
| Interpolation for longitude of station $5^h08^m$ W., and time of observation $3^h42^m$, p. m.; $8^h50^m$ after Greenwich noon, or 8.83/24 of change ($17.64^s$) in 24 hours | $= -6.5^s$ | |
| Equation of time | $+8^m16.9^s$ | $+8^m17^s$ |
| Local mean time of observation | | $=3^h50^m28^s$ |
| Watch time of observation | | $=3^h57^m53^s$ |
| Watch fast of local mean time | | $= \quad 7^m25^s$ |

## Time in its Relation to Polaris Observations

**60.** Polaris, a star of the second magnitude, occupies a position in the northern heavens about 1° from a line defined by the axis of the earth's rotation. On account of its brightness and proximity to the polar axis it ranks as the most useful circumpolar star. It will be assumed that the engineer has learned how to identify the north star among its associates in the clear starlit heavens, especially with reference to the "pointers" in the constellation of the "Great Bear," 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 engineer may note the relative position of the three stars, if it is a clear night, and this will give 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 (sec. 99) 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 employed for verification of a night observation, if there should be any doubt, as in case the neighboring constellations are obscured by clouds.

An experienced engineer can readily observe Polaris at sunset or sunrise 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. At any time that Polaris is visible any of the various methods of Polaris observation for meridian, properly followed, is superior to any single observation upon the sun. In general, in public-land surveying, the customary practice is the use of a solar instrument adjusted to the meridian as established by Polaris observation.




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.

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

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

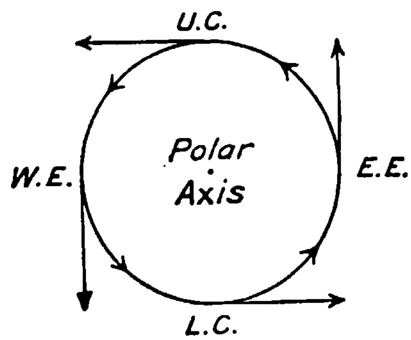


Fig. 7.

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

By reference to the preceding diagram showing the direction of motion of Polaris in its diurnal circle, the motion at western elongation is shown to be vertically downward; at eastern elongation the motion is shown to be vertically upward. At the epoch of either 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 $90°0'0'' = 6^h0^m0^s$ sidereal hour angle $= 5^h59^m1.02^s$ mean time hour angle, but as stations of observation are occupied in the higher latitudes the hour angle of Polaris at elongation decreases progressively. The reason for this is found in the fact that all vertical planes intersect at the zenith, and the point of tangency of a vertical plane with the diurnal circle of Polaris occurs at points corresponding to decreasing hour angles with the higher latitudes. The "spread" of the two vertical planes intersecting Polaris at eastern and western elongation increases with the higher latitudes, giving increasing azimuths at elongation with the more northern latitudes.

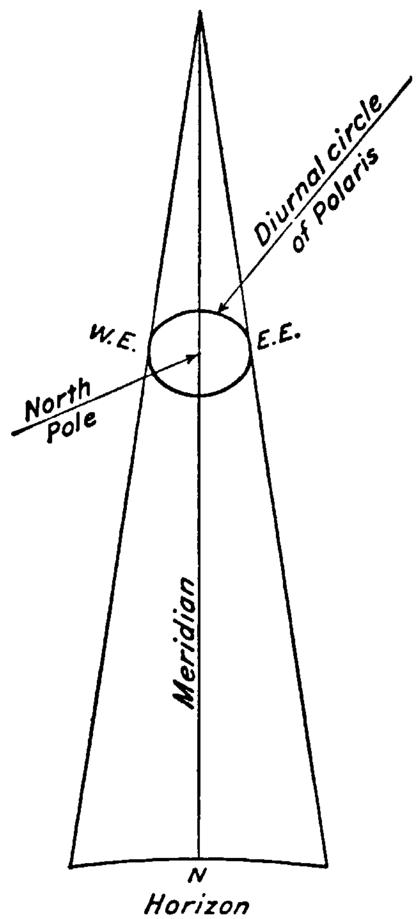



Fig.8.

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

## Star Identification, Equatorial Belt

**61.** There are two customary methods of star identification, first, the brighter naked-eye stars may be found individually, during starlight, each by means of its position within its own constellation and with the aid of a chart [2] that shows the outline of that and the neighboring constellations; second, any star may be found by reference to vertical angle and horizontal angle from the meridian, both values to be 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; this method is a necessity for twilight or daylight observations.

[2] Charts of the constellations are given in the text books on general astronomy. The diagram in the Ephemeris, facing p. 9, is based on the plan of the navigational star chart of The American Nautical Almanac, published by the U. S. Naval Observatory: Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

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 facing page 9 of the Ephemeris; an explanation of its use is given on the diagram. The simple steps are these: first interpolate for the date, then 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 (explanation sec. 62). The hour angle for the position is the *time interval* between the anticipated time of observation and the time of the meridian passage (explanation sec. 66).

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

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

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°.

If the result for "$\cos A$" is $\begin{Bmatrix}\text{positive}\\ \text{negative}\end{Bmatrix}$ the horizontal angle counts from the $\begin{Bmatrix}\text{north.}\\ \text{south.}\end{Bmatrix}$

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

$$v \neq 90° - \phi \pm \delta$$

An explanation and example of preparing for an observation is given on pages 25 and 30 of the Ephemeris. However, starting with an approximate north and south line, and with approximate values for latitude and watch correction to local mean time, and having computed the approximate angular settings for "*A*" and "*h*" (or "*v*" for this purpose), the direction of the telescope pointing, at the anticipated time of observation, will be to the selected star. The objective lens should be set carefully to *celestial focus*. There should be no doubt of the star identification during starlight (by naked eye), nor by twilight if the values are sufficiently close to bring the star within the field of the telescope.

For *daylight observations*, and referring more especially to the brighter stars (first magnitude or brighter) that would naturally be selected for daylight observation, the care to be exercised in arriving at 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. Section 68.

The star magnitudes, and the planets: Manual Appendix II.

## The Meridian Passage of Polaris and Other Stars. Reduction to Local Mean Time. Elongation

**62.** 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.

The Greenwich mean time of the meridian transit of the selected bright stars of the equatorial belt is tabulated 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 is then to be converted to the local mean time of transit, as shown in the next section.

Example of computation (for the tabulation in the Ephemeris, Bureau of Land Management) of the Greenwich mean time of the meridian transit of a star: Manual Appendix II.

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

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

| | |
|---|---|
| Aug. 12, 1945, Gr. U. C. of Polaris | $=4^h25.2^m$ a. m. |
| Red. to long. 111°15′ W., $1^m13^s$ | $=-1.2$ |
| L. M. T. of U. C. of Polaris | $=4^h24.0^m$ a. m. |

The local mean time of the meridian passage of any other star is to be reduced in the same way, or amount, 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° (or 1 hour) of longitude, subtractive to the west; and note also, that the meridian passage of each star comes approximately 4 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.

**63.** The Greenwich mean time of elongation of Polaris, latitude 40°, is tabulated in the Ephemeris for every day in the year, arranged for the ordinary civil date, a. m. or p. m. This in turn is to be reduced to the local mean time for the position of the station, in two steps: first, for longitude; second, for latitude; both as shown in the next section.

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

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

*Eastern Elongation*

| | |
|---|---|
| Sept. 9, 1945, Gr. E. E. of Polaris, lat. 40° | $=8^h36.0^m$ p. m. |
| Red. to long. 146°30′ W., $1^m36^s$ | $=-1.6$ |
| Red. to lat. 64°30′ N. | $=+5.0$ |
| L. M. T. of E. E. of Polaris | $=8^h39.4^m$ p. m. |

*Western Elongation, same station*

| | |
|---|---|
| Oct. 26, 1945, Gr. W. E. of Polaris, lat. 40° | $=5^h26.9^m$ a. m. |
| Red. to long. 146°30′ W., $1^m36^s$ | $= -1.6$ |
| Red. to lat. 64°30′ N. | $= -5.0$ |
| L. M. T. of W. E. of Polaris | $=5^h20.3^m$ a. m. |

## Hour Angles

**65.** The interval between the time of a star's meridian passage (or transit) and any other position in its diurnal circle is termed *the star's hour angle* at that moment. 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. See table page 27 of the Ephemeris, or table 19 of the Standard Field Tables. The conversion increment is to be subtracted from a sidereal interval, or added to a mean time interval, 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, table 19, Standard Field Tables, without computation.

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

| | |
|---|---|
| Mean time hour angle of Polaris for an assumed observation in Alaska $=7^h32.6^m$ | $= 7^h32^m36^s$ |
| Conversion into equivalent sidereal hour angle | $= +\ 1\ 14$ |
| Sidereal hour angle | $= 7^h33^m50^s$ |

$7^h = 105°$
$33^m = 8°15′$
$50^s = 12′30″$
$= 113°27′30″$

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.

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

The above application of the term "hour angle" is a departure from conventional usage, which has been employed in order to 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 $11^h58^m02^s$. 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 $11^h58^m02^s$.

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, facing page 9 of 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 ($11^h58^m$) of the sidereal day ($23^h56.1^m$). 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. Sections 60, 61, and 62.

Examples of computing hour angles of Polaris, both west and east of the meridian, with diagrams: Manual Appendix II.

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

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

Example of computing the mean time hour angle of Polaris at elongation, April 3, 1945, in latitude 65°0′ N., on which date the declination of Polaris=89°00′15.6″ N.:

| | | | |
|---|---|---|---|
| $\phi$=65°0′; | log tan $\phi$ | = | 0. 331327 |
| $\delta$=89°0′15.6″; | log cotan $\delta$ | = | 8. 240035 |
| | log cos $t$ | = | 8. 571362 |
| Sidereal hour angle | | = | 87°51′51″ |
| | 87° | = | $5^h48^m$ |
| | 51′ | = | $3^m24^s$ |
| | 51″ | = | $3^s$ |
| | | | $5^h51^m27^s$ |
| Reduction to mean time hour angle | | = | −0 57 |
| Mean time hour angle at elongation | | = | $5^h50^m30^s$ |

**68.** Example, daylight stellar altitude observation, equatorial belt, for time and azimuth. The example is given at this point in the text to show the derivation of the finding positions, and the conversion to mean time hour angle. The data being at hand, the reductions are carriod out to demonstrate the values of the watch correction local mean time, and the azimuth, or bearing angle of the reference mark.

July 28, 1944, at my station in latitude 38°53′30″ N., and longitude 77°02′ W., at $6^h45^m20^s$ p. m., by my watch, which reads approximate local mean time, I observe the vertical angle on the star No. 25/49, $\alpha$ Acquilæ (Altair), declination +8°43.4′, Mag. 0.9, to obtain the watch correction, as follows:

| | |
|---|---|
| Observed vertical angle: | $v$=21°44′ |
| Refraction: | $r$= −2′24″ |
| True vertical angle: | $h$=21°41′36″ |

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

| | *cos* | *sin* | *tan* | |
|---|---|---|---|---|
| $h$= | | . 36964 | | |
| $\phi$= | . 77833 | | . 80666 | |
| $\delta$= | . 98844 | | . 15342 | |
| | . 76933 | | . 12376 | (Products) |
| | | . 48050 | | (Fraction) |
| | | . 12376 | | |
| cos $t$= | . 35674 | (Diff. +) | | |

| | |
|---|---|
| 69°= | $4^h36^m00^s$ |
| 06′= | 24 |
| | $4^h36^m24^s$ |

| | |
|---|---|
| $t=69°06'$ = Sidereal hour angle: | $4^h36^m24^s$ |
| Conversion into equivalent mean time hour angle: | $-45$ |
| Mean time hour angle: | $4^h35^m39^s$ |

| | | |
|---|---|---|
| Greenwich mean time of star's transit, July 19: | $11^h57.5^m$ | p. m. |
| Reduction to July 28: | $-35.4$ | |
| Reduction to long. 77°02′ W. | $-0.8$ | |
| **Star's transit, local mean time, July 28:** | $11^h21.3^m$ | |
| | $11^h21^m18^s$ | p. m. |
| Mean time hour angle, moment of observation, east of meridian | 4 35 39 | |
| Correct local mean time of observation: | $6^h45^m39^s$ | |
| Watch time of observation: | $6^h45^m20^s$ | p. m. |
| Watch *slow* of local mean time | $19^s$ | |

The above observation was made by daylight (l. m. t. of sunset $7^h11^m$ p. m.); a reference mark was set to the south by solar transit orientation at $4^h30^m$ p. m., app. t. The finding positions for the star were derived as follows:

| | | |
|---|---|---|
| Star's transit, l. m. t., July 28, as above | $11^h21.3^m$ | p. m. |
| Anticipated time of observation, l. m. t. | 6 40 | p. m. |
| Hour angle SE. ($t=70°15'$) | $4^h41^m$ | |

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

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

| | *cos* | *sin* | | *cos* | *sin* | *tan* | |
|---|---|---|---|---|---|---|---|
| $t=$ | .3379 | | | | | | |
| $\phi=$ | .7783 | .6278 | | .7783 | | .8067 | |
| $\delta=$ | .9884 | .1516 | | | .1516 | | |
| | .2599 | .0952 | (Products) | | | | |
| | | 2599 | | | | | |
| $\sin h=$ | | .3551 | (Sum) | .9348 | | .3799 | |
| $h=20°48'$ | | | | .7276 | | .3065 | (Products) |
| | | | | | .2084 | .2084 | (Fraction) |
| | | | $\cos A=$ | .0981 | | | (Diff. −) |

$A=$ S. 84°22′ E.

With the above settings, at $6^h40^m$ p.m., l.m.t., I find the star in good position and proceed with 6 observations for time and azimuth, the 1st as follows: (Note the observed vertical angle, and the reduction of the time observation, in the example above.)

Observed horizontal angle from star to reference mark **83°36′00″**

| | *cos* | *sin* | *tan* | | |
|---|---|---|---|---|---|
| $h$ = | .92918 | | .39781 | | |
| $\phi$ = | .77833 | | .80666 | | |
| $\delta$ = | | .15166 | | | |
| | .72321 | | .32090 | (Products) | |
| | | .20970 | .20970 | (Fraction) | |
| cos $A$= | .11120 | | | (Diff.—) | |
| $A$= | S. 85°37′00″ E. | | | | **S. 83°37′00″ E.** |

True bearing of the reference mark, 1st obsn. **S. 0°01′00″ E.**

Summary of the six observations:

| | Watch Time | Observed Vert. Ang. | Observed Hor. Ang. | Watch slow l. m. t. | Bearing reference mark |
|---|---|---|---|---|---|
| 1 | $6^h45^m20^s$ p. m. | 21°44′00″ | 83°36′00″ | $19^s$ | S. 0°01′00″ E. |
| 2 | 6 51 00 | 22 50 30 | 82 40 00 | 24 | S. 0 00 30 W. |
| 3 | 6 57 30 | 24 05 00 | 81 34 00 | 20 | South |
| 4 | 7 00 00 | 24 35 00 | 81 08 00 | 25 | S. 0 00 30 W. |
| 5 | 7 04 54 | 25 31 00 | 80 18 00 | 22 | S. 0 00 30 W. |
| 6 | 7 08 12 | 26 09 00 | 79 43 00 | 23 | South |
| | | | Mean | $22^s$ | S. 0°00′05″ W. |

## Altitude Observation of the Sun for Apparent Time

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

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

Or,

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

The product "tan $\phi$ tan $\delta$" is subtractive for north declinations; additive for south declinations.

If the result for "cos $t$" is $\left\{\begin{matrix}\text{positive}\\ \text{negative}\end{matrix}\right\}$ the hour angle is $\left\{\begin{matrix}\text{less}\\ \text{more}\end{matrix}\right\}$ than six hours or 90°.

The equations as written are applicable for the northern latitudes; suitable transpositions are required for observations in the southern latitudes.

The first equation is designed for logarithmic reduction; it is especially convenient when the altitude observation is to be reduced both for time and azimuth.

The second equation is to be preferred when using natural trigonometric functions in combination with logarithms of numbers; or, the natural functions and the computing machine; the solving of the equation may be accomplished quickly on either plan.

Both equations are applicable for the altitude observation, either upon the sun, or upon a star in the equatorial belt.

The hour angle for an observation on the sun is rated directly in the solar time interval, giving at once the apparent time of a p. m. observation. Subtracting the hour angle from noon ($12^h00^m$) gives the apparent time of an a. m. observation. In both reductions the equation of time is applied to obtain the correct local mean time of the observation.

In the stellar observation, the hour angle ($t$) is in terms of the sidereal rate; a subtraction of 10 seconds per hour will give the equivalent mean time hour angle. Sec. 65; example, sec. 68.

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

### A. M. Observation

Thoroughly level the transit.

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

Reverse the transit.

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

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

### P. M. Observation

Thoroughly level the transit.

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

Reverse the transit.

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

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

70

In all altitude observations on the sun, the value of the sun's parallax at that elevation is to be added to the observed vertical angle.

In the recording of the above and similar observations, the conventional usage of the term "direct sighting" means that in this position the telescope-bubble is beneath the telescope; in "reversed sighting," the telescope-bubble is above.

The refinement of the result depends upon the certainty of the latitude, and upon the accuracy of the vertical angle readings. The possibility of slight error in vernier setting, or in eccentricity of the vertical circle, is largely compensated by making two observations and reductions, one in the a. m. and one in the p. m.

The vertical angle readings to a star should be made in both direct and reversed positions of the telescope, taking the mean for watch time and vertical angle.

As noted above, additional refinement may be secured by two observations, one upon a star SE. and the second upon the same star SW., or another star SW., usually the latter. An observation may be made on the sun SW. and a star SE., or the sun SE. and a star SW., to give the desired compensation in vertical angle readings.

#### Uncertainty in Latitude

In either of the above observations, on the sun or on a star, the balancing of an observation SE. with one SW. will compensate for an uncertainty in latitude, approaching elimination when the vertical angle readings have about the same value, and the positions in declination not too far apart.

Example of altitude observation of the sun for apparent time; and reduction to watch correction local mean time:

*Transcribed field notes*

September 4, 1944, at camp in sec. 5, T. 28 S., R. 3 W., Willamette meridian, Oregon, in latitude 43°25′30″ N., and longitude 123°04′25″ W., at temperature 96° F., and elevation above sea level 950 ft., I make an altitude observation of the sun for time, making two observations, one each with the telescope in direct and reversed positions, observing opposite limbs of the sun:

| | |
|---|---|
| Mean observed vertical angle | =28°18′30″ |
| Sun's declination | =6°57′02″ N. |
| Mean watch time of observation | $=3^h59^m27^s$ p. m. |
| Watch fast of local mean time | $= 11^m56^s$ |

*Field record*

| Telescope | Sun's limbs | Watch time | Vertical angle |
|---|---|---|---|
| Direct | | $3^h\ 58^m\ 00^s$ | 28° 19′ 00″ |
| Reversed | | 4 00 54 | 28 18 00 |
| Mean | | $3^h\ 59^m\ 27^s$ | 28° 18′ 30″ = v. |
| Refraction = 1′ 47″ × .92 × .98 | | = | −1 36 |
| Parallax | | = | +0 08 |
| | | | h = 28° 17′ 02″ |

True vertical angle $= h = 28°17'02''$
Zenith distance $= \zeta = 61°42'58''$
Sun's declination $= \delta = 6°57'02''$ N.
Latitude $= \phi = 43°25'30''$ N.

| | | | |
|---|---|---|---|
| $\zeta = 61°42'58''$ | | | $\zeta = 61°42'58''$ |
| $\phi = 43\ 25\ 30$ | | | $\phi = 43\ 25\ 30$ |
| $(\zeta+\phi) = 105°08'28''$ | | | $(\zeta-\phi) = 18°17'28''$ |
| $\delta = 6\ 57\ 02\ (+)$ | ½ values = | | $\delta = 6\ 57\ 02\ (+)$ |
| $(\zeta+\phi+\delta) = 112°05'30''$ | 56°02′45″ | 12°37′15″ | $(\zeta-\phi+\delta) = 25°14'30''$ |
| $(\zeta+\phi) = 105°08'28''$ | | | $(\zeta-\phi) = 18°17'28''$ |
| $\delta = 6\ 57\ 02\ (+)$ | ½ values = | | $\delta = 6\ 57\ 02\ (+)$ |
| $(\zeta+\phi-\delta) = 98°11'26''$ | 49°05′43″ | 5°40′13″ | $(\zeta-\phi-\delta) = 11°20'26''$ |

| | | | |
|---|---|---|---|
| log sin $\frac{1}{2}(\zeta+\phi-\delta)$ = | | 9.878407 | |
| " sin $\frac{1}{2}(\zeta-\phi+\delta)$ = | | 9.339448 | |
| " cos $\frac{1}{2}(\zeta+\phi+\delta)$ = | 9.747046 | 9.217855 | |
| " cos $\frac{1}{2}(\zeta-\phi-\delta)$ = | 9.997870 | | |
| | 9.744916 | 9.744916 | |
| | | | $57° = 3^h48^m00^s$ |
| " $\tan^2 \frac{1}{2}t$ = | | 9.472939 | $11' = 0^m44^s$ |
| " $\tan \frac{1}{2}t$ = | | 9.736469 | $20'' = 1^s$ |
| $\frac{1}{2}t = 28°35'40''$ | | $t = 57°11'20''$ | $t = 3^h48^m45^s$ |

| | |
|---|---|
| Apparent time of observation | $= 3^h48^m45^s$ p. m. |
| Equation of time | = − 1 12 |
| Local mean time of observation | $= 3^h47^m33^s$ p. m. |
| Watch time of observation | = 3 59 27 p. m. |
| Watch fast of local mean time | $= 11^m54^s$ |



700004°—47——6

## Example of altitude observation of a star for local mean time:

*Transcribed field notes*

October 25, 1944, $1^h7^m$ after sunset, at my station in SW¼ NW¼ sec. 25, T. 1 N., R. 1 E., Willamette Meridian, Oregon, in latitude 45°32′30″ N., and longitude 122°39′ W., at temperature 50° F., and barometric pressure 29.6 ins., I make an observation of the star $\alpha$ Ophiuchi, No. 22/44, Mag. 2.1, for time, making two observations, one each with the telescope in direct and reversed positions:

| | | |
|---|---|---|
| Mean observed vertical angle | = | 41°52′ 45″ |
| Mean watch time of observation | = | $6^h12^m13^s$ |
| Watch fast of local mean time | = | $11^m02^s$ |

*Field record*

| Telescope | Watch time | Vertical angle |
|---|---|---|
| Direct | $6^h10^m34^s$ | 42°07′30″ |
| Reversed | 6 13 53 | 41 38 00 |
| Mean | $6^h12^m13^s$ | 41°52′45″ = v. |
| Refraction | | = −1 04 |
| | | h = 41°51′41″ |

| | |
|---|---|
| Gr. m. t. star's transit, Oct. 16 | = $3^h52^m12^s$ p. m. |
| Reduction to Oct. 25 | = −35 24 |
| Reduction to long. 122°39′ W | = −1 20 |
| Star's transit, l.m.t., Oct. 25 | = $3^h15^m28^s$ p. m. |

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

| | |
|---|---|
| True vertical angle | $= h = 41°51'41''$ |
| Latitude | $= \phi = 45°32'30''$ N. |
| Star's declination | $= \delta = 12°36'12''$ N. |

| | *Cos* | *Sin* | *Tan* | |
|---|---|---|---|---|
| $h=$ | | .66733 | | |
| $\phi=$ | .70039 | | 1.01909 | |
| $\delta=$ | .97951 | | .22359 | |
| | .68352 | | .22786 | (Products) |
| | | .97631 | | (Fraction) |
| | | .22786 | | |
| Cos $t=$ | | .74845 | | (Diff.+) |

| | | |
|---|---|---|
| $t=$ | 41°32′37″ | |
| = | $2^h46^m10^s$ | Sidereal h. a. |
| | −27 | Reduction to m. t. h. a. |
| | $2^h45^m43^s$ | Mean time h. a. |
| | 3 15 28 | Star's transit, p. m., l. m. t. |
| | $6^h01^m11^s$ | Correct l. m. t. of obsn. |
| | 6 12 13 | Watch time of obsn. |
| | $11^m02^s$ | Watch fast of l. m. t. |

## Meridian Observation of the Sun for Apparent Noon

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

$$v \neq 90° - \phi \pm \delta$$

## Observing Program

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

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

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

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

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

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, i. e.—to secure a watch correction in local mean time with necessary accuracy for making the Polaris observations for azimuth and latitude by the hour angle method.

## Stellar Observations

The stellar observation is useful any time of year; it is especially desirable in the period when the sun reaches a meridian altitude exceeding 60° or 65°.

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

After the initial preparations have been made for a Polaris observation, including the marking of a meridian reference mark 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 arriving at the watch correction local mean time just when needed and on the most direct plan under the usual field conditions.

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

*Transcribed field notes*

September 9, 1944, in latitude 42°32′24″ N., and longitude 119°46′30″ W., Oregon, with the telescope in the meridian and elevated to the sun's altitude, I observe the sun's transit for time, noting the watch time of transit of each limb:

Mean watch time of apparent noon $= 11^h55^m52^s$
Watch slow of local mean time $= 1^m18^s$

*Field record*

| | | |
|---|---|---|
| Setting: | | 90°00′ |
| $\phi \neq$ | (−) | 42°32′ |
| $\delta \neq$ | (+) | 5°08′ |
| $v \neq$ | | 52°36′ |

| | |
|---|---|
| Watch time of transit, W. limb | $= 11^h54^m48^s$ |
| Watch time of transit, E. limb | = 11 56 56 |
| Watch time of apparent noon | $= 11^h55^m52^s$ |
| Apparent noon $= 12^h00^m00^s$ | |
| Equation of time = −2 50 | |
| Local mean time of apparent noon | = 11 57 10 |
| Watch slow of local mean time | $= 1^m18^s$ |

Example of meridian observation of a star for local mean time:

*Transcribed Field Notes*

October 26, 1944, on a meridian previously established at my station, in SW¼ NW¼ sec. 25, T. 1 N., R. 1 E., Willamette Meridian, Oregon, in latitude 45°32′30″ N., and longitude 122°39′ W., with the telescope in the meridian and elevated to the star's altitude, I observe the transit of the star $\alpha$ Aquilae (Altair), No. 25/49, Mag. 0.9, for time:

Watch time of star's transit $= 5^h37^m55^s$ p. m.
Watch fast of local mean time $= 10^m\ 57^s$

*Field Record*

| | | |
|---|---|---|
| Setting: | | 90°00′ |
| $\phi \neq$ | (−) | 45 32 |
| $\delta \neq$ | (+) | 8 43 |
| $v \neq$ | | 53°11′ |

| | | |
|---|---|---|
| Gr. m. t. star's transit, Oct. 16 | = | $6^h07^m36^s$ p. m. |
| Reduction to Oct. 26 | =(−) | 39 18 |
| Reduction to long. 122°39′ W. | =(−) | 1 20 |
| Star's transit, l. m. t. | = | $5^h26^m58^s$ p. m. |
| Watch time of star's transit | = | $5^h37^m55^s$ p. m. |
| Watch fast of local mean time | = | $10^m57^s$ |

## Apparent Time From the Solar Unit

**72.** The solar unit of the General Land Office solar transit has a graduated hour circle that is 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 ± 1 or 2 minutes. This accuracy is good 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 give a watch reading in local mean time sufficiently accurate for the finding positions for the stellar observations. This watch reading is also sufficiently accurate for making the azimuth observation on Polaris at elongation; also, the latitude observation on Polaris at culmination.

One of the exact methods for time determination should be made when needed to ascertain the watch correction in local mean time with necessary accuracy for use in the hour angle observations on Polaris.

## LATITUDE

**73.** Emphasis must be given to precision in latitude. The value at the station of observation enters into the determination of the direction of the lines and related calculations in practically all of the work, day by day through the field season, and in the platting and mapping of the cadastral survey.

Many of the older maps (sec. 47) can not be relied upon for value in latitude. The maps bearing later dates need checking for the sources and reliability of the latitude data. The values that are given on the township plats must be questioned in the same manner. Heretofore the plats have not indicated the sources of the data. If field observations have been made the record should be found in the field notes. If connecting lines have been run to geodetic stations of the United States Coast and Geodetic Survey, or to stations of the Geological Survey, this data should be entered in the field notes. The values given on the township plats should not be shown in seconds unless based on accurate data.

So much importance attaches to the true value in latitude that the cadastral survey is scarcely complete without including a number of latitude observations within the area of the survey. The values that are derived from the several observations should be reduced to a common line for comparison, usually the south boundary of the township.

A careful distinction should be made between *true latitude*, and *instrumental latitude*. The latter is a term that is applied to the reading of the *latitude arc of the solar unit* in the noon observation when the declination has been set by exact methods (independently of the reading of the graduations). The instrumental latitude is a convenience for setting the readings of the latitude arc in solar transit orientation; it differs from the true latitude by the amount of the vernier error or index correction in that position of the arc. Section 46; Manual Appendix II, section 79.

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

## Meridian Altitude Observation for Latitude

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

$$\phi = 90° + \delta - h$$

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:

$$\phi = 90° \pm \delta - h$$

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 latitude observation on Polaris by the hour angle method.

Example of meridian altitude observation of the sun for latitude:

*Transcribed field notes*

October 27, 1944, at the cor. of secs. 32 and 33, on the S. bdy. of T. 1 S., R. 27 W., 5th Prin. Mer., Arkansas, in approximate latitude 34°36′ N., and longitude 93°54′ W., I make a meridian 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:

| | |
|---|---|
| Apparent time of observation, noon | $=12^h00^m00^s$ |
| Mean observed altitude | =42°30′ 00″ |
| Reduced latitude | =34°36′ 03″ |

*Field record*

**Setting:**

| | | |
|---|---|---|
| | | 90°00′ |
| | $\phi \neq (-)$ | 34°36′ N. |
| | $\delta \neq (-)$ | 12°55′ S. |
| | $v \neq$ | 42°29′ |
| Lower limb | | 42°13′ |
| Upper limb | | 42°45′ |

| | |
|---|---|
| Observed alt., lower limb, tel. dir. | =42°13′30″ |
| Observed alt., upper limb, tel. rev. | =42°46′30″ |
| Mean observed altitude, $v$ | =42°30′00″ |
| Transit index correction | = −0 30 |
| Refraction | = −1 03 |
| Parallax | = +0 08 |
| | $h$=42°28′35″ |

| | |
|---|---|
| Decl., Gr. app. noon | = 12°50′05. 0″ S. |
| Reduced to long. 93°54′= | |
| 6.26 ×50.69″=317.3″ = | +5′17. 3″ S. |
| | 12°55′22. 3″ S. |

| | |
|---|---|
| | 12°55′22″ S. |
| $\phi$=34°36′03″ N.=$90° - \delta - h$ | =34°36′03″ |
| | 90°00′00″ |

Example of meridian altitude observation of a star for latitude:

*Transcribed field notes*

**March 7, 1945, $6^h$ $10^m$ p.m. l.m.t., at my station on the S. shore of Sanibel Island, Florida, in approximate latitude 26°25′ N., and longitude 82°04′15″ W., at temperature of 55° F., with the telescope in the meridian and elevated to the star's altitude, I make a meridian altitude observation of the star $\beta$ Orionis (Rigel), No. 7/11, Mag. 0.3, for latitude, making two observations, one each with the telescope in direct and reversed positions:**

| | |
|---|---|
| Local mean time of star's transit | $=6^h\ 10.6^m$ p. m. |
| Mean observed altitude | =55°19′00″ |
| Reduced latitude | =26°25′40″ |

*Field record*

| | | |
|---|---|---|
| Setting: | 90°00′ | |
| | $\phi\neq$ 26°25′ N. | |
| | $\delta\neq$ 8°16′ S. | |
| | $v\neq$ 55°19′ | |
| Observed altitude, tel. dir. | =55°19′00″ | |
| " " tel. rev. | =55°19′00″ | |
| Mean | v=55°19′00″ | |
| Refraction | r= −0 40 | |
| | h=55°18′20″ | |
| | | 90°00′00″ |
| | | $\delta$=(−) 8 16 00 S. |
| | | h=(−)55 18 20 |
| $\phi=90°-\delta-h$ | | = 26°25′40″ N. |

**75.** The usual field practice is to combine the meridian passage observation to include the watch time, for correction in local mean time, and vertical angle for reduction to the latitude of the station.

In observing the sun, take simultaneously the lower and west limbs, recording the watch time and the vertical angle. There will be an interval of about 2 minutes in which to reverse the position of the telescope. Then observe simultaneously the sun's upper and east limbs, recording the watch time and the vertical angle.

The settings for the approximate altitudes may be derived from the equation:

$$v\neq 90°-\phi\pm\delta\mp 16'$$

A similar observation for time and latitude may be made on any star within the equatorial belt. There will be the time record just at meridian passage; the transit may be reversed for the second reading in vertical angle.

**74**

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

*Transcribed field notes*

September 10, 1944, in approximate latitude 41°35′ N., and longitude 109°58.′3 W., Wyoming, at temperature +50° 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:

| | |
|---|---|
| Mean observed altitude | =53°11′45″ |
| Reduced latitude | =41°35′07″ |
| Mean watch time of observation | =11ʰ 57ᵐ 22ˢ |
| Watch fast of local mean time | = 33ˢ |

*Field record*

| | |
|---|---|
| Setting: | 90°00′ |
| φ≠(−) | 41°35′ N. |
| δ≠(+) | 4°46′ N. |
| v≠ | 53°11′ |
| Lower limb≠ | 52°55′ |
| Upper limb≠ | 53°27′ |

| Telescope | Sun | Watch time transit | Observed vertical angle |
|---|---|---|---|
| Direct |  | 11ʰ 56ᵐ 18ˢ | 52° 55′ 30″ |
| Reversed |  | 11 58 26 | 53 28 00 |
| Mean | | 11ʰ 57ᵐ 22ˢ | 53° 11′ 45″ |

| | |
|---|---|
| Refraction (43″ x 0.8) | = −34 |
| Parallax | = +05 |
| h | =53° 11′ 16″ |
| δ=4°46′23″ N.; 90°+δ | =94 46′ 23″ |
| φ=41°35′07″ N.=90°+δ−h | =41° 35′ 07″ |

| | | |
|---|---|---|
| Watch time of apparent noon | | =11ʰ57ᵐ22ˢ |
| Apparent noon | =12ʰ00ᵐ00ˢ | |
| Equation of time, Gr. noon | = −3ᵐ04ˢ | |
| Red. to long. 109° 58.1′ W | = −07 | |
| | −3ᵐ11ˢ= | −3 11 |
| Local mean time of apparent noon | =11ʰ56ᵐ49ˢ= | 11 56 49 |
| Watch fast of local mean time | = | 33ˢ |

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. Section 76.

For a test of the accuracy of the time observation, the watch may be compared with accurate standard time corrected for the longitude of the station, as follows:

| | |
|---|---|
| 105th meridian time of comparison, radio time signal | $=12^h00^m00^s$ |
| Correction for long. 109°58.1′ W | $=\ -19\ \ 53$ |
| Local mean time of comparison | $=11^h40^m07^s$ |
| Watch time of comparison | $=11\ \ 40\ \ 40$ |
| Watch fast of local mean time | $=\ \ 33^s$ |

## Example of meridian observation of a star for time and latitude:

### *Transcribed field notes*

August 29, 1944, in camp in sec. 19, T. 45 N., R. 5 E., New Mexico Prin. Mer., Colorado, in approximate latitude 38°08′ N., and longitude 106°21.1′ W., at approximate temperature 60° F., and barometric pressure 22.1 ins., I make a meridian observation of the star $\sigma$ Sagittarii, No. 24/48, Mag. 2.1, for time and latitude, observing simultaneously the time of transit and the star's altitude, reversing the telescope and observing the star's altitude:

| | |
|---|---|
| Mean observed altitude | =25°31′30″ |
| Reduced latitude | =38°07′58″ N. |
| Watch time of observation | = $8^h24^m42^s$ p. m |
| Watch fast of local mean time | = $5^m57^s$ |

### *Field record*

Setting: 90°00′
$\phi \neq$ 38°08′ N.
$\delta \neq$ 26°22′ S.

$v \neq$ 25°30′

| Telescope | Watch time | Vertical angle |
|---|---|---|
| Direct | $8^h24^m42^s$ | 25°31′30″ |
| Reversed | | 25 31 30 |
| Mean | | =25°31′30″ |
| Refraction (120″×.75×.98) | | =−1 28 |
| $h$ | | =25°30′02″ |
| $\delta$=26°22′00″ S.; $90°-\delta$ | | =63 38 00 |
| $\phi$=38°07′58″ N.$=90°-\delta-h$ | | =38°07′58″ |

| | | |
|---|---|---|
| Watch time of star's transit | | = $8^h24^m42^s$ p. m. |
| Star's transit, Gr. m. t., Aug. 16 | = $9^h11^m00^s$ p. m. | |
| Red. to Aug. 29 | = −51 06 | |
| Red. to long. 106°21.1′ | − 1 09 | |
| Star's transit, local mean time | $8^h18^m45^s$ | $8^h18^m45^s$ p. m. |
| Watch fast of local mean time | | = $5^m57^s$ |

## Altitude Observation of Polaris for Latitude

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

$$\phi = h + \delta - 90°$$

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

$$\phi = h + 90° - \delta$$

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

$$v \neq \phi \pm (90° - \delta)$$

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 the mean observed altitude to use in the reduction.

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

*Transcribed field notes*

August 31, 1944, at camp, in approximate latitude 33°23′ N., and longitude 107°11.6′ W., New Mexico, at approximate temperature 60° F., and elevation 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:

| | |
|---|---|
| Watch correct for 105th meridian time by comparison with radio signals. | |
| Mean watch time of observation | = $3^h17^m01^s$ a. m. |
| Mean observed vertical angle | = 34°24′ 52″ |
| Reduced latitude | = 33°23′ 26″ N. |

*Field record*

$$
\begin{array}{rl}
\text{Setting: } & 90^\circ 00' \\
\delta \neq & 89\ 00 \\
\hline
90^\circ - \delta \neq & 1^\circ 00' \\
\phi \neq & 33\ 23 \\
\hline
v \neq & 34^\circ 23' \quad \phi + (90^\circ - \delta) \\
\end{array}
$$

| | | |
|---|---|---|
| U. C. of Polaris, Gr. m. t., August 31, 1944 | = | $3^h09.5^m$ a. m. |
| Reduced to long. 107°11.6′ W. | = | −1.2 |
| | | $3^h08.3^m$ |
| L. m. t. of U. C. of Polaris, August 31 | = | $3^h08^m18^s$ a. m. |
| Correction for long. 107°11.6′ | = | +8 47 |
| Computed watch time of upper culmination | = | $3^h17^m05^s$ a. m. |

| Telescope | Watch time | Vertical angle |
|---|---|---|
| Direct | $3^h13^m03^s$ | 34°24′00″ |
| Reversed | 3 15 01 | 34 26 00 |
| Reversed | 3 19 00 | 34 26 30 |
| Direct | 3 21 00 | 34 23 00 |
| Mean | $3^h17^m01^s$ | 34°24′52″ |
| Refraction (1′24″ x .89 x .98) | | −1 13 |
| | | $h=$ 34°23′39″ |
| $\delta = 88^\circ 59' 47''$; $90^\circ - \delta$ | | = −1 00 13 |
| $\phi = 33^\circ 23' 26''$ N. $= h - (90^\circ - \delta)$ | | = 33°23′26″ |

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

*Transcribed field notes*

**October 18, 1944, in approximate latitude 40°44′ N., and longitude 111°52′ W., Utah, at approximate temperature 50° F., and approximate altitude above sea level 4,500 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:**

| | |
|---|---|
| **Watch correct for 105th meridian time by comparison with radio signals.** | |
| **Mean watch time of observation** | **= $0^h28^m20^s$ a. m.** |
| **Mean observed vertical angle** | **=41°44′ 45″** |
| **Reduced latitude** | **=40°43′ 52″ N.** |

*Field record*

Setting: 90°00′
$\delta \neq 89°00'$

$90° - \delta \neq 1°00'$
$\phi \neq 40°44'$

$v \neq 41°44' = \phi + (90° - \delta)$

| | | |
|---|---|---|
| U. C. of Polaris, Gr. m. t., Oct. 18, 1944 | = | $0^h1.2^m$ a. m. |
| Reduction to longitude 111°52′ W. | | −1.2 |
| | | $0^h0.0^m$ |
| L. M. T. of U. C. of Polaris, midnight, Oct. 17–18, 1944 | = | $0^h00^m00^s$ a. m. |
| Correction for longitude | = | +27 28 |
| Computed watch time of U. C., Oct. 18, 1944 | = | $0^h27^m28^s$ a. m. |

| Telescope | Watch time | Vertical angle |
|---|---|---|
| Direct | $0^h23^m04^s$ | 41°44′30″ |
| Reversed | 0 27 07 | 41 45 00 |
| Reversed | 0 30 02 | 41 45 00 |
| Direct | 0 33 07 | 41 44 30 |
| Mean | $0^h28^m20^s$ | 41°44′45″ |
| Refraction (1′06″ x .86 = 56″) | = | −56 |
| | | $h$ = 41°43′49″ |
| $\delta$ = 89°00′03″; 90° − $\delta$ | = | −59 57 |
| $\phi$ = 40°43′52″ N. = $h - (90° - \delta)$ | = | 40°43′52″ |

## Hour Angle Observation of Polaris For Latitude

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

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

The vertical angle reduction is tabulated in the Ephemeris in a simplified form in which the two principal arguments are employed to secure a primary adjustment to the elevation of the pole, subtractive when Polaris is above the pole and additive when below; a small supplemental correction is then secured from the table, with the arguments of mean time hour angle and observed altitude.

In order to proceed with the analytical reduction, it is convenient to begin with an angle $\alpha$, computed from the equation:

Tan $\alpha=\dfrac{\tan \delta}{\cos t}$, in which equation the factor "cos $t$" becomes negative for hour angles exceeding 90°, whereupon $\alpha$ will exceed 90°.

The latitude may then be derived from the equation:

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

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

*Transcribed field notes*

June 23, 1944, in the SE¼ sec. 16, T. 7 N., R. 3 E., Salt Lake Meridian, Utah, in approximate latitude 41°20′ N., and longitude 111°37′ W., at approximate temperature 50° F., and elevation above sea level 6800 ft., I make an hour angle observation of Polaris for latitude, making four observations, two each with the telescope in direct and reversed positions:

| | |
|---|---|
| Mean observed vertical angle | 42°00′ 30″ |
| Mean watch time of observation | $4^h46^m38^s$ a. m. |
| Watch fast of local mean time, by comparison with radio time signal corrected for long | $26^m28^s$ |
| Reduced latitude | 41°20′ 50″ N. |

*Field record*

| Telescope | Vertical angle | Watch time |
|---|---|---|
| Direct | 41°58′30″ | $4^h44^m45^s$ a. m. |
| Reversed | 41 59 30 | 4 45 50 |
| Reversed | 42 01 30 | 4 47 20 |
| Direct | 42 02 30 | 4 48 37 |
| Mean | 42 00 30 | $4^h46^m38^s$ a. m. |

| | | |
|---|---|---|
| Watch fast of local mean time | | $-26\ 28$ |
| L. M. T. of observation, June 23, 1944 | | $=4^h20^m10^s$ a. m. |
| | | $=4^h20.2^m$ a. m. |
| Gr. U. C. of Polaris, same date | $=7^h39.4^m$ a. m. | |
| Red. to long. 111°37′ W | $=-1.2$ | $=7\ 38.2^m$ a. m. |
| Hour angle of Polaris east of meridian | | $=3^h18.0^m$ |
| Declination of Polaris | | 88°59′ 39″ |

| Mean time hour angle | Primary adjustment, subtractive, Polaris above the pole | | |
|---|---|---|---|
| | Declination | Mean observed vert. angle, | $v=-42°00'30''$ |
| | | Refraction, 64″×.79 | $=\quad -0\ 51$ |
| | | | $h=\quad 41°59'39''$ |
| | 88°59′40″ | Primary adjustment to elev. of pole | $=-\ 0°38'47''$ |
| | | Supplemental correction | $=\quad -02$ |
| $3^h17.5^m$ | 0°38′53″ | Latitude of sta. | $=\ 41°20'50''$ N. |
| 3 18.0 | 0 38 47 | | |
| 3 23.4 | 0 37 39 | | |

The above example may be reduced analytically as follows:

$$\text{Tan}\ \alpha=\frac{\tan\delta}{\cos t}\qquad \text{Cos}\ (\phi-\alpha)=\frac{\sin\alpha\sin h}{\sin\delta}$$

| | | | |
|---|---|---|---|
| M. t. h. a. | $3^h18^m00^s$ | log tan $\delta$=1. 7555520 | log sin $\alpha$=9. 9999719 |
| | | " cos $t$=9. 8113212 | " " $h$=9. 8254618 |
| Red. to sid. h. a. | +33 | | |
| | | " tan $\alpha$=1. 9442308 | 9. 8254337 |
| Sidereal h. a. | $3^h18^m33^s$ | | " " $\delta$=9. 9999331 |
| Sid. h. a. in ang. meas., $t$ = | 49°38′ 15″ | $\alpha$=89°20′ 55″ | |
| | | | log cos $(\phi-\alpha)$ =9. 8255006 |
| | | By inspection, $(\phi-\alpha)$ is a negative angle. | $(\phi-\alpha)=-48°00'04''$ |
| | | | $\alpha=$ 89 20 55 |
| | | Latitude of station | = 41°20′51″ |

The reduction may also be made by the equation:

$$\phi=h-p\cos t+\tfrac{1}{2}\sin 1'\ p^2\sin^2 t\tan h$$

In the above equation, $p$=polar distance $(90°-\delta)$, *expressed in minutes of angle.* The first part of the equation gives a primary reduction to the elevation of the pole, in this the factor "$p \cos t$" becomes additive for hour angles that exceed 6 hours or 90°. The latter part of the equation gives a supplemental correction, in the order of *seconds of angle;* it increases rapidly in the higher latitudes.

As an illustration of the use of the latter equation, the elements are taken from the observation given above: $h=41°59'39''$; sidereal hour angle, after converting from time to arc, $t=49°38'15''$; declination of Polaris, $\delta=88°59'39''$ N.; polar distance, $p=1°00'21''=60.35'$; with this data, the reduction may be made as follows:

| | | | | |
|---|---|---|---|---|
| log $p$ | $=1.780677$ | $h=41°59'39''$ | log sin 1′ | $=6.4637$ |
| " cos $t$ | $=9.811321$ | $+\quad 17$ | " 2 | $=\ .3010$ |
| " product | $=1.591998$ | | " quotient | $=6.1627$ |
| nat | $=39.084'$ | | " $p$ | $=1.7807$ |
| | $=39'05.040''$ | $-39\quad 05$ | " " | $=1.7807$ |
| | | | " sin $t$ | $=9.8819$ |
| | | | " " " | $=9.8819$ |
| Latitude of station: | | $=41°20'51''$ | " tan $h$ | $=9.9543$ |
| | | | " product | $=9.4422$ |
| | | | nat | $=0.277'$ |
| | | | | $=0'16.6''$ |

# AZIMUTH

## The General Land Office Solar Transit

**77.** The methods long in use have been developed for the correct operation of the General Land Office solar transit, in which the solar unit is depended upon for a large share of the line running, in combination with observations on the sun, Polaris, and the brighter stars for the more exact determination of time, latitude, and azimuth, where needed. Almost without exception in beginning new surveys and in occupying any new station for which there has been no previous station established for a reference in azimuth, the starting value in azimuth is determined with the solar unit. Then, where a higher degree of accuracy may be required, no other preliminary steps are needed in readiness for a twilight observation upon Polaris, or any of the bright stars within the equatorial belt, other than the simple computations for the setting values in horizontal and vertical angles. No other instrument adapted to land surveying so well combines accuracy in performance, speed in execution, and economy in cost per mile.

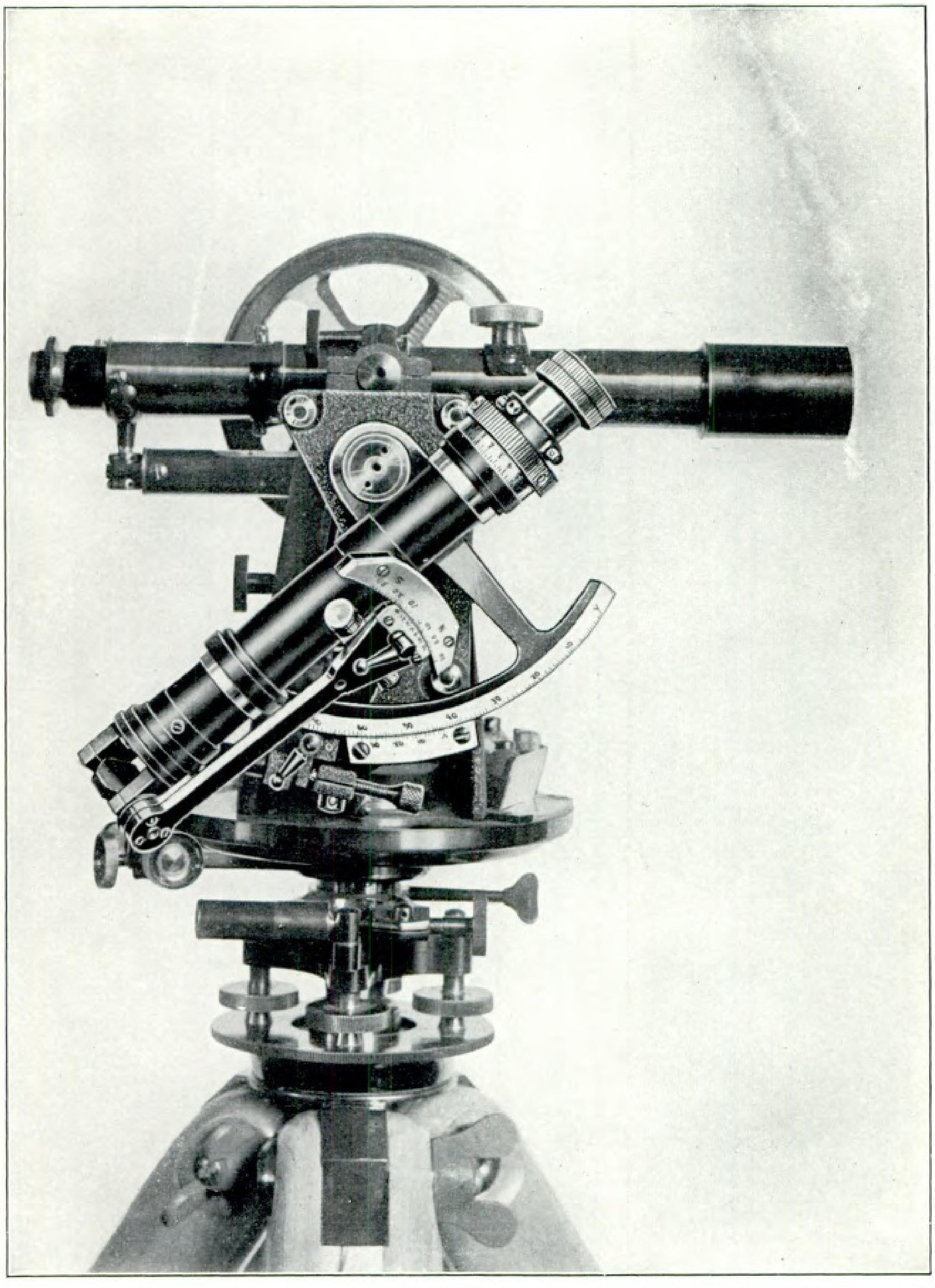


FIGURE 9.—The solar transit as it appears in use.

Model A: The first solar transit constructed on specifications of the General Land Office, 1914. Essentially the Smith solar unit, with redesign to facilitate complete adjustment in the field.

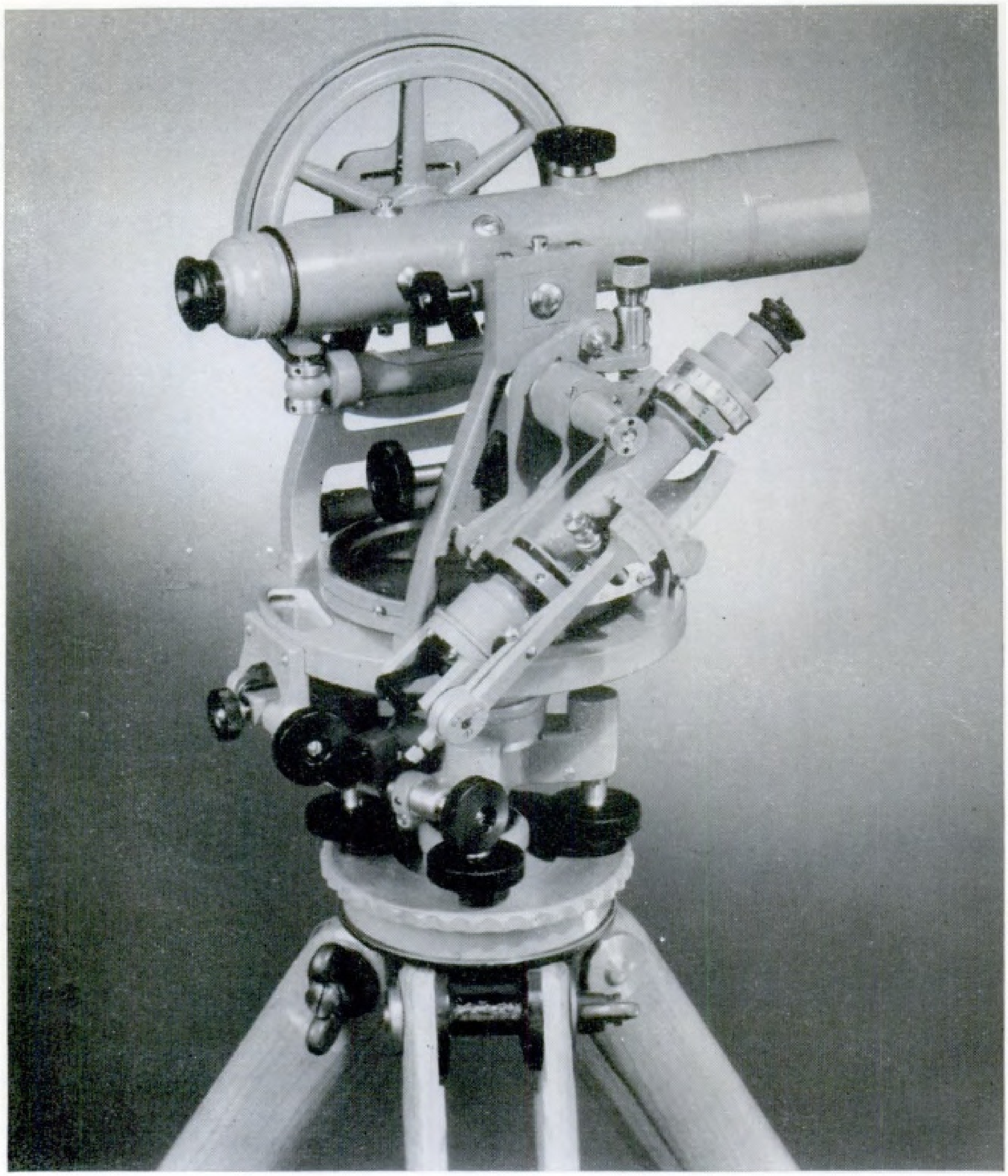


FIGURE 9a.—This instrument is constructed for accuracy, speed, and economy of operation.

Model C: The latest solar transit constructed on specifications of the General Land Office, 1945. The latitude clamp operates on the latitude axis; the declination clamp operates on the reflector axis; greatly improved optical construction in the solar telescope. The reticle of the transit telescope is designed to include a solar circle.

The standard models are illustrated in Figures 9 and 9a. Note that the solar unit is in fact a second instrument, operating in its own right, independently. The 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° minus the sun's north declination, or 90° 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.

Skillfully handled in the hands of an experienced engineer, and within a period of less than 2 minutes by the watch, after a set-up and careful leveling, the solar transit may be oriented instrumentally. The accuracy or acceptable "tolerance" is equal to any single, unverified, average direct altitude observation on the sun.

In line running, through timber and undergrowth, there may be 20, 30, or more set-ups to the mile, each by solar orientation without cutting or opening the line to secure an exact back sight. 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 Manual 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"



700004°—47——7

or "secant" method requires the careful running of a "back-and-foresight" line with measured offsets.

The solar unit avoids the accumulative error quite usual in long "back-and-foresight" lines, and in traverse lines where there are many turns, excepting as time may be taken for the necessary refinements. A traverse line may be run *by occupying each alternate station*, dividing by two the amount of time required for the instrumental work. Heavy winds or insecure ground, windfalls, timber, undergrowth, and obstructions that require offset, are not in themselves any preventative to rapid and accurate solar orientation.

A more complete description of the transit, section 41.

The requirements as to the adjustments, sections 40 to 46, incl.

The transit adjustments, Manual Appendix II, section 41.

The development of the General Land Office solar transit, Manual Appendix II, section 78.

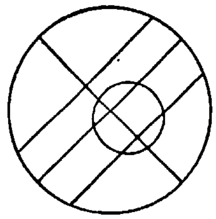
The adjustments of the solar unit, Manual Appendix II, section 79.

An extension of the description, requirements as to adjustment, use, and test of the solar unit, follows in sections 78 to 81, incl.

## Construction

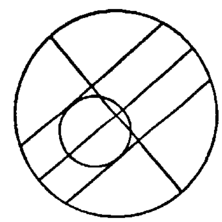
**78.** The instrumental orientation of the solar unit is made possible through five elements in the construction, as follows:

1. A telescope whose line of collimation is the polar axis; the latter 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 from the base frame gives the reading in latitude; the center of the limb is called the latitude axis, mounted in horizontal.
3. There is a reflector at the objective end of the telescope designed to pick up the light rays of the sun; its axis is normal to the line of collimation. There is an arm that controls the angle of the reflector in the plane of the great circle that passes through the pole and the sun; a vernier on this arm gives the reading on a graduated declination arc.
4. There is a small graduated circle mounted on the telescope, normal to the line of collimation, that 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.*



*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.

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). The fourth is a single cross wire, normal to the others, passing through the line of collimation, indicating the center of the field in *time*.

The frame of the solar unit that supports the latitude axis is itself 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° is graduated for reading 10°; this is because a movement of 5° in the reflector position makes an angle of 10° between the light rays of incidence and those reflected. At zero declination the plane of the reflector is at 45° to the line of collimation. The declination arc is graduated from zero both ways 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° 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 an adjustment (corresponding to the mounting of a telescope level) that is arranged to bring the polar axis into normal to the latitude axis. This is needed to provide a movement of the polar axis in a true vertical plane when the solar telescope is changed in latitude setting.

Manual Appendix II.

## Requirements as to Adjustment

**79.** Each solar transit has its own record as to *performance*. This of course takes in its own life history beginning with the inspection tests at the maker's at time of acceptance under purchase contract. It becomes an invaluable record which reveals, or should show, exactly how that instrument may be expected to perform, its own personal equation, when it has been given the needed general cleaning and lubrication, what repairs have been required, in what instrument shop, and the subsequent tests. The summary of this record and the assignments of that instrument for the field work are maintained in the regional office.

The detail of the field tests and adjustments is kept by the chief of the field party in the field tablets belonging with the record of the survey. A brief summary only of the field tests is transcribed for inclusion in the field-note record that is prepared for official approval; the purpose here is to show affirmatively that the tests have been attended to as required, and that the instrument was in satisfactory condition while being used on the survey.

If a "touch-up" adjustment is required in the field, the field tablet record should show at what *point of adjustment, and the direction of the touch-up, and, as nearly as can be indicated, the amount*. The analysis of the tests or observations before and after adjustment is also important. This makes for systematic improvement in performance.

There are a number of points concerning which the data should always be at hand, and the tests repeated from time to time so that the data may be reliable. If this is done methodically, and the tests found satisfactory within reasonable limits, the solar unit may be depended upon to perform well in the line running. The most important of this detail, all derived in the field tests, and all to be noted in the field tablet, includes the data as follows:

1. The reading of the latitude vernier when sighting in true horizontal.

2. The known or observed *true latitude* of the field station; and, the *instrumental latitude* of that station as determined by noon solar observation, when preceded by the pre-noon careful setting of the declination arc by the prime vertical method.

3. The reading of the declination vernier when set in true zero declination, prime vertical method.

4. Same, 15° north declination.

5. Same, 15° south declination.

6. Same, in declination for the period of the use of the instrument.

7. The test for parallelism when the solar telescope is set and clamped in the latitude of the station, prime vertical method.

8. The tests for orientation in comparison with the true meridian established in camp by any of the Manual methods best suited to the time, place, and other conditions of the survey.

9. The line tests at two or three intervals each week, observing on Polaris or an equatorial star, or by altitude observation on the sun, for comparison with the azimuth as determined by the solar orientation.

10. A notation of any consistent discrepancy that comes near or exceeds the Manual tolerance of 1′30″.

The data for (7), (2), and (6) correspond to the preliminary field tests (1), (2), and (3), Manual Appendix II, section 79; this data, if satisfactory, insures that the solar unit is ready for the orientation tests. All that is ordinarily required in the beginning of the survey is to run through these tests. If no serious discrepancies are present, the instrument is ready for the survey, and the work may proceed. The remainder of the tests are made and recorded as time and opportunity permit.

The requirements as to orientation are closely related to the limits of closure on the survey (sec. 234). Note carefully that there will be no difficulty in the closures, Class "C," traceable to error in the direction of the lines, if the instrument meets the requirements as to the above tests. A more severe condition as to the closures is presented when *two instruments* are employed on the same survey, one closing against the lines run with the second instrument. This in effect admits of a limiting discrepancy of 3′00″ between the two instruments, which would be quickly apparent in the section closures. It is an eloquent tribute to the solar transit that the survey can be carried through within that accuracy, speed, and economy as to cost per mile. This would be impossible to duplicate by ordinary land-survey methods, referring as it does to the every day, week in and week out, through the season performance.

To sum up these requirements, let the field tablet record show that the tests (7), (2), and (6) give assurance that no hidden discrepancy is present, or left unchecked or uncorrected, and that the meridian comparisons have been reasonably frequent and satisfactory.

Manual Appendix II.

## Use

**80.** The General Land Office solar transit is an instrument that is equipped for making any type of stellar or solar observation that may be employed profitably in land surveying practice, and as adapted to the one-minute transit. This means accuracy in performance within any practical limit set out in the Manual down to a tolerance of $\pm 15''$ in the direction of lines, where that may be required. That accuracy is much inside the tolerance that must ordinarily be allowed in the *measurement* of lines, unless the character of the survey is such as to justify the greatly increased cost of exactness in measurement. Secs. 17, 35, 37, 41, 44, 45, 47, 142, 143, 156, 161, 162, 174, 234, 480, 691, 704.

By the use of the instrument, therefore, it is meant to include every type of line running down to close "tack-point" back-and-foresight work, and every kind of observation upon the sun, Polaris, or the bright equatorial stars, for time, latitude, and azimuth, by daylight, twilight, or at night.

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

For these reasons, the preparation for 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 latitude. Section 54. Additionally, the known true or observed latitude of the station, and the *instrumental latitude*. Section 79.

Due accuracy in solar orientation becomes attainable as soon as the sun is high enough to reduce the refraction increment to not over 4′ or 5′, and continuing then until 10:30 a. m. or a little later with care and suitable checks; correspondingly in the p. m. hours. 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.

Thus, in the above practices, and with the transit and solar unit in satisfactory adjustment, the simple steps in solar orientation at any station or set-up, are these: carefully level, preferably with the solar unit on the west; turn to solar unit on the east 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 if check is thought to be needed (these arcs remain clamped); 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 practice requires the daily noon solar observation, and that the data be recorded in the field tablet.

## Test

**81.** The purpose here is to give an example of a field-tablet record that shows a typical hour by hour (or half-hour) orientation test of the solar unit, the instrument being in good order, and the adjustments satisfactory. There are many such tests during the season, the one here being an all-day test in the early stage of a new field assignment. From this record test an affirmative statement may be transcribed to be carried forward into the field notes that are to be submitted for official approval, to show that the instrument was in fact ready for the survey.

By way of caution (and much to the credit of the solar unit, when in good adjustment), if the tests show that the vertical plane of the polar axis, when set and clamped in the latitude of the station, is closely parallel to the vertical plane of the transit, and at the same time that the solar unit gives an orientation consistently to one side of the test meridian, the next important step is to verify the accuracy of that meridional line, doing so by some method or observing program that will compensate for any possible uncertainties in the values or factors that entered into the previous observation. Note that a solar unit (if in adjustment) cannot give a consistent orientation through the day in the same amount to one side of the true meridian.

Example:

*Field record*

**July 31, 1945, at** the camp site in sec. 33, T. 65 N., R. 9 W., 4th Prin. Mer., on the south shore of Basswood Lake in the International Boundary Waters, Minnesota, in latitude 48°03′30″ N., and longitude 91°30′35″ W., I examine the adjustments of General Land Office solar transit, Buff No. 19421, and find that no corrections are required. I make an altitude observation on the sun, p. m., for time and azimuth; and a daylight hour angle on Polaris for latitude and azimuth. The resulting azimuth of the two observations is in agreement. The detail of these observations is omitted here.

Aug. 1: Test the orientation of the solar unit in the a. m. and p. m. At noon, make a meridian observation on the sun for time and latitude, which verify the previous observations; determine the instrumental latitude by noon solar observation. Detail omitted here.

Aug. 2: Continue the tests in the a. m. and at noon; instrument in good adjustment without correction.

The basic elements of the observations for time, latitude, and azimuth are required in the transcribed field notes.

The record of the test of the orientation of the solar unit may take the following form, modified to conform with the facts:

*Transcribed field notes*

On Aug. 1 and 2, 1945, at about half-hour intervals from 8:30 a. m. to 4:45 p. m., I make orientation tests of Buff solar transit No. 19421, including latitude tests by noon observation both days. The tests give a maximum error in orientation of less than 1′30″.

The record also will show that the solar transit has been maintained in satisfactory adjustment for the duration of each survey; the following statement, duly modified to conform with the facts, is suggested (Manual Appendix VIII, sec. 427):

*Transcribed field notes*

The arcs are tested daily by noon observation when conditions are favorable, and the meridional indications are verified at frequent intervals throughout the survey.

**82.** Each instrument requires an inspection between the seasonal field-use, for attention to needed cleaning, lubrication, and repair, including a record of all detail, and the checking of many items that are not regularly referred to as among the field adjustments. This record may be adapted to memorandum form, with a check-off as the items are found satisfactory, or have been attended to. Explanations and detail as to the tests and adjustments, repairs, etc., should be stated fully on sheets to be attached to the schedule. This is a record for which the regional office is primarily responsible (sec. 79), with copy for the information of the chief of field party. A field-tablet record begins at this point.

A memorandum form for reference purpose, to indicate the completeness of the between-season inspection: Manual Appendix II.

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

**83.** It may frequently happen with a solar transit, especially at the beginning of a 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 table 22, 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 $9^h40^m$ a. m., app. t., at a station in latitude assumed to be 46°20′ N., a test was made with a solar transit whereby the trial indication was found to be S. 0°05′ W., or 0°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°21′.5 N., and that the vernier of the declination arc had an index error which gave readings 0°00′.5 S. of the calculated declination (i. e. reading 15°19′.5 N. for a calculated declination of 15°20′ N.). Thus in the test the latitude arc was set 1′.5 S. of the correct latitude of the station, and the declination arc was actually set 0′.5 N. of the value that would have been set had the index error been known.

Table 22 is entered to obtain the correction coefficients:

| Latitude | Hours from noon | | | |
|---|---|---|---|---|
| | $2^h0^m$ | $2^h20^m$ | $3^h0^m$ | |
| 45° 00′ | 2. 83 | 2. 55 | 2. 00 | Declination coefficient. |
| 46 21. 5 | | 2. 62 | | |
| 50 00 | 3. 11 | 2. 81 | 2. 20 | |
| 45 00 | 2. 45 | 2. 10 | 1. 41 | Latitude coefficient. |
| 46 21. 5 | | 2. 16 | | |
| 50 00 | 2. 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, but these are not intended for use in line work, and can not be accepted in lieu of subsequent tests based on correct values.

In the above connection it should be explained that it is not deemed desirable to burden the official record with the detail of index errors found in the verniers of the latitude and declination arcs, other than to state, when determined, that the same are corrected, or are allowed for in subsequent observations. Section 46.

## Polaris at Elongation

**84.** Attention is now directed to the approved methods of observation to establish the true meridian with which to make comparisons of the orientation of the solar unit as a necessary test of that instrument, or without a solar instrument, the establishment of the true meridian from which to project transit lines and to test a calculated course.

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:

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

Example of computing the azimuth of Polaris at elongation, October 20, 1945, in latitude 46°20′ N., on which date the declination of Polaris=89°00′23″ N.:

$$\begin{aligned} \log \cos \delta &= 8.\ 239072 \\ \text{"} \cos \phi &= 9.\ 839140 \\ \hline \text{"} \sin \text{A} &= 8.\ 399932 \end{aligned}$$

$A$=Azimuth of Polaris at elongation=1°26′21″.

**85.** 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.

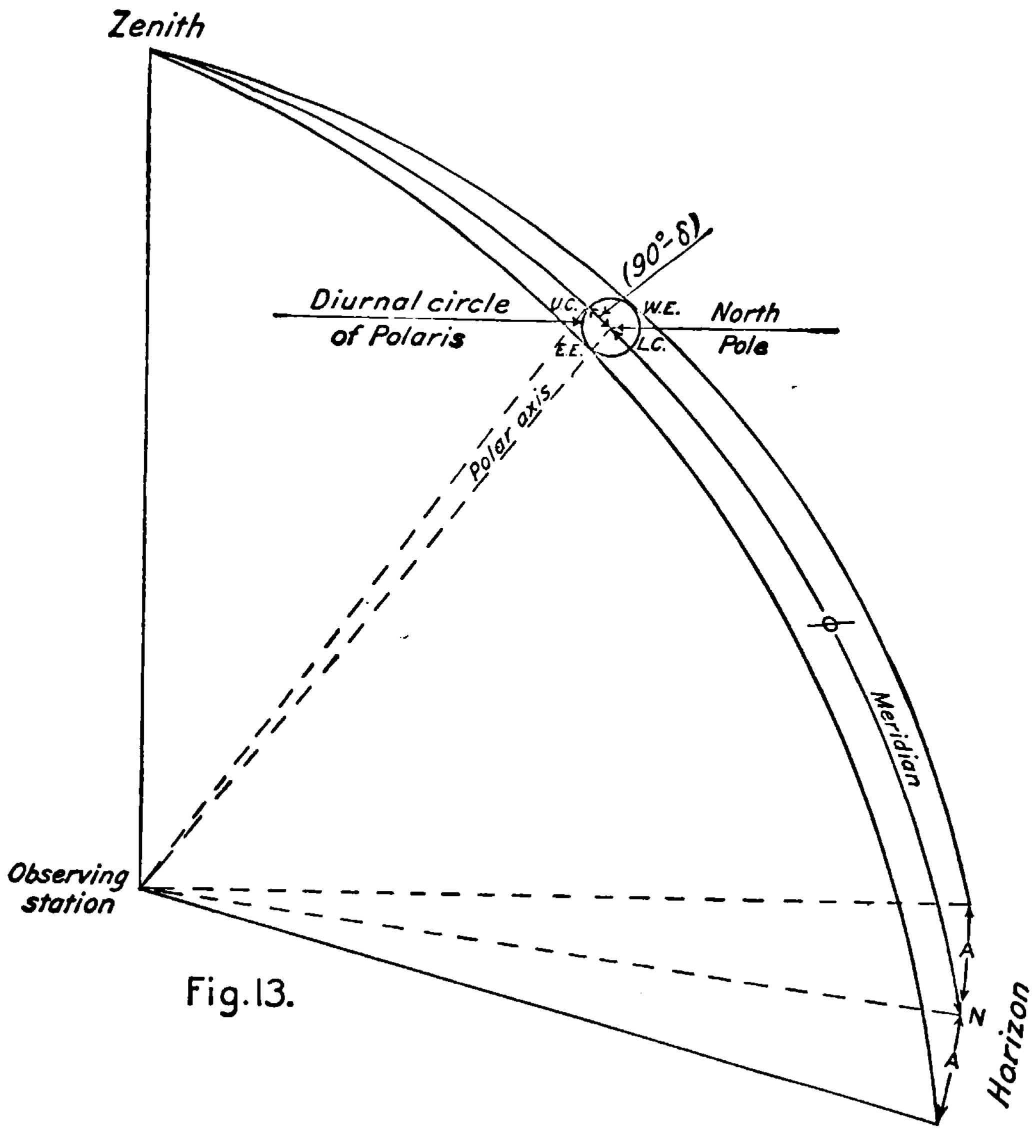



Fig. 13.

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

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°00′20″ | 89°00′23″ | 89°00′30″ |
| | Azimuths at elongation | | |
| 46°00′ | 1°25′54″ | 1°25′50″ | 1°25′40″ |
| 46 20 | | 1 26 21 | |
| 47 00 | 1 27 30 | 1 27 25 | 1 27 15 |

By interpolation in the table the required azimuth of Polaris at elongation is therefore found to be 1°26′21″.

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

## Polaris at Elongation, Observing Program "a."

**87.** Select the observing station and make suitable provision to mark the line defining the direction of Polaris at elongation; the flag point should be not less than from 5 to 10 chains N. of the transit point, and the line should be cleared of all obstruction before dark. Determine the local mean and watch time of elongation of Polaris, provide suitable illumination for both the transit and flag point, and have everything in readiness as much as 15 minutes before the time of elongation.

Thoroughly level the transit.

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

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

Again level the transit.

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

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

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

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

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

Occasionally conditions obtain where it is impossible to define or mark the direction of the observation; the program may then be altered to the reading of deflection angles as shown in observing program "*b*."

Example of observation of Polaris at elongation for azimuth, observing program "*a*":

| *Field record* | *Transcribed field notes* |
|---|---|
| November 2, 1944, Gr. m. t., E. E. of Polaris, lat. 40° = 5h02.6m p. m.<br>Red. to long. 111°33′ W = −1.2<br>Red. to lat. 46°24′ N = +0.8<br>L. m. t. of E. E. of Polaris = 5h02.2m p. m.<br>Watch fast of l. m. t. by reduced radio time signal = +26.2<br>Watch time of E. E. = 5h28.4m p. m. | November 2, 1944, at the cor. of secs. 1, 2, 11, and 12, T. 7 N., R. 1 E., Principal Meridian, Montana, in latitude 46°24′ N., and longitude 111° 33′ W., at 5h02.2m p. m., l. m. t., observe Polaris at eastern elongation, making four observations, two each with the telescope in direct and reversed positions, and mark the mean point in the line thus determined, on a peg driven in the ground, 10.00 chs. N. of my station.<br><br>Azimuth of Polaris at eastern elongation 1°26′47″.<br><br>I lay off the azimuth of Polaris, 1°26′47″ to the west, and mark the meridian thus determined, by a tack in a peg driven firmly in the ground. The value of the angle determined by measurement 16.665 ft. (25.25 lks.) due west from the observing mark; then verified by repetition of the angle at the transit station. |

| Telescope | Watch time |
|---|---|
| Direct | 5h26m20s p. m. |
| Reversed | 5 28 30 |
| Reversed | 5 29 30 |
| Direct | 5 30 20 |
| Mean | 5h29m40s p. m. |

Declination of Polaris = 89°00′09″ N.

| Latitude | Declination 89°00′00″ | Declination 89°00′09″ | Declination 89°00′10″ |
|---|---|---|---|
| | Azimuth | Azimuth | Azimuth |
| 46°00′00″ | 1°26′23″ | 1°26′09″ | 1°26′08″ |
| 46 24 00 | | 1 26 47 | |
| 47 00 00 | 1 27 59 | 1 27 45 | 1 27 44 |

## Polaris at Elongation, Observing Program "b."

**88.** Select the observing station and mark a point by driving a tack in a peg driven firmly in the ground in the meridian as determined by the solar before sunset, or choose some other suitable reference mark in any direction. The reference point should not be less than 5 to 10 chains distant. Determine the local mean and watch time of elongation of Polaris, provide suitable illumination for both the transit and flag point, and have everything in readiness as much as 10 minutes before the time of elongation.

Thoroughly level the transit.

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

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

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

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

As the position of Polaris remains within about 0°00′01″ of true elongation for a period of about five or six minutes either side of the time of exact elongation, the observation may be considered satisfactory if the watch readings fall within that period.

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

A reference point in any direction may be used in the above method; the direction of the deflection from the reference point to Polaris should always be clearly stated in the field-note record.

It may be stated further that experienced observers usually prefer observing program "b" for the elongation observation, modified by using the method of repetition to secure a more accurate determination of the horizontal angle. On this plan, read and record the angle first turned; loosen the lower clamp and set back to the observing mark (using the lower tangent motion); then turn the angle a second time for the second sighting. Leave the plate clamp set. Reverse the transit, and set back to the observing mark. Make two more sightings on the same plan. This has repeated the horizontal angle *four* times; the 1st and 2nd, direct position of the telescope; the 3rd and 4th, reversed position. Record the last reading, and divide that value by four. The quotient is the desired horizontal angle for the mean of the observation. References: repetition of angles, sec. 36; explanation of repetition of angles in reference to Polaris observations, sec. 55; example of repetition, hour angle observation on Polaris, sec. 98.

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

**Field record**

| | |
|---|---|
| **Sept. 4, 1944, Gr. m. t., E. E. of Polaris, lat. 40°** | $8^h54.2^m$ p. m. |
| **Red. to long. 106°22′ W.** | −1.3 |
| **Red. to lat. 37°45′ N.** | −0.2 |
| **L. m. t. of E. E. of Polaris** | $8^h52.7^m$ p. m. |
| **Watch fast of l. m. t.** | +5.3 |
| **Watch time of E. E.** | $8^h58.0^m$ p. m. |

| Telescope | Watch time | Deflection angle |
|---|---|---|
| Direct | $8^h56^m38^s$ | 1°16′00″ |
| Reversed | 8 57 28 | 1 16 00 |
| Reversed | 8 57 43 | 1 16 00 |
| Direct | 8 58 56 | 1 16 00 |
| **Mean** | $8^h57^m41^s$ | 1°16′00″ |

**Declination of Polaris = 88°59′48″ N.**

| Latitude | Declination 88°59′40″ | Declination 88°59′48″ | Declination 88°59′50″ |
|---|---|---|---|
| | Azimuth | | |
| 37°00′00″ | 1°15′33″ | 1°15′23″ | 1°15′20″ |
| 37 45 00 | | 1 16 09 | |
| 38 00 00 | 1 16 34 | 1 16 24 | 1 16 21 |

**Transcribed field notes**

Sept. 4, 1944, at a point near the SE. cor. of T. 41 N., R. 5 E., New Mex. Prin. Mer., Colorado, in latitude 37°45′ N., and longitude 106°22′ W., at $8^h52.7^m$ p. m., l. m. t., I observe Polaris at eastern elongation, making four observations, two each with the telescope in direct and reversed positions, reading the deflection angle from a point on a cliff 8 chs. N., east to Polaris:

| | | |
|---|---|---|
| Azimuth of Polaris at eastern elongation | = | 1°16′09″ |
| Mean deflection angle | = | 1 16 00 |
| True bearing of mark | = | N. 0°00′09″ E. |

From reference point, I measure west, 0.02 ft. (¼ inch), and mark the true meridian.

**89.** The observing programs "a" and "b" require the engineer to compute in advance the correct watch time of elongation. In so conducting the observation the minimum period is consumed in the observing program; opportunity is afforded for reversals to eliminate instrumental errors of adjustment. Should the watch error be unknown the observation may be conducted by following the motion of Polaris in azimuth during an ample period preceding elongation to insure that the epoch of the vertical motion of Polaris in its diurnal circle or zero motion in azimuth, is taking place, when the sight should be taken for the direction thus defined.

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

## Polaris at Elongation, Observing Program "c"

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

Thoroughly level the transit.

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

Reverse and level the transit.

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

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

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

Example of observation of Polaris at elongation for azimuth, observing program *"c"*:

<table>
<tr><th>Field record</th><th>Transcribed field notes</th></tr>
<tr><td>

May 31, 1944, Gr. m. t., E. E. of Polaris, lat. 40° — $3^h13.8^m$ a. m.<br>
Red. to long. 104°17'05.5" W. — −1.1<br>
Red. to lat. 33°23'40.8" N. — −0.7<br>
L. m. t. of E. E. of Polaris — $3^h12.0^m$ a. m.<br>
<br>
Declination of Polaris=88°59'41.5"

<table>
<tr><th rowspan="2">Latitude</th><th colspan="3">Declination</th></tr>
<tr><th>88°59'40"</th><th>88°59'41.5"</th><th>88°59'50"</th></tr>
<tr><th></th><th colspan="3">Azimuth</th></tr>
<tr><td>33°00'00"</td><td>1°11'56"</td><td></td><td>1°11'44"</td></tr>
<tr><td>33 23'40.8"</td><td>1 12 16</td><td>1°12'14"</td><td>1 12 04</td></tr>
<tr><td>34 00 00</td><td>1 12 47</td><td></td><td>1 12 34</td></tr>
</table>

</td><td>

May 31, 1944, at the closing Tp. cor., on the 2nd Standard Parallel South, in latitude 33°23'40.8" N., and longitude 104°17'05.'5 W., as computed from tie to U. S. Coast and Geodetic Survey station "Comanche" in sec. 36, T. 10 S., R. 26 E. in order to verify the alinement of the east bdy. of T. 11 S., R. 26 E., I bisect Polaris, follow the motion of the star to eastern elongation, at $3^h12^m$ a. m., l. m. t., and mark the direction upon a peg driven firmly in the ground 8 chs. N.; I then reverse the instrument, again bisect Polaris, and mark the direction upon the peg. Without changing the instrument in horizontal motion, I sight to Polaris to make certain that the settings were made at elongation; there appeared to be no deviation in azimuth for some 15 or 20 minutes.<br>
I lay off the azimuth of Polaris, 1°12'14", to the west of the mean direction determined by the observation and set a point for the test meridian; then by direct and reversed sights, I ascertain that the angle subtended by the flag on the cor. of secs. 1, 6, 7, and 12, is 0°13'08", or 0°00'08" from the reported bearing.

</td></tr>
</table>

## Azimuth of Polaris at Any Hour Angle

**91.** While there is no better method for the establishment of the true meridian than the observation upon Polaris at elongation, yet most of the year this requires night observing. Should Polaris be obscured by clouds at the time of elongation the observation must fail.

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

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

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

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

A table of azimuths of Polaris at all hour angles, for latitudes from 10° to 65° 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 engineer will be required to solve the above equation.



700004°—47——8

**93.** Example of computing the azimuth of Polaris, February 21, 1945, at a mean time hour angle of $2^h37.4^m$, in latitude 33°20′ N., on which date the declination of Polaris=89°00′26″ N.:

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

| | | | |
|---|---|---|---|
| log cos $\phi$ | = 9.921940 | log sin $\phi$ | =9.739975 |
| " tan $\delta$ | = 1.761227 | " cos $t$ | =9.887666 |
| " cos $\phi$ tan $\delta$ | = 1.683167 | " sin $\phi$ cos $t$ | =9.627641 |
| nat cos $\phi$ tan $\delta$ | =48.213 | nat sin $\phi$ cos $t$ | =0.424 |
| nat sin $\phi$ cos $t$ | = 0.424 (−) | | |
| | | log sin $t$ | =9.803127 |
| Algebraic sum | =47.789 | " 47.789 | =1.679328 |
| | | " tan $A$ | =8.123799 |
| Azimuth of Polaris at above hour angle, $A$ | | | =0°45′43″ |

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

| Mean time hour angle | Azimuth of Polaris — Mean declination +89°00′20″ — Latitude 32° | 33°20′ | 34° | Correction subtractive for declination +89°00′30″ |
|---|---|---|---|---|
| $2^h29.6^m$ | 43′.2 | 43′.9 | 44′.2 | 0′.1 |
| 37.4 | | 45.8 | | 0.1 |
| 39.6 | 45.6 | 46.3 | 46.7 | 0.1 |

By interpolation in the table the required azimuth of Polaris is therefore found to be 0°45.8′−0′.1=0°45′42″.

**94.** Example of computing azimuth of Polaris Sept. 15, 1945, at a mean time hour angle of $7^h25.1^m$, in latitude 42°54′ N., on which date the declination of Polaris=89°00′10″ N.:

| | | |
|---|---|---|
| Mean time hour angle | $=7^h25.1^m$ | $7^h=105°$ |
| | $=7^h25^m06^s$ | $26^m=\ \ 6°30'$ |
| Reduction to sidereal hour angle | $=\ +1^m13^s$ | $19^s=\ \ \ \ 4'45''$ |
| Sidereal hour angle | $=7^h26^m19^s$ | $=111°34'45''$ |

| | | | |
|---|---|---|---|
| $\log \cos \phi$ | $=9.864833$ | $\log \sin \phi$ | $=9.832969$ |
| " $\tan \delta$ | $=1.759287$ | " $\cos t$ | $=9.565596$ |
| " $\cos \phi \tan \delta$ | $=1.624120$ | " $\sin \phi \cos t$ | $=9.398565$ |
| nat $\cos \phi \tan \delta$ | $=42.084$ | nat $\sin \phi \cos t$ | $=.250$ |
| " $\sin \phi \cos \delta$ | $=\ .250(+)$ | $\log \sin t$ | $=9.968441$ |
| Algebraic sum | $=42.334$ | " 42.334 | $=1.626689$ |
| | | " $\tan A$ | $=8.341752$ |
| Azimuth of Polaris at above hour angle, A | | | $=1°15'30''$ |

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

| Mean time hour angle | Azimuth of Polaris — Mean declination +89°00′20″ — Latitude | | | Correction additive for declination +89°00′ |
|---|---|---|---|---|
| | 42° | 42°54′ | 44° | 10″ |
| $7^h18.8^m$ | 75′.0 | 76′.1 | 77′.5 | 0′.2 |
| 25.1 | | 75.3 | | |
| 28.8 | 73.7 | 74.8 | 76.1 | 0.2 |

By interpolation in the table the required azimuth of Polaris is therefore found to be $1°15'.3+0'.2=1°15'30''$.

**95.** When vertical angle readings are taken in the hour angle observation on Polaris, the reduction can be extended to include the latitude of the station.

In the example in sec. 93 the mean time hour angle was $2^h37.4^m$; the declination of Polaris was 89°00′26″ N. By including the mean observed vertical angle of 34°07′30″ in the record of the observation the latitude may be reduced from the table in the Ephemeris, arriving at the value $\phi=33°20'$ N., as follows:

| Mean time hour angle | Primary adjustment, subtractive, Polaris above the pole | | |
|---|---|---|---|
| | Declination | | |
| | 89°00'10" | 89°00'26" | 89°00'30" |
| $2^h35.6^m$ | 0°46'18" | 0°46'05" | 0°46'02" |
| 2 37.4 | | 0 45 57 | |
| 2 47.5 | 0 44 14 | 0 44 02 | 0 43 59 |

| | |
|---|---|
| Mean observed vert. ang., | $v=34°07'30''$ |
| Refraction, | $r=\quad -1\ 27$ |
| | $h=34°06'03''$ |
| Prim. adj. to elev. of pole | $=-45'57''$ |
| Supplemental correction | $=\quad -04''$ |
| Latitude of station, | $\phi=33°20'02''$ N. |

In the example in sec. 94 the mean time hour angle was $7^h25.1^m$; the declination of Polaris was 89°00'10" N. By including the mean observed vertical angle of 42°32'30" in the record of the observation, the latitude may be reduced from the table in the Ephemeris, arriving at the value $\phi=42°54'$ N., as follows:

| Mean time hour angle | Primary adjustment, additive, Polaris below the pole |
|---|---|
| | Declination |
| | 89°00'10" |
| $7^h22.8^m$ | 0°21'54" |
| 7 25.1 | 0 22 27 |
| 7 28.8 | 0 23 20 |

| | |
|---|---|
| Mean observed vert. ang., | $v=42°32'30''$ |
| Refraction, | $r=\quad -1\ 03$ |
| | $h=42°31'27''$ |
| Prim. adj. to elev. of pole | $=+22'27''$ |
| Supplemental correction | $=\quad -02''$ |
| Latitude of station, | $\phi=42°53'52''$ N. |

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

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

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

Latitude: By meridian altitude observation of the sun.

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

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

The most frequent substitutions and supplemental observations include: For time, radio time signals, and the meridian passage of a star in the equatorial belt. For latitude, vertical angle readings on a star in the equatorial belt at meridian passage, and vertical angle readings on Polaris by the hour angle method when observing for azimuth. Azimuth for check observations at the camp meridian and on the line of the survey, altitude observation on the sun and the brighter stars in the equatorial belt by daylight methods, two well placed observations, one southeast and one southwest.

The methods as outlined afford positive verification of every element essential to the observations for time, latitude, and azimuth.

## Hour Angle Observation of Polaris, Observing Program "a."

**97.** Select the observing station and make suitable provision to mark the line defining the direction of Polaris; the flag point should be not less than from 5 to 10 chains north of the transit point; provide suitable illumination for both the transit and flag point.

Thoroughly level the transit.

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

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

Again level the transit.

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

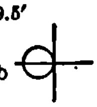
Turn the transit to the direct position of the telescope, bisect Polaris, note the watch time, and mark the direction of sight.

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

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

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

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

| Field record | Transcribed field notes |
|---|---|
| **Meridian observation of the sun for apparent noon:**<br>$\phi = 43°\ 25.5'$ N.     $90°\ 00'$<br>$\delta = 6\ \ 16$ N.     $37°\ 09.5'$<br>$\phi - \delta = 37°\ 09.5'$     $v = 52°\ 50.5'$<br>Watch time.<br>Sun's W. limb  $12^h09^m26^s$<br>Sun's E. limb  12 11 34<br>Watch time of app. noon $12^h10^m30^s$<br>App. noon $= 12^h00^m00^s$<br>Equation of time $= -1\ \ 49$<br>L. m. t. of app. noon $11^h58^m11^s$<br>Watch fast of l. m. t. $12^m19^s$ | Sept. 6, 1944, in camp in sec. 5, T. 25 S., R. 3 W., Willamette Meridian, Oregon, in latitude 43°25′30″ N., and longitude 123°04′30″ W., I make a meridian observation of the sun for apparent noon:<br>Watch time of obsn. $= 12^h10^m30^s$<br>Watch fast of l. m. t. $= 12^m19^s$ |

Hour angle observation of Polaris:

| Telescope | Watch time | Transcribed field notes |
|---|---|---|
| Direct | $6^h27^m00^s$ p. m. | At the same station, at $6^h18.9^m$ p. m., l. m. t., I make an hour angle observation of Polaris east of the meridian, making four observations, two each with the telescope in direct and reversed positions, and mark the mean point in the line thus determined, on a peg driven firmly in the ground, 10 chs. N. |
| Reversed | 6 30 10 | |
| Reversed | 6 33 00 | |
| Direct | 6 34 45 | |
| Mean | $6^h31^m14^s$ p. m. | |
| Watch fast of l. m. t | −12 19 | |
| L. m. t. of observation | $6^h18^m55^s$ p. m.<br>$6^h18.9^m$ p. m. | |

| Field record | | Transcribed field notes |
|---|---|---|
| Sept. 7, 1944, Gr. m. t., U. C. of Polaris | $= 2^h42.1^m$ a. m. | |
| Red. to long. 123°04.5′ W. | $= -1.3$ | |
| L. m. t., U. C. of Polaris | $= 2^h40.8^m$ a. m.<br>+12 | |
| L. m. t. of obsn., Sept. 6 | = 6 18.9 | |
| Hour angle of Polaris east of the meridian | $= 8^h21.9^m$ | Watch time of obsn., mean of four readings $= 6^h31^m14^s$ p. m. |
| Declination of Polaris | $= 88°59'48.7''$ | |

| Mean time hour angle | Azimuth of Polaris, Mean declination 89°00′00″, Latitude 42° | 43°25.5′ | 44° | Correction additive for declination 88°59′50″ |
|---|---|---|---|---|
| $8^h18.6^m$ | 65.5 | | 67.7 | 0.2′ |
| 21.9 | 64.8 | 66.4 | 67.0 | 0.2 |
| 28.6 | 63.4 | | 65.5 | 0.2 |

Azimuth of Polaris $= 1°06.4' + 0.2'$<br>$= 1°06'36''$

Sept. 7, I lay off the azimuth of Polaris, 1°06′36″, to the west, and mark the meridian thus determined, by a tack in a peg driven firmly in the ground, 10 chs. N.

## Hour Angle Observation of Polaris, Observing Program "b"

**98.** Select the observing station and choose a suitable reference mark in any direction. The reference point should be not less than from 5 to 10 chains distant.

Thoroughly level the transit.

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

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

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

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

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

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

The hour angle observation for azimuth should always be coupled with an observation for time, or some other determination of the exact watch correction in terms of local mean time. By reading the vertical angle at each setting it may be combined with the latitude observation. The latter observing program is generally regarded as the most useful in the everyday practical work, and most convenient if made during the twilight period at sunset or sunrise.

Increased accuracy in the horizontal angle determination may be secured through modifying the observing program, by using the method of repetitions instead of the four separate readings. On some important surveys (transit methods apart from orientation by the solar unit) this observing program may be carried through daily, giving assurance that no appreciable accumulative errors have entered into the calculated direction of the lines.

On the plan as described above, the observing program "b" may be restated as follows:

Thoroughly level the transit.

With the telescope in the direct position, first set on the reference mark, then turn the plate angle and vertical angle positions to bisect Polaris for both horizontal and vertical angle; note the watch time; record both angles. Leave the plate clamp set.

An assistant should multiply the first horizontal angle by 2, 3, and 4, to give the settings for the subsequent sightings.

Loosen the lower clamp, reverse the position of the telescope, set back to the observing mark, using the lower tangent motion. Turn the horizontal and vertical angles a second time, for the second sighting on Polaris; note the watch time; record the vertical angle. Leave the plate clamp set.

With the telescope unchanged for position, loosen the lower clamp, set back to the observing mark, using the lower tangent motion. Make the 3rd sighting on Polaris; note the watch time; record the vertical angle. Leave the plate clamp set.

Turn the telescope to the direct position, loosen the lower clamp, set back to the observing mark, using the lower tangent motion. Make the 4th sighting on Polaris; note the watch time; record the vertical angle. On this setting, record the plate reading, for which the horizontal angle has been repeated, or accumulated, four times.

Divide the last plate reading by four; the quotient is the value of the mean horizontal angle of the observation. References: repetition of angles, secs. 36 and 55.

The following example is by the method of repetitions, observation for azimuth (the data for the vertical angle readings, and the reduction for latitude not being included).

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

**Field record**

**Hour angle observation of Polaris:**

| Telescope | Horizontal angle from post to Polaris, by repetition | Watch time |
|---|---|---|
| Direct | 1°13′30″ | 5h42m42s p. m. |
| Reversed | | 5 44 22 |
| Reversed | | 5 45 22 |
| Direct | 4 54 30 | 5 46 12 |
| Mean | 1°13′38″ | 5h44m39s p. m. |

| | | |
|---|---|---|
| Watch slow of 90th mer. standard time | +10 40 | |
| Correction for longitude | −35 12 | |
| L. m. t. of obsn., Oct. 13, 1944 | =5h20m07s | p. m. |
| | =5h20.1m | p. m. |
| Gr. m. t., U. C. of Polaris Oct. 14, 1944 | =0h17.0m | a. m. |
| Red. to long. 98°47.9′ W. | = −1.1 | |
| L. m. t. of U. C., Oct. 14 | =0h15.9m | a. m. |
| | +12 | |
| L. m. t. of obsn., Oct. 13 | =5 20.1 | p. m. |
| Hour angle of Polaris east of the meridian | =6h55.8m | |

**Declination of Polaris** =89°00′01″ N.

| Mean time hour angle | Azimuth of Polaris — Mean declination +89°00′00″ — Latitude 38° | 39°07.4′ | 40° |
|---|---|---|---|
| 6h48.9m | 74.1′ | | 76.2′ |
| 55.8 | 73.55 | 74.75′ | 75.65 |
| 58.9 | 73.3 | | 75.4 |

Azimuth of Polaris = 1°14.75′
= 1°14′45″

**Transcribed field notes**

Oct. 13, 1944, at a transit point, on a tract of land identified as Outlot Lettered H, situated in the town of Waldo, Russell County, Kansas, in W½SW¼ Sec. 5, T. 11 S., R. 13 W., 6th Prin. Mer., in latitude 39°07′24″ N., and longitude 98°47.9′ W., I find by comparison with a Western Union telegraph clock that my watch is 10m40s slow of 90th meridian standard time.

At the same station, at 5h20m07s p. m., l. m. t., I make an hour angle observation of Polaris, east of the meridian, two each with the telescope in direct and reversed positions, reading the horizontal deflection angle, by repetition, from the W. edge of a post, 20.50 chs. N., east to Polaris.

| | |
|---|---|
| Watch time of observation | =5h44m39s p. m. |
| Mean horizontal angle, Polaris to W. edge of post | =1°13′38″ W. |
| Azimuth of Polaris | =1°14′45″ E. |
| True bearing of W. edge of post | =N.0°01′07″ E. |

Example of hour angle observation of Polaris for *azimuth and latitude*, observing program "*b*":

*Transcribed field notes*

July 7, 1944, at a transit point at Curley Seep Guard Station, Coconino National Forest, in the SE¼SW¼ sec. 21, T. 24 N., R. 6 E., Gila and Salt River Mer., Arizona, in approximate latitude 35°26′ N., and longitude 111°46′ W., elevation approximately 7,600 ft., at $7^h40.4^m$ p. m., l. m. t., I make an hour angle observation of Polaris east of the meridian, for azimuth and latitude, making four observations, two each with the telescope in direct and reversed positions, observing simultaneously the vertical angle to Polaris and the horizontal angle from a well defined point on a dead pine approximately 15 chs. N., E. to Polaris. My watch reads correct Mountain Standard Time, as checked by radio time signals.

| Telescope | Watch time p. m. | Horizontal angle | | Observed vertical angle |
|---|---|---|---|---|
| Dir. | $8^h03^m00^s$ | 1°31′30″ | | 34°31′00″ |
| Rev. | 8 05 45 | 1 29 00 | | 34 28 00 |
| Rev. | 8 08 50 | 1 30 30 | | 34 28 30 |
| Dir. | 8 12 12 | 1 34 00 | | 34 31 30 |
| Mean | $8^h07^m27^s$ | 1°31′30″ | | =34°29′45″ |

| | | | |
|---|---|---|---|
| | | Refraction, *r* | |
| Azimuth of Polaris | =N. 0°18′42″ E. | (84″ × .77=65″) | = −1 05 |
| | | Primary adj. to | |
| Bearing of mark | =N. 1°12′48″ W. | elevation of pole | = +58 25 |
| | | Supplemental corr. | = 0 00 |
| | | Latitude, $\phi$ | =35°27′05″ |

*Field record*

| | |
|---|---|
| Watch time of observation | = $8^h07^m27^s$ p. m. |
| Watch fast of l. m. t. | = −27 04 |
| L. m. t. of observation | = $7^h40^m23^s$ p. m. |
| U. C. of Pol., Gr. m. t., July 8 | = $6^h40.8^m$ a. m. |
| Red. to long. 111°46′ W. | −1.2 |
| L. m. t. of Upper Cul., July 8 | = $6^h39.6^m$ a. m. |
| | +12 |
| L. m. t. of observation, July 7 | = 7 40.4 p. m. |
| Mean time hour angle of Polaris east of the meridian | =$10^h59.2^m$ |
| Declination of Polaris | =88°59′38″ |

Interpolation from tables in Ephemeris:

| Hour angle | For latitude | | | For azimuth | | | |
|---|---|---|---|---|---|---|---|
| | Declination | | | Latitude | | | Correction additive |
| | 88°59′20″ | 88°59′38″ | 88°59′40″ | 34°00′ | 35°27′ | 36°00′ | |
| $10^h58.2^m$ | 0°58′38″ | | 0°58′19″ | 18.5′ | | 19.0′ | 0.1′ |
| 10 59.2 | 0 58 42 | 0°58′25″ | 0 58 23 | 18.2 | 18.6′ | 18.7 | 0.1 |
| 11 08.2 | | | | 15.5 | | 15.9 | 0.1 |
| 11 10.2 | 0 59 22 | | 0 59 02 | | | | |

| | | | |
|---|---|---|---|
| Prim. adj. to elev. of pole | =0°58′25″ | Azimuth of Polaris | =0°18.6′ |
| Supplemental correction | =0 00 00 | Correction | = +0.1 |
| | | | =0°18.7′ |
| | | | N. 0°18′42″ E. |

## Polaris at Sunset or Sunrise

**99.** 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 position in altitude is found as indicated in section 76, hour angle method. 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 this 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 proceed in accordance with either observing program "a" or "b" of 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, 1945, at a station in latitude 47°20′ N., and longitude 102°40′ W.:

From the Ephemeris the declination of the sun is found to be 16°40′ N.; the equation of time $3^m$, to be subtracted from apparent time; upper culmination of Polaris, Greenwich meridian $10^h48.8^m$ a. m.; the declination of Polaris +89°00′06″. By entering Table 17, Standard Field Tables, the apparent time of sunset is found to be $7^h15^m$ p. m.

| | | | |
|---|---|---|---|
| May 6, 1945: Sunset | | = | $7^h15^m$ p. m., app. t. |
| Equation of time | | = | −3 |
| Anticipated time of obsn. | | = | $7^h12^m$ p. m., l. m. t. |
| | | | +12 |
| Gr. U. C. of Polaris | $=10^h48.8^m$ a. m. | | |
| Red. to long. 102°40′ | = −1.1 | | 10 48 a. m., " |
| Hour angle of Polaris, west of meridian | | | $8^h24^m$ $A \neq 1°10'$ W. |
| Latitude of station | =47°20′ | | |
| Vertical angle adjustment, Polaris below the pole | = −36 | | $v \neq 46°44'$ |

Example of the computation of the position of Polaris at sunset, November 6, 1945, same station:

Declination of the sun 16°06′ S.; equation of time $16^m$ to be subtracted from apparent time; upper culmination of Polaris, Greenwich meridian $10^h44.0^m$ p. m.; declination of Polaris +89°00′30″.

| | | | |
|---|---|---|---|
| November 6, 1945: Sunset | | = | $4^h47^m$ p. m., app. t. |
| Equation of time | | = | −16 |
| Anticipated time of obsn. | | = | $4^h31^m$ p. m., l. m. t. |
| Gr. U. C. of Polaris | $=10^h44.0^m$ p. m. | | |
| Red. to long. 102°40′ | = −1.1 | | 10 43 " " |
| Hour angle of Polaris, east of meridian | | | $6^h12^m$ $A \neq 1°27'$ E. |
| Latitude of station | =47°20′ | | |
| Vertical angle adjustment, Polaris below the pole | = −04 | | $v \neq 47°16'$ |

Example of the computation of the position of Polaris at sunrise, November 7, 1945, same station:

Declination of the sun 16°17′ S.; equation of time $16^m$ to be subtracted from apparent time; upper culmination and declination of Polaris same as above.

| | | |
|---|---|---|
| November 7, 1945: Sunrise | = | $7^h13^m$ a. m., app. t. |
| Equation of time | = | −16 |

| | | |
|---|---|---|
| Anticipated time of obsn. | = | $6^h57^m$ a. m., l. m. t. |
| | | +12 |
| Upper culmination of Polaris, *Nov. 6th* | = | 10 43 p. m., " |
| Hour angle of Polaris, west of meridian | | $8^h14^m$ $A \neq 1°12'$ W. |

| | | |
|---|---|---|
| Latitude of station | $= 47°20'$ | |
| Vertical angle adjustment, Polaris below the pole | $= -33$ | $v \neq 46°47'$ |

References and examples, sunset or daylight observations of Polaris: Sections 60, 61, 71, 76, 87, 97, 98, 113, 115, 116.

## Altitude Observation of the Sun for Azimuth, and of the Stars Within the Equatorial Belt

**100.** While the several methods of observation of Polaris for azimuth are employed most extensively in the public-land surveying-practice, there are many times and situations where the direct altitude observation upon the sun is extremely useful in order to expedite the progress on the survey and to add to the accuracy where needed. The bright stars within the equatorial belt, well placed through the whole 24-hour period, are available in the same manner, and may be observed in addition to the sun, or be substituted therefor whenever the sun may not be in favorable position. These alternatives should be understood, and be taken advantage of whenever and wherever the progress and/or the accuracy of the survey may be improved thereby. In general these observations are supplemental to the normal running of the lines by solar transit orientation, in order to improve and to verify the line work, and to secure known accuracy in the test meridian that is usually established at the party camp-site. Some of the conditions will be enumerated so as to emphasize the usefulness of the methods.

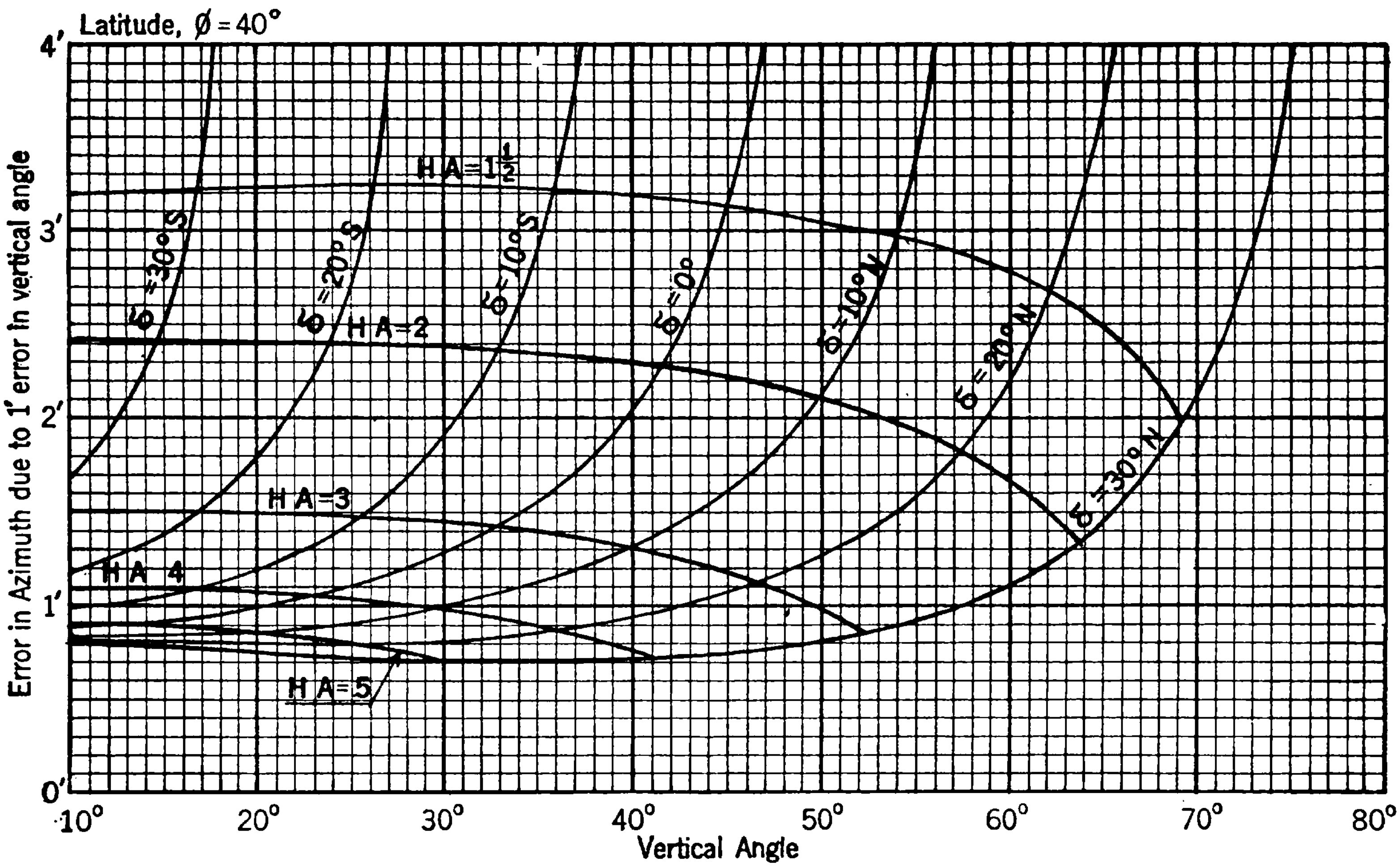
The sun is available at all times when in favorable position and not obscured. The altitude observation will frequently permit a prompt start on the survey in advance of an opportunity for the usual Polaris observation. Also, at stations far removed from the party camp, wherever and whenever the solar transit orientation should be verified or supplemented in this manner. The direct observations during the progress of the survey, on the lines as run, to check or verify the orientation will contribute immeasurably to the certainty that the solar unit is performing well. The altitude observation will give prompt notice if the instrumental adjustments have been disturbed to the point of disqualifying the instrument for continued use, until the adjustments have been corrected.

Note that the sun is not always in favorable position for the best observing. Some of the stars are always in favorable position, both in hour angle and declination. Some of them may be selected in favorable position at any time or place. 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 during the periods when the sun is not in favorable position. For example, 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, or for solar transit orientation. The bright north declination stars are especially helpful for the observing in Alaska; the south declination stars for the meridian time-and-latitude observations in Florida.

The trigonometric elements for 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. Sections 73 to 76, inclusive. If the latitude has not been well determined previously, the azimuth observation on the sun southeasterly should be balanced by one southwesterly, at about the same vertical angle. The two results, when combined, will compensate for the unknown discrepancy in latitude.

The precision with which the azimuth may be determined by the altitude observation of the sun or a star is directly related to the certainty with which the vertical angle may be determined. The error in azimuth that results from a discrepancy in vertical angle increases rapidly in the higher altitudes, with a decrease in the hour angle, and with the southerly declinations. (This is illustrated in the graph, page 119). Presuming appropriate care in the observing, and that the instrumental adjustments are in good order, but with the possibility of an uncertain residual discrepancy in vertical angle readings, it is shown in the graph that the error in azimuth which would result from such discrepancy may be multiplied one, two, or three times, depending upon the sun's position in altitude, hour angle, and declination. The check for this uncertainty is to balance an observation southeasterly with one southwesterly, at about the same vertical angle. The azimuth "*A*" derived from the reductions of the observations will be either too large or too small in both a. m. and p. m., and will be compensated by taking the mean of the two results. If this discrepancy is found to exist in performance, the difference between the a. m. and the p. m. results will be kept at the minimum in the vertical angles from 20° to 50°, at hour angles not less than 3 hours. A bright star in north declination should be substituted for the sun when the latter's south declination exceeds 10°.




Errors in azimuth determination that result from a one minute discrepancy in vertical angle, at various altitudes, computed for observations in latitude 40°, for declinations within the equatorial belt.

The altitude observation calls for accuracy in the instrumental adjustments, and for good judgment in the selection of a well-formed pole-zenith-sun triangle. Vertical angles from 20° to 50° are to be preferred, not less than 3 hours from meridian passage, and north declination. A bright star in north declination is much better than the sun when the latter's south declination 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. Sections 112 to 116, inclusive.

The General Land Office solar transit is equipped with a full vertical circle; a neutral-tint colored-glass in the dust shutter of the eye-piece; a removable prismatic eye-piece; 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 is equipped with a solar circle in the reticle of the transit telescope; this gives the horizontal and vertical angle sightings to the sun's center (instead of to the limbs). Sections 41, 77, 112. Note that in the diagram of this reticle (line cut, sec. 112), 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).

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. The examples will illustrate the several uses. 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 as thought desirable, although it is regarded as good practice to limit the number of sightings to not over four or 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; these differences in the readings may be checked quickly by slide-rule method.

It should be 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 1-minute transit until duly verified by a completely independent method, such as the Polaris observation to check the altitude observation, or the altitude observaion southeasterly balanced with one southwesterly.

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

**102.** *Altitude observation of the sun for azimuth.*—Reverse the signs of "$\delta$" for south declinations:

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

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.

102

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

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

**104.** *Altitude observation of the sun for azimuth.*—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 $= 90° - \phi =$ colat.;
Pole to sun $= 90° - \delta =$ codecl.;
Zenith to sun $= 90° - h =$ coalt.;
$S = \frac{1}{2}$ sum of the three sides:

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

## Observing Program, Morning

**105.** Thoroughly level the transit.

With the telescope in direct position observe and record 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:

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 time at the moment of the observation:

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

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

First observation, telescope direct, observe the sun's right and lower limbs:

Second observation, telescope reversed, observe the sun's left and upper limbs:

**107.** By the above observing programs the horizontal and vertical angles in the direct positions of the telescope will be found of about the same numerical values as in the reversed position of the telescope, by reason of the sun passing in a direction that will carry it across the field of the telescope during the time taken in the reversal and second setting. Differential refraction is therefore 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.

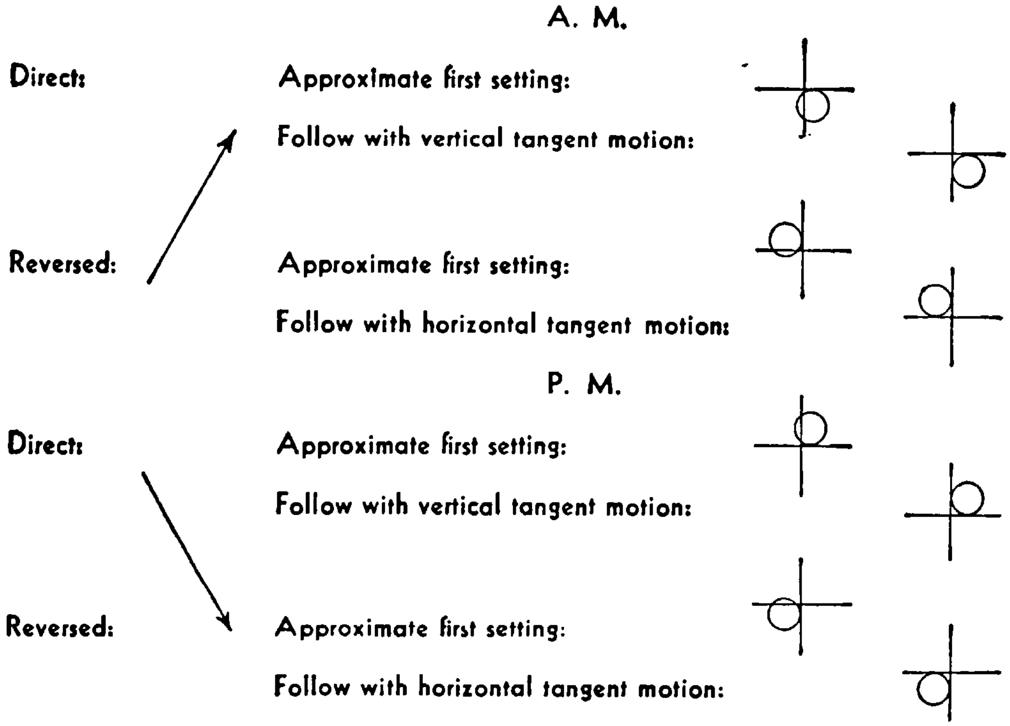
The most suitable hour for this observation is when the sun is moving rapidly in altitude. Section 100. When the sun has been brought into about the proper position in the field of the telescope the observer by horizontal tangent motion on the plates keeps the vertical wire tangent to the sun's right 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 shown 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 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

| | 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 |

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.

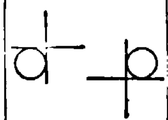
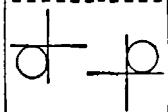
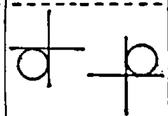
An equivalent observing plan, thought by many engineers to be a simpler tangent-motion manipulation, may be substituted if desired, as follows:




**108.** Example of direct altitude observation of the sun for azimuth and time, sun north declination:

*Transcribed field notes*

August 4, 1944, at a point 35 lks. south of the cor. of Tps. 7 and 8 N., Rs. 1 and 2 E., Salt Lake Meridian, Utah, in latitude 41°22′40″ N., and longitude 111°46′40″ W., at $9^h17^m$ a. m., l. m. t., in order to verify the alinement of my random south boundary of sec. 31, T. 8 N., R. 2 E. (S. 89°59′ W.), and to determine the correct local mean time, I make a series of three altitude observations of the sun for azimuth and time, each with the telescope in direct and reverse positions, observing opposite limbs of the sun, and reading the horizontal angle from a flag on my line to the east, southward to the sun. My watch carries approximate local mean time.

| Observation | Telescope | Sun | Watch time | Vertical angle | Horizontal angle, flag to sun |
|---|---|---|---|---|---|
| 1st set | Direct<br>Reversed |  | $9^h\ 15^m\ 05^s$<br>9 15 59 | 46° 34′ 00″<br>46 10 00 | 21° 00′ 00″<br>20 29 00 |
| | Mean | | $9^h\ 15^m\ 32^s$ | 46° 22′ 00″ | 20° 44′ 30″ |
| 2d set | Direct<br>Reversed |  | $9^h\ 17^m\ 02^s$<br>9 17 36 | 46° 54′ 00″<br>46 26 00 | 21° 28′ 00″<br>20 49 00 |
| | Mean | | $9^h\ 17^m\ 19^s$ | 46° 40′ 00″ | 21° 08′ 30″ |
| 3d set | Direct<br>Reversed |  | $9^h\ 18^m\ 41^s$<br>9 19 20 | 47° 12′ 00″<br>46 45 00 | 21° 52′ 00″<br>21 16 00 |
| | Mean | | $9^h\ 19^m\ 00^s$ | 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. | $=25^s$ |
| " " " " 2nd " | =20 |
| " " " " 3rd " | =25 |
| Mean watch time slow of l. m. t. | $=23^s$ |

*Field record*

The declination of the sun for the mean period of the three observations is 17°09′30″ N.

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

| | 1st obsn. | 2nd obsn. | 3rd obsn. |
|---|---|---|---|
| *v* | 46°22′00″ | 46°40′00″ | 46°58′30″ |
| Refraction | −55″ | −55″ | −54″ |
| Parallax | +06″ | +06″ | +06″ |
| *h* | 46°21′11″ | 46°39′11″ | 46°57′42″ |

The following examples of reduction are all by the equation:

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

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:

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

**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 | | |

$t=42°30'05''=2^h50^m00^s$ $=9^h10^m00^s$ a. m.
Equation of time = +5 57

L.m.t. of observation $=9^h15^m57^s$ a. m.
Watch time of observation = 9 15 32 a. m.

Watch slow of l.m.t. = $25^s$

**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 |

$t=42°04'23''=2^h48^m18^s$ $=9^h11^m42^s$ a. m.
Equation of time = +5 57

L.m.t. of observation $=9^h17^m39^s$ a. m.
Watch time of observation = 9 17 39 a. m.

Watch slow of l.m.t. = $20^s$

**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 |

$t=41°37'54''=2^h46^m32^s$ $=9^h13^m28^s$ a. m.
Equation of time = +5 57
L.m.t. of observation $=9^h19^m25^s$ a. m.
Watch time of observation = 9 19 00 a. m.
Watch slow of local mean time = $25^s$

Example of similar direct altitude observation of the sun for azimuth and time, sun south declination: Manual Appendix II.

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

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

$$\begin{array}{lll}
(90^\circ - \phi) & 90^\circ - 41^\circ 22' 40'' = & 48^\circ 37' 20'' = \text{colat.} \\
(90^\circ - \delta) & 90^\circ - 17^\circ 09' 30'' = & 72^\circ 50' 30'' = \text{codecl.} \\
(90^\circ - h) & 90^\circ - 46^\circ 21' 11'' = & 43^\circ 38' 49'' = \text{coalt.} \\
\hline
 & 2\,S = & 165^\circ 06' 39'' \\
 & S = & 82^\circ 33' 20'' \\
 & \text{codecl.} = & 72^\circ 50' 30'' \\
\hline
 & S\text{-codecl.} = & 9^\circ 42' 50''
\end{array}$$

$$\begin{array}{lll}
\log \sin S & & 9.996324 \\
\log \sin (S\text{-codecl.}) & & 9.227188 \\
\hline
 & & \log 9.223512 \\
\log \sin \text{colat.} & 9.875274 & \\
\log \sin \text{coalt.} & 9.838983 & \\
\hline
 & \log 9.714257 & 9.714257 \\
\hline
\log \cos^2 \tfrac{1}{2} A & & 9.509255 \\
\log \cos \tfrac{1}{2} A & & 9.754628 \\
\tfrac{1}{2} A & & 55^\circ 21' 49'' \\
A & & \text{N. } 110^\circ 43' 38'' \text{ E.} \\
\text{True bearing of sun} & & \text{S. } 69^\circ 16' 22'' \text{ E.} \\
\text{Angle, flag to sun} & & +20^\circ 44' 30'' \\
\hline
 & & \text{S. } 90^\circ 00' 52'' \text{E.} \\
\text{True bearing of flag} & & \text{N. } 89^\circ 59' 08'' \text{ E.}
\end{array}$$

Example of similar reduction by the same equation, sun south declination: Manual Appendix II.

**110.** The first set of the above series is again selected for an example of reduction by the equation:

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

$$\begin{array}{rl}
 & 90^\circ 00' 00'' \\
h = & 46^\circ 21' 11'' \\
\hline
\zeta = & 43^\circ 38' 49'' \\
\phi = & 41^\circ 22' 40'' \\
\hline
\zeta + \phi = & 85^\circ 01' 29'' \\
\delta = & 17^\circ 09' 30'' \\
\hline
\zeta + \phi + \delta = & 102^\circ 10' 59'' \\
\tfrac{1}{2}(\zeta + \phi + \delta) = & 51^\circ 05' 30''
\end{array}
\qquad
\begin{array}{rl}
\zeta = & 43^\circ 38' 49'' \\
\phi = & 41^\circ 22' 40'' \\
\hline
\zeta - \phi = & 2^\circ 16' 09'' \\
\delta = & 17^\circ 09' 30'' \\
\hline
\zeta - \phi + \delta = & 19^\circ 25' 39'' \\
\tfrac{1}{2}(\zeta - \phi + \delta) = & 9^\circ 42' 50''
\end{array}$$

| | | | |
|---|---|---|---|
| $\zeta+\phi=$ | 85°01′29″ | $\zeta-\phi=$ | 2°16′09″ |
| $\delta=$ | 17°09′30″ | $\delta=$ | 17°09′30″ |
| $\zeta+\phi-\delta=$ | 67°51′59″ | $\zeta-\phi-\delta=$ | −14°53′21″ |
| $\frac{1}{2}(\zeta+\phi-\delta)=$ | 33°56′00″ | $\frac{1}{2}(\zeta-\phi-\delta)=$ | −7°26′41″ |

| | | |
|---|---|---|
| log cos $\frac{1}{2}(\zeta+\phi+\delta)$ | | 9.798012 |
| log sin $\frac{1}{2}(\zeta+\phi-\delta)$ | | 9.746812 |
| | | 9.544824 |
| log cos $\frac{1}{2}(\zeta-\phi-\delta)$ | 9.996324 | |
| log sin $\frac{1}{2}(\zeta-\phi+\delta)$ | 9.227188 | |
| | 9.223512 | 9.223512 |
| log tan² $\frac{1}{2}A$ | | 0.321312 |
| log tan $\frac{1}{2}A$ | | 0.160656 |
| $\frac{1}{2}A$ | | 55°21′50″ |
| $A$ | | N. 110°43′40″ E. |
| True bearing of sun | | S. 69°16′20″ E. |
| Angle, flag to sun | | +20°44′30″ |
| True bearing of flag | | N. 89°59′10″ E. |

Example of similar reduction by the same equation, sun south declination: Manual Appendix II.

**111.** The first set of the above series is likewise selected for an example for the computation for time by the equation:

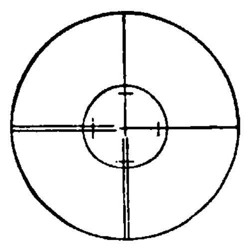
$$\operatorname{Tan} \tfrac{1}{2} t=\sqrt{\frac{\sin \frac{1}{2}(\zeta+\phi-\delta) \sin \frac{1}{2}(\zeta-\phi+\delta)}{\cos \frac{1}{2}(\zeta+\phi+\delta) \cos \frac{1}{2}(\zeta-\phi-\delta)}}$$

| | | |
|---|---|---|
| log sin $\frac{1}{2}(\zeta+\phi-\delta)$ | | 9. 746812 |
| log sin $\frac{1}{2}(\zeta-\phi+\delta)$ | | 9. 227188 |
| | | 8. 974000 |
| log cos $\frac{1}{2}(\zeta+\phi+\delta)$ | 9. 798012 | |
| log cos $\frac{1}{2}(\zeta-\phi-\delta)$ | 9. 996324 | |
| | 9. 794336 | 9. 794336 |
| log tan² $\frac{1}{2}t$ | | 9. 179664 |
| log tan $\frac{1}{2}t$ | | 9. 589832 |
| $\frac{1}{2}t$ | 21°15′03″ | |
| $t$ | 42°30′06″ | $=2^h50^m00^s$ |
| Apparent time of observation | | $=9^h10^m00^s$a.m. |
| Equation of time | | = +5 57 |
| L.m.t. of observation | | $=9^h15^m57^s$a.m. |
| Watch time of observation | | =9 15 32 a.m. |
| Watch slow of local mean time | | = $25^s$ |

Example of similar reduction by the same equation, sun south declination: Manual Appendix II.

## The Solar Circle

**112.** 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 by slide rule method, to make certain which reading, if any, shows a discrepancy in excess of what should be expected in good observing.

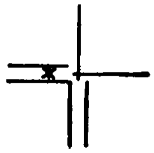


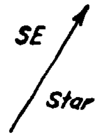
The solar circle has a radius of 15′45″; this is spaced for the sun's semidiameter on July 1, which is the approximate minimum for the year.

The design of the reticle provides for stadia observations by using both the vertical and horizontal rod, on the ratio of 1:132; this is explained in sections 33 and 34.

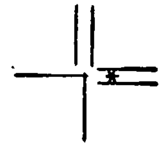
The double cross-wires in the left and in the lower halves (direct position of the telescope) are spaced at 40″; this is to improve the daylight stellar observation. The double lines avoid the covering of the star by the cross wire (which may easily obscure the star). The centering and the manipulation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

**Direct**



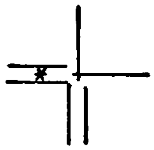


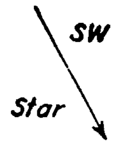

**Reversed**

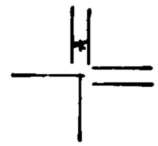


**Follow star with vertical tangent motion**

**Both tangent motions required. Center in one position, and back-up to follow star while bringing to center in the second position**





**Follow star with vertical tangent motion**

**Follow star with horizontal tangent motion.**

The practices and other comments with respect to the reticle of the above design are referred to in sections 33, 34, 41, 77, 100, and Manual Appendix II, section 78, model C.

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

*Transcribed field notes*

June 15, 1945, at observation station No. 1, a cross in the sidewalk on the south side of C Street, opposite the south entrance to the Interior Building, Washington, D. C., in latitude 38°53′30″ N., and longitude 77°02′ W., elevation above sea level 10 feet, and temperature 70° F., at $8^h15^m$ a. m., apparent time, I make a series of altitude observations of the sun for azimuth, making six observations, three each with the telescope in direct and reversed positions, observing simultaneously the vertical angle to the sun's center and the horizontal angle from the tip of the Washington Monument, approximately 40 chains southeasterly, to the left to the sun:

| Observation | Telescope | Apparent time | Vertical angle | Horizontal angle, monument to sun |
|---|---|---|---|---|
| 1 | Direct | $8^h13^m25^s$ | 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 | | $8^h14^m55^s$ | | |

By 1st obsn. monument bears ................ S. 54°40′06″ E.
By 2nd obsn. monument bears ................ S. 54°41′01″ E.
By 3rd obsn. monument bears ................ S. 54°40′56″ E.
By 4th obsn. monument bears ................ S. 54°40′50″ E.
By 5th obsn. monument bears ................ S. 54°40′43″ E.
By 6th obsn. monument bears ................ S. 54°40′22″ E.

**Mean** ................ S. 54°40′40″ E.

June 20, 1945, at the same station, in temperature 70° F., at $3^h42^m$ p. m., apparent time, I repeat the above observation, observing the horizontal angle from the tip of the Washington Monument to the right to the sun:

| Observation | Telescope | Apparent time | Vertical angle | Horizontal angle, monument to sun |
|---|---|---|---|---|
| 1 | Direct | $3^h42^m30^s$ | 40°59′00″ | 143°20′30″ |
| 2 | Direct | | 40°52′30″ | 143°26′00″ |
| 3 | Direct | | 40°45′00″ | 143°32′00″ |
| 4 | Reversed | | 40°13′00″ | 143°57′00″ |
| 5 | Reversed | | 40°03′30″ | 144°05′00″ |
| 6 | Reversed | 3 50 25 | 39°27′00″ | 144°34′00″ |
| Mean | | $3^h46^m27^s$ | | |

| | |
|---|---|
| By 1st obsn. monument bears | S. 54°41′09″ E. |
| By 2nd obsn. monument bears | S. 54°41′17″ E. |
| By 3rd obsn. monument bears | S. 54°41′05″ E. |
| By 4th obsn. monument bears | S. 54°39′48″ E. |
| By 5th obsn. monument bears | S. 54°41′03″ E. |
| By 6th obsn. monument bears | S. 54°39′24″ E. |
| Mean | S. 54°40′40″ E. |
| Mean of June 15, a. m. obsn | S. 54°40′40″ E. |
| True bearing of monument | S. 54°40′40″ E. |

Observation No. 6, p.m., delayed by a passing cloud.

**113.** The observations for time, latitude, and azimuth may be combined and each value verified by arranging one complete and well balanced stellar observing program. This should include: (1) the meridian passage of one star for time and latitude; (2) Polaris for azimuth and latitude; and, (3) two well placed stars in the equatorial belt, one easterly and one westerly, both for azimuth, and one or both for time. The program will require from 2 to 4 hours, late afternoon, twilight, and possibly some observing by illumination, mostly depending upon the conditions for visibility, and the positions of the two equatorial-azimuth stars for well-balanced pole-zenith-star triangles. The program is designed for the refinements in all detail, including compensation for the uncertainties of vertical angle readings, and for the verification of all results.

It is essential that the observing program be carried through with the *same instrument* as the underlying principle is to secure a compensation for residual discrepancies in the transit adjustments, including any small uncertain factors of eccentricity in the mounting of the vertical circle.

It is unnecessary that the observing be carried through as one program the same day, as at sunrise or sunset, excepting that at least one time determination should be coupled with the Polaris observation. The remainder may be accomplished at the most convenient times for the observing over a period of several days if desired, but especially that the program, when needed in order to accomplish these refinements, be carried through at the camp meridian with completeness in all respects as promptly as can be consistent with due attention to other necessary work incident to making progress on the survey.

The points to be kept in mind with this program are the balancing conditions in vertical angle determinations; to make certain that the test meridian in camp may be relied upon for accuracy; that the latitude of the station has been duly verified; and, that if there may be some small factor of eccentricity in the mounting of the vertical circle, that this is not to be disregarded in the use and performance of the instrument.

An example of one complete stellar program is set out below, including the data for the observation for the first (easterly) star. The data for the second (westerly) star will be carried to section 114; the Polaris observation, and summary for azimuth, section 115; the equatorial star at meridian passage, and summary for time and latitude, section 116.

*Transcribed field notes*

May 31, 1945, at the testing station, "Troy Cabin," situated on State Highway No. 2, 6 miles east of Troy, N. Y., and ½ mile east of the village of Eagle Mills; in latitude 42°44′03″ N. and longitude 73°35′15″ W.; these values as scaled from the U. S. Geological Survey topographic map, "Troy" quadrangle.

I prepare for one complete stellar observing program. The horizontal angles were turned from a *temporary* meridian marker, placed at a distance of 24.08 chains north. The mean of a number of previous observations for azimuth indicated that the temporary marker had a bearing of N. 00°00′50″ E. By observation on the sun at apparent noon today my watch was found to be $0^m24^s$ slow of local mean time.

The following observing program was carried through *prior* to setting a permanent marker in the true meridian:

| For finding position<br>Star | Approx. l. m. t., p. m. | Direction of sight | Vertical angle |
|---|---|---|---|
| No. 19/35 $\alpha$ Bootis (Arcturus) 0.2<br>$\delta = +19°28'06''$ | $5^h16^m$ | S. 88°27′ E. | 31°07′ |
| No. 13/20 $\beta$ Geminorum (Pollux) 1.2<br>$\delta = +28°09'42''$ | 7 18 | N. 84°20′ W. | 37°39′ |
| No. 4/ 6 $\alpha$ Urs. Min. (Polaris) 2.2<br>$\delta = +89°00'00''$ | 7 30<br>Sunset | N. 00°32′ W. | 41°48′ |
| No. 17/33 $\alpha$ Virginis (Spica) 1.2<br>$\delta = -10°52'36''$ | 8 45 | South | 36°23′ |

*Summary of all results*

| | Time<br>Watch slow of l. m. t. | Latitude | Azimuth<br>Indicated bearing of reference mark. |
|---|---|---|---|
| **1st** equatorial star, SE | 0m23s | | N. 0°00′16″ E. |
| **2nd** equatorial star, NW | 0 28 | | N. 0 01 18″ E. |
| Mean | | | N. 0°00′47″ E. |
| **Polaris** | | 42°43′44″ | N. 0 00 57′ E. |
| **3rd equatorial star** at meridian passage | 0 30 | 42 44 27 | |
| Mean of all | 0m27s | 42°44′05″ | N. 0°00′52″ E. |
| U. S. Geol. Sur. topographic map | | 42°44′03″ | |

1st Star: No. 19/35: $\alpha$ Bootis (Arcturus); $\delta = +19°28'06''$; meridian passage=$9^h\ 36^m.3$ p. m., l. m. t., May 31, 1945; for time and azimuth.

| Telescope | Watch time p. m. | Horizontal angle | Observed vertical angle |
|---|---|---|---|
| Dir | $5^h19^m05^s$ | 92°07′30″ | 31°44′00″ |
| Rev | 5 23 17 | 92 52 30 | 32 29 00 |
| " | 5 25 15 | 93 13 00 | 32 51 30 |
| Dir | 5 28 17 | 93 45 00 | 33 26 00 |
| Mean | $5^h23^m58^s$ | 92°59′30″ | $v$=32°37′37″ |
| | | | Refraction $r$= −1 30″ |
| | | | $h$=32°36′07″ |

| | | |
|---|---|---|
| $5^h23^m58^s$ | | Watch time, p. m. |
| | 92°59′30″ | Horizontal angle. |
| | S.87°00′14″ E. | =Reduced azimuth of star. |
| | 179°59′44″ | |
| | N.00°00′16″ E. | =Indicated bearing of reference mark. |
| | $9^h36^m18^s$ | =Mer. pass. of star, p. m., l. m. t. |
| | 4 11 57 | =Reduced mean time hour angle. |
| $5^h24^m21^s$ | $5^h24^m21^s$ | =Local mean time of observation. |
| $0^m23^s$ | | =Watch slow of local mean time. |

*Field record*

| | |
|---|---|
| Apparent noon | $12^h00^m00^s$ |
| Equation of time, subtractive | $-2\ 29$ |
| Local mean time of apparent noon | 11 57 31 |
| Watch time of sun's meridian passage | 11 57 07 |
| Watch slow of local mean time | $24^s$ |

1st Star: No. 19/35:

| | |
|---|---|
| Star's transit, May 16, meridian of Greenwich | $=10^h36.1^m$p. m. |
| Reduction to " 31 | $=-59.0$ |
| " " long. 73°35′15″ | $=-\ 0.8$ |
| Meridian passage of star, l. m. t. | $=\ 9^h36.3^m$p. m. |

$\phi=42°44'03''$ $\delta=+19°28'06''$ $h=32°36'07''$

| $\cos t=\frac{\sin h}{\cos\phi\cos\delta}-\tan\phi\tan\delta$ | | | | $\cos A=\frac{\sin\delta}{\cos\phi\cos h}-\tan\phi\tan h$ | | |
|---|---|---|---|---|---|---|
| log | cos | sin | tan | cos | sin | tan |
| $h=$ | | 9.731427 | | 9.925536 | | 9.805891 |
| $\phi=$ | 9.865998 | | 9.965615 | 9.865998 | | 9.965615 |
| $\delta=$ | 9.974431 | | 9.548385 | | 9.522817 | |
| | 9.840429 | 9.840429 | 9.514000 | 9.791534 | 9.791534 | 9.771506 |
| | | 9.890998 | | | 9.731283 | |
| nat | | .77803 | .32659 | | .53862 | .59089 |
| | | .32659 | | | | .53862 |

$\cos t=$ .45114(+) $\cos A=$ .05227(−)

$t=63°09'50''$ $A=$S. 87°00′14″ E.

$=4^h12^m39^s=$sidereal hour angle.
$-42$ =reduction to mean time hour angle.

$4^h11^m57^s=$mean time hour angle.

**114.** Continuation of the complete stellar program as begun and explained in the preceding section.

*Transcribed field notes*

2nd Star: No. 13/20: $\beta$ Geminorum (Pollux); $\delta=+28°09'42''$; meridian passage $=3^h\ 06.1^m$ p. m., l. m. t., May 31, 1945; for time and azimuth.

| Telescope | Watch time p. m. | Horizontal angle | Observed vertical angle |
|---|---|---|---|
| Dir | $7^h19^m59^s$ | 84°06′00″ | 37°22′00″ |
| Do | 7 20 53 | 83 57 00 | 37 12 00 |
| Rev | 7 23 39 | 83 31 00 | 36 40 30 |
| Do | 7 24 53 | 83 19 00 | 36 28 00 |
| Mean | $7^h22^m21^s$ | 83°43′15″ | $v=36°55'37''$ |
| | | | Refraction, $r=\ -1\ 17$ |
| | | | $h=36°54'20''$ |

| | | | |
|---|---|---|---|
| $7^h22^m21^s$ | | | Watch time, p. m. |
| | 83°43′15″ | | Horizontal angle. |
| | N.83°41′57″ W. | = | Reduced azimuth of star. |
| | N.00°01′18″ E. | = | Indicated bearing of reference mark. |
| | $3^h06^m06^s$ | = | Mer. pass. of star, p. m., l. m. t. |
| | 4 16 43 | = | Reduced mean time hour angle. |
| $7^h22^m49^s$ | $7^h22^m49^s$ | = | Local mean time of observation |
| $0^m28^s$ | | = | Watch slow of l. m. t. |

*Field record*

2nd Star: No. 13/20:

| | |
|---|---|
| Star's transit, May 16, meridian of Greenwich | $=4^h05.9^m$ p. m. |
| Reduction to May 31 | $=-59.0$ |
| Reduction to long. 73°35′15″ | $=-0.8$ |
| Meridian passage of star, l.m. t. | $=3^h06.1^m$ p. m. |

$\phi=42°44'03''$ $\delta=+28°09'42''$ $h=36°54'20''$

| | $\cos t=\frac{\sin h}{\cos\phi\cos\delta}-\tan\phi\tan\delta$ | | | $\cos A=\frac{\sin\delta}{\cos\phi\cos h}-\tan\phi\tan h$ | | |
|---|---|---|---|---|---|---|
| log | cos | sin | tan | cos | sin | tan |
| $h=$ | | 9. 778511 | | 9. 902887 | | 9. 875624 |
| $\phi=$ | 9. 865998 | | 9. 965615 | 9. 865998 | | 9. 965615 |
| $\delta=$ | 9. 945281 | | 9. 728625 | | 9. 673906 | |
| | 9. 811279 | 9. 811279 | 9. 694240 | 9. 768885 | 9. 768885 | 9. 841239 |
| | | 9. 967232 | | | 9. 905021 | |

| | | | | |
|---|---|---|---|---|
| nat | .92733 | .49458 | .80356 | .69381 |
| | .49458 | | .69381 | |

cos $t$= .43275 (+) cos $A$= .10975 ( +)
$t$=64°21′28″ $A$=N. 83°41′57″ W.

= $4^h17^m26^s$=sidereal hour angle.
−43 =reduction to mean time hour angle.

$4^h16^m43^s$=mean time hour angle.

**115.** Continuation of the complete stellar program as begun and explained in sec. 113; the summary of the time and latitude determination in section 116; the summary of the azimuth determination in this section.

*Transcribed field notes*

**3rd Star: No. 4/6: α Urs. Min. (Polaris); δ=+89°00′00″; meridian passage at upper culmination=$9^h10^m00^s$ a. m., l. m. t., May 31, 1945; sunset observation for azimuth and latitude.**

| Telescope | Watch time p. m. | Horizontal angle repeated | Observed vertical angle |
|---|---|---|---|
| Dir. | $7^h28^m03^s$ | 0°34′30″ | 41°50′30″ |
| " | 7 30 07 | | 41 49 00 |
| " | 7 32 35 | 1°41′30″ | 41 49 00 |
| Mean | $7^h30^m15^s$ | 0°33′50″ (1/3) | 41°49′30″ |
| Rev. | $7^h35^m01^s$ | 0°33′00″ | 41°50′00″ |
| " | 7 36 33 | | 41 50 00 |
| " | 7 38 07 | 1°38′00″ | 41 50 00 |
| Mean | $7^h36^m34^s$ | 0°32′40″ (1/3) | 41°50′00″ |
| | $7^h33^m24^s$ | 0°33′15″Mean of all. | Refraction, v=41°49′45″ |
| | 0 27 | Watch slow of l. m. t. | r= − 1 04 |
| | | | h=41°48′41″ |
| | $7^h33^m51^s$ | p. m., l. m. t. of observation | |
| | 12 | | |
| | $9^h10^m00^s$ | a. m., U. C. | |
| | $10^h23^m51^s$ | =Hour angle of Polaris, west of meridian. | |

Vertical angle, corrected for refraction $h$=41°48′41″
Vertical angle correction to elevation of pole for hour angle 10h 23.85m, additive =+0°55′03″

Latitude = 42°43′44″



700004°—47——10

| | | |
|---|---|---|
| Observed horizontal angle | | = 0°33′15″ |
| Azimuth of Polaris for hour angle $10^h$ $23.85^m$ west of the meridian | | $A$=N.0°32′18″W. |
| Indicated bearing of reference mark | | N.0°00′57″E. |
| Same, 1st equatorial star, SE. | N.0°00′16″E. | |
| " 2nd " " , NW | N.0°01′18″E. | |
| Mean of the equatorial stars | N.0°00′47″E. | N.0°00′47″E. |
| Determined true bearing of reference mark | | N.0°00′52″E. |

*Field record*

3rd Star: Polaris

| | |
|---|---|
| Upper culmination, May 31, meridian of Greenwich | $9^h10.8^m$ a. m. |
| Reduction to long. 73°35′15″ | =−0.8 |
| | $9^h10.0^m$ a. m. |

Interpolation from tables in the Ephemeris:

| Hour angle | For azimuth | | | For latitude | | |
|---|---|---|---|---|---|---|
| | Latitude | | | Declination | | |
| | 42°00′ | 42°44′ | 44°00′ | 88°59′50″ | 89°00′00″ | 89°00′10″ |
| | ′ | ′ | ′ | | | |
| $10^h18.3^m$ | 33. 5 | | 34. 5 | | | |
| 22.3 | | | | 0°55′03″ | 0°54′54″ | 0°54′45″ |
| 23.85 | 31. 7 | 32. 1 | 32. 7 | | 0 55 03 | |
| 28.3 | 30. 3 | | 31. 3 | | | |
| 34.3 | | | | 0 56 14 | 0 56 05 | 0 55 56 |

| | | |
|---|---|---|
| 32. 1 | | |
| For $\delta$=89°00′00″+0.2 | Primary adjustment to elevation of pole, additive; | |
| 32. 3 | no supplemental correction | 0°55′03″ |
| $A$= N.0°32′18″ W. | | |

**116.** Continuation of the complete stellar program as begun and explained in sec. 113; the summary of the azimuth determination in sec. 115; the summary of the time and latitude determinations in this section.

*Transcribed field notes*

4th Star: No. 17/33: $\alpha$ Virginis (Spica); $\delta$=−10°52′36″; meridian passage= $8^h45.6^m$ p. m., l. m. t., May 31, 1945; for time and latitude.

| | |
|---|---|
| Star's transit, May 16, meridian of Greenwich | =$9^h45.4^m$ p. m. |
| Reduction to " 31 | =−59.0 |
| " " long. 73°35′15″ | =− 0.8 |
| Meridian passage of star, l. m. t. | =$8^h45.6^m$ p. m. |
| | =$8^h45^m36^s$ p. m. |

| Telescope | Observed vertical angle | Watch time p. m. | | |
|---|---|---|---|---|
| Dir. | 36°24′00″ | $8^h45^m06^s$ | Watch time = | $8^h45^m06^s$ |
| Rev. | 36 24 30 | | | |
| | | | Watch slow of l. m. t. = | $0^m30^s$ |
| Mean | 36°24′15″ | | Same, 1st star = | 0 23 |
| | −1 18 | = refraction. | " 2nd " = | 0 28 |
| | 36°22′57″ = h | | Mean = | $0^m27^s$ |
| $\delta$ = | 10 52 36 S. | | | |
| | 47°15′33″ | | | |
| $\phi$ = | 42 44 27 | Latitude of station | | = 42°44′27″ |
| | 90°00′00″ | Same, by Polaris observation | | = 42 43 44 |
| | | | Mean | 42°44′05″ |

## Equal Altitude Observations of the Sun for Meridian

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

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

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

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

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

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

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

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

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

## Equal Altitude Observations of the Sun, Observing Program

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

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

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

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

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

The above program constitutes one observation. A series of three observations are taken by three successive a. m. settings at intervals of about four or five minutes of time. In the p. m. the settings are made beginning with the highest vertical angle.

Consider each equal altitude observation separately and subtract the lesser horizontal angle from the greater and divide by two; this gives the value of the angle to be turned to the uncorrected south point for that pair.

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

In order to determine the true south point, compute the differential azimuth correction due to the change in the sun's declination from the mean period of the a. m. to the mean period of the p. m. observations, and apply this angle to the mean of the half-differences as stated above. The differential azimuth correction is to be applied to the east (or to the left, counterclockwise) when the hourly change in the sun's declination is northerly; to the west (or to the right, clockwise) when the hourly change in the sun's declination is southerly. The computed resultant angle indicates the bearing of the reference point counting from the true meridian.

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

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

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

*Transcribed field notes*

September 2, 1944, near the cor. of secs. 5, 6, 31, and 32, on the south boundary of T. 13 S., R. 90 W., 6th Prin. Mer., Colorado, in latitude 38°52.4′ N., and longitude 107°29′ W., at approximate altitude above sea level 6,000 ft., and at temperature 50° F., at $8^h34^m$ a. m. and $3^h30^m$ p. m., app. time, I make a series of three equal altitude observations of the sun for azimuth, reading the horizontal angle from a nail driven in a post approximately 6 chs. NNE., to the right to the sun's right limb in the a. m., and to the left to the sun's left limb in the p. m.; equal vertical angles having been taken to the sun's lower limb. My watch carries approximate apparent time.

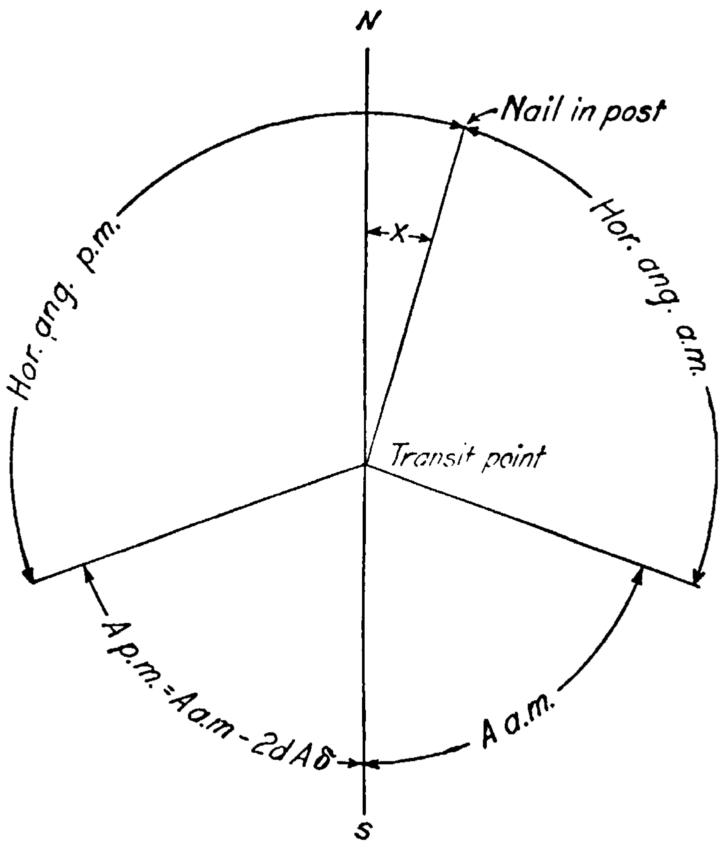
| Observation | Sun | Watch time | Vertical angle | Horizontal angle, nail to sun |
|---|---|---|---|---|
| 1st, a. m. | | $8^h\ 34^m\ 44^s$ | 34° 15′ 00″ | 104° 08′ 30″ to rt. |
| 3d, p. m. | | 3 26 00 | | 116 37 30 " lt. |
| | | | | 12° 29′ 00″ (Diff.) |
| 2d, a. m. | | $8^h\ 37^m\ 00^s$ | 34° 40′ 00″ | 104° 36′ 30″ to rt. |
| 2d, p. m. | | 3 23 42 | | 117 05 30 " lt. |
| Sum of hour angles | | $6^h\ 46^m\ 42^s$ | | 12° 29′ 00″ (Diff.) |
| Mean hour angle | | 3 23 21 | | |
| 3d, a. m. | | $8^h\ 39^m\ 39^s$ | 35° 08′ 00″ | 105° 10′ 00″ to rt. |
| 1st, p. m. | | 3 21 18 | | 117 38 30 " lt. |
| | | | | 12° 28′ 30″ (Diff.) |

One half differences, or bearing angles from uncorrected north point to nail:

| | |
|---|---|
| By 1st obsn. | = N. 6°14′30″ E. |
| " 2nd " | = N. 6 14 30 E. |
| " 3rd " | = N. 6 14 15 E. |
| Mean | = N. 6°14′25″ E. |
| Differential azimuth correction | = −5 07 (Subt.: the southerly change in declination increased the larger, or p. m. horizontal angle.) |
| Mean true bearing of nail | = N. 6°09′18″ E. |

*Field record*

The hourly change in the sun's declination = 54.76″ S.




Hor. ang. a. m. = $180° - (A \text{ a. m.} + X) = 180° - A - X$
Hor. ang. p. m. = $180° - A \text{ p. m.} + X = 180° - A + X + 2dA_\delta$
Hor. ang. p. m. − hor. ang. a. m. = $2(X + dA_\delta)$
$X = \frac{1}{2}$ (Hor. ang. p. m. − hor. ang. a. m.) $- dA_\delta$

The following computation is made to obtain the differential azimuth correction for the above series:

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

$\frac{1}{2}d\delta = \frac{1}{2} \times 6.78 \times 54.76'' = 186''$; log $\frac{1}{2}d_s = 2.268578$

$\phi = 38°52.4'$ N.; log cos $\phi$ $= 9.891278$

$\frac{1}{2}(t_1+t_2) = 3^h23^m21^s$

$= 50°50'15''$

log sin $\frac{1}{2}(t_1+t_2)$ ---------------- $= 9.889499$

9.780777 9.780777

log $dA_s = 2.487801$

$dA_s$ = differential azimuth correction = 307''

= 5'07''

**121.** The following reduction to obtain the value of the differential azimuth correction for the above series is made with the use of table 22 of the Standard Field Tables:

| Latitude | $\frac{1}{2}(t_1+t_2)$, or hours from app. noon. | | |
|---|---|---|---|
| | $3^h$ | $3^h23.3^m$ | $4^h$ |
| 35°00'<br>38°52.4'<br>40°00' | 1. 73<br>1. 82<br>1. 85 | 1. 68 | 1. 41<br>1. 49<br>1. 51 |

Declination coefficient = 1.68

$dA_s = 1.68 \times \frac{1}{2}d\delta = 1.68 \times 186''$ = 312''

$dA_s$ = differential azimuth correction = 5'12''

The small difference (05'') in the computation of "$dA_s$" in the two processes of reduction is due to the error in adopting a coefficient obtained by linear interpolation in table 22 of the Standard Field Tables, the tabular interval of which is large. Ordinarily the equal altitude method would be used when the latitude of the station, or the vertical angle adjustment, are uncertain. The slight error in using the declination coefficient taken by linear interpolation from table 22 is small enough to be negligible.

**122.** The second a. m. and p. m. observations of the above series are selected for an example of the reduction to the sun's center and direct computation of the sun's azimuth, and true bearing of the nail, by the equation:

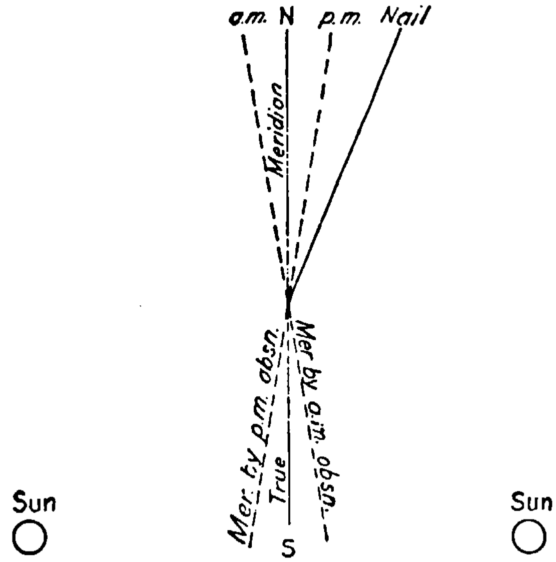
$$\text{Cos } A = \frac{\sin \delta}{\cos \phi \cos h} - \tan \phi \tan h$$

| | |
|---|---|
| Vertical angle to sun's lower limb | = 34°40'00'' |
| Reduction to sun's center | = +15 53 |
| Refraction (83'' x .82=68'') | = − 1 08 |
| Parallax | = + 07 |

| | | |
|---|---|---|
| Sun's center, $h$ | | = 34°54′52″ |
| Declination of the sun, Greenwich app. noon | | = 7°52′10″ N. |
| Diff. in time to a. m. obsn: | | |
| For long. 107°29′ W. = | $7^h09^m56^s$ | |
| For time, a. m. | = −3 23 00 | |
| $3.78^h$ | = $3^h46^m56^s$ | |
| Diff. in declination to app. time of a. m. obsn.: | | |
| 3.78 x 54.76″ = 207″ | | = 3′27″ S. |
| Sun's declination, a. m. observation | | = 7°48′43″ N. |
| Diff. to p. m. obsn. (6.78 x 54.76″ = 371″) | | = 6 11 S. |
| Sun's declination, p. m. observation | | = 7°42′32″ N. |

| | | | a. m. obsn. | | | p. m. obsn. |
|---|---|---|---|---|---|---|
| log sin $\delta$ | | | = 9.133290(+) | | | 9.127558(+) |
| " cos $\phi$ | = 9.891278 | | | | | |
| " " $h$ | = 9.913818 | | | | | |
| | 9.805096 | | 9.805096 | | | 9.805096 |
| " tan $\phi$ | = 9.906405 | | 9.328194 | log | = | 9.322462 |
| " " $h$ | 9.843846 | | = .21291 | nat. | = | .21012 |
| log | = 9.750251 | | | | | |
| nat. (−) | = .56267 | (−) | .56267 | (−) | | .56267 |
| Cos $A$ = | | (−) | .34976 | (−) | | .35255 |
| $A$, true bearing of sun | | | S. 69°31′39″ E. | | | S. 69°21′24″ W. |

| | | a. m. obsn. | p. m. obsn. |
|---|---|---|---|
| Hor. angle from nail to sun's right and left limbs | = | 104° 36′30″ | 117°05′30″ |
| Reduction to sun's center: $\dfrac{15'53''}{\cos 34°55'53''\ (v)}$ | = | −19 22 | −19 22 |
| Hor. angle to sun's center | = | 104° 17′08″ | 116°46′08″ |
| Sun's azimuth, as computed above | = | S. 69° 31′39″ E. | S. 69°21′24″ W. |
| | | 173° 48′47″ | 186°07′32″ |
| | | 180 00 00 | 180 00 00 |
| Bearing of nail | = | N. 6° 11′13″ E. | N. 6°07′32″ E. |
| Mean, true bearing of nail | = | N. 6° 09′22″ E. | |




The *discrepancy* between the results obtained in the a. m. and p. m. observations indicates a *probable* instrumental error in measuring the vertical angle, making it approximately 1′20″ too large, or in using a latitude value which is approximately 1′33″ north of the true latitude of the station, or in a combination of errors in these elements. However, these errors, discrepancies in values, or residuals of instrumental adjustments, are *compensated* by taking the mean of the results obtained in the a. m. and p. m. observations.

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

$$\begin{aligned} \text{By direct computation, } A \text{ a. m.} &= 69°31'39'' \\ A \text{ p. m.} &= 69°21'24'' \\ \hline \text{Difference} = 2dA_\delta &= \quad 10'15'' \\ dA_\delta &= \quad 5'07'' \end{aligned}$$

This value for $dA_\delta$ (5′07″) agrees with same function as first computed.

**123.** Example of stellar equal altitude observation for time, latitude, and azimuth:

October 26, 1944, at a transit station in Salt Lake City, Utah, in approximate latitude 40°45′ N., and longitude 111°49′ W., approximate elevation above sea level, 4,900 ft., at $3^h30^m$ p. m., app. time ($3^h14^m$ p. m., l. m. t.), I set the arcs of the solar unit, lat. 40°45′ N., and decl. 12°38′ S., and orient to the meridian, and determine the bearing, N. 27°06′ E., to a beacon light approximately 2 miles distant.

Oct. 26, $6^h29^m$ p. m., and Oct. 27, $4^h39^m$ a. m., l. m. t., I make a series of four equal altitude observations, including vertical angle at meridian passage, of the star α Arietis, No. 5/7, Mag. 2.2, for time, latitude, and azimuth, reading the horizontal angle from the beacon light, to the right, to the star in the p. m., and to the left, to the star in the a. m., equal vertical angles having been taken. My watch carries approximate local mean time.

Summary of results:

| | |
|---|---|
| Watch fast of l. m. t. | $0^m08^s$ |
| Latitude of station | 40°44′52″ |
| Indicated bearing of beacon light | N. 27°05′56″ E. |

The complete field record follows:

| | | |
|---|---|---|
| Greenwich m. t. star's transit, | Oct. 22 = $11^h58^m$ | p. m. |
| Red. to | Oct. 26 = −15.7 | |
| " " long. 111°49′ W. | = − 1.2 | |
| Star's transit, l. m. t., | Oct. 26 = $11^h41.1^m$ | p. m. |
| Anticipated l. m. t. of obsn. | = 6 11 | p. m. |
| Hour angle = 82°30′ | = $5^h30^m$ | |
| Declination of star | = 23°12.1′ | N. |

$$\sin h = \cos t \cos \phi \cos \delta + \sin \phi \sin \delta. \qquad \cos A = \frac{\sin \delta}{\cos \phi \cos h} - \tan \phi \tan h.$$

| | *cos* | *sin* |
|---|---|---|
| $t=$ | .1305 | |
| $\phi=$ | .7567 | .6528 |
| $\delta=$ | .9191 | .3939 |
| | .0909 | .2571 |
| | | .0909 |
| $\sin h=$ | | .3480 |
| $h=$ | | 20°22′ |

| | *cos* | *sin* | *tan* |
|---|---|---|---|
| $\phi=$ | .7567 | | .8616 |
| $h=$ | .9375 | | .3712 |
| $\delta=$ | | .3939 | |
| | .7103 | .7103 | −.3198 |
| | | .5546 | +.5546 |
| $\cos A=$ | | | +.2348 |
| $A=$ | | N. | 76°25′ E. |

With the above settings, at $6^h11^m$ p. m., l. m. t., I find the star in good position and proceed with a series of four equal altitude observations:

| Observation | Watch time | Vertical angle | Horizontal angle, beacon light to star |
|---|---|---|---|
| 1st p. m., Oct. 26 | $6^h28^m58^s$ | 23°29′30″ | 51°46′00″ to rt. |
| 4th a. m., Oct. 27 | 4 53 32 | | 105 57 30 to lt. |
| Sum of hour angles | $10^h24^m34^s$ | | 54°11′30″ (Diff.) |
| Mean hour angle | 5 12 17 | | 27 05 45 (½ diff.) |
| Watch time, star's transit, Oct. 26 | $11^h41^m15^s$ | | |
| 2nd p. m., Oct. 26 | $6^h32^m12^s$ | 24°07′30″ | 52°16′30″ to rt. |
| 3rd a. m., Oct. 27 | 4 50 16 | | 106 29 00 to lt. |
| Sum of hour angles | $10^h18^m04^s$ | | 54°12′30″ (Diff.) |
| Mean hour angle | 5 09 02 | | 27 06 15 (½ diff.) |
| Watch time, star's transit, Oct. 26 | $11^h41^m14^s$ | | |
| 3rd p. m., Oct. 26 | $6^h36^m54^s$ | 25°00′30″ | 52°58′00″ to rt. |
| 2nd a. m., Oct. 27 | 4 45 35 | | 107 10 00 to lt. |
| Sum of hour angles | $10^h08^m41^s$ | | 54°12′00″ (Diff.) |
| Mean hour angle | 5 04 20 | | 27 06 00 (½ diff.) |
| Watch time, star's transit, Oct. 26 | $11^h41^m15^s$ | | |
| 4th p. m., Oct. 26 | $6^h43^m32^s$ | 26°15′00″ | 53°59′00″ to rt. |
| 1st a. m., Oct 27 | 4 38 54 | | 108 10 30 to lt. |
| Sum of hour angles | $9^h55^m22^s$ | | 54°11′30″ (Diff.) |
| Mean hour angle | 4 57 41 | | 27 05 45 (½ diff.) |
| Watch time, star's transit, Oct. 26 | $11^h41^m13^s$ | | |

One-half differences of horizontal angles, or bearings of reference point, and watch time of star's transit:

| | *Bearing of reference point* | *Watch time of star's transit* |
|---|---|---|
| By 1st obsn. | = N. 27°05′45″ E. | $11^h41^m15^s$ p. m. |
| " 2nd " | = N. 27°06′15″ E. | 11 41 14 p. m. |
| " 3rd " | = N. 27°06′00″ E. | 11 41 15 p. m. |
| " 4th " | = N. 27°05′45″ E. | 11 41 13 p. m. |
| Mean | = N. 27°05′56″ E. | Mean = $11^h41^m14^s$ p. m. |
| | | Star's transit = 11 41 06 p. m. |
| | | Watch fast of l. m. t. = $0^m08^s$ |

Meridian altitude observation of the star for latitude:

**Local mean time of star's transit, Oct. 26, $11^h41^m06^s$ p. m.**

Setting: 90°00′

$\delta \neq$ 23 12 N.

$90° + \delta \neq 113°12'$

$\phi \neq$ 40 45 N.

$v \neq 72°27' = (90° + \delta) - \phi$

| Telescope | Watch time | Vertical angle |
|---|---|---|
| Direct | 11ʰ37ᵐ16ˢ p. m. | 72°28′00″ |
| Reversed | 11 39 35 " | 72 27 00 |
| Direct | 11 43 22 " | 72 29 00 |
| Reversed | 11 46 42 " | 72 26 00 |
| Mean | 11ʰ41ᵐ44ˢ " | 72°27′30″ |
| Refraction (19″ × .85=16″) | | = −16 |
| | | $h$= 72°27′14″ |
| $\delta$=23°12′06″ N.; 90°+$\delta$ | | =113 12 06 |
| $\phi$=40°44′52″ N.=(90°+$\delta$)−$h$ | | = 40°44′52″ |

The above series of observations may be reduced for azimuth individually, giving a check on the instrumental performance and the accuracy of the observed values, as follows, using the equation:

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

$$\phi=40°44'52'' \text{ N.}; \delta=23°12'06'' \text{ N.}$$

| Function | 1st p. m. 4th a. m. | 2nd p. m. 3rd a. m. | 3rd p. m. 2nd a. m. | 4th p. m. 1st a. m. |
|---|---|---|---|---|
| $v$ | 23°29′30″ | 24°07′30″ | 25°00′30″ | 26°15′00″ |
| Refraction | −1 52 | −1 49 | −1 45 | −1 39 |
| $h$ | 23°27′38″ | 24°05′41″ | 24°58′45″ | 26°13′21″ |
| sin $\delta$ | .393969 | .393969 | .393969 | .393969 |
| Cos $\phi$ | .757590 | .757590 | .757590 | .757590 |
| Cos $h$ | .917334 | .912872 | .906461 | .897085 |
| Cos $\phi$ cos $h$ | .694963 | .691583 | .686726 | .679623 |
| $\frac{\sin \delta}{\cos \phi \cos h}$ | +.566892 | +.569663 | +.573692 | +.579688 |
| Tan $\phi$ | .861588 | .861588 | .861586 | .861588 |
| Tan $h$ | .433994 | .447211 | .465865 | .492549 |
| Tan $\phi$ tan $h$ | −.373924 | −.385312 | −.401384 | −.423374 |
| Cos $A$ | +.192968 | +.184351 | +.172308 | +.155314 |
| $A$ (From N.) | 78°52′26″ | 79°22′26″ | 80°04′41″ | 81°03′54″ |
| Hor. ang. p. m | 51 46 00 | 52 16 30 | 52 58 00 | 53 59 00 |
| Bearing of beacon light | N. 27°06′26″E. | N. 27°05′56″E. | N. 27°06′41″E. | N. 27°04′54″E. |
| Hor. ang. a. m | 105°57′30″ | 106°29′00″ | 107°10′00″ | 108°10′30″ |
| $A$ (From N.) | 78 52 26 | 79 22 26 | 80 04 41 | 81 03 54 |
| Bearing of beacon light | N. 27°05′04″E. | N. 27°06′34″E. | N. 27°05′19″E. | N. 27°06′36″E. |

Mean bearing, p. m. observations =N. 27°05′59″ E.
Mean bearing, a. m. observations =N. 27°05′53″ E.

Mean, true bearing of beacon light =N. 27°05′56″ E.

# THE GEODESY OF LARGE-SCALE CADASTRAL SURVEYS

## Transfer of Azimuth, Station Error and Curvature

**124.** When carrying forward the direction of lines through intermediate transit stations by the method of forward and back sights and deflection angles, there are two elements that require correction. The corrections become important where the purpose is to maintain an accuracy within a small limit of error.

Each station set-up involves more or less uncertainty in the maintenance of the direction of a line, or in the value of the angle that may be turned, called "station error."

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 the accumulative errors of the strictly 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, figure 15, 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 ±180° 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 ±180° 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 counting from the two end stations. The discrepancy will be the accumulated error in the transit operations.

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 *accumulative error*. The latter value, in terms of seconds, may be divided by the number of the intermediate stations; the quotient is the accumulative 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 6 miles*, or 480 chains, for each degree of latitude; table 11. Sections 129 and 130. 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*, or interval between the turns in direction.

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 $\pm 180°$. 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.

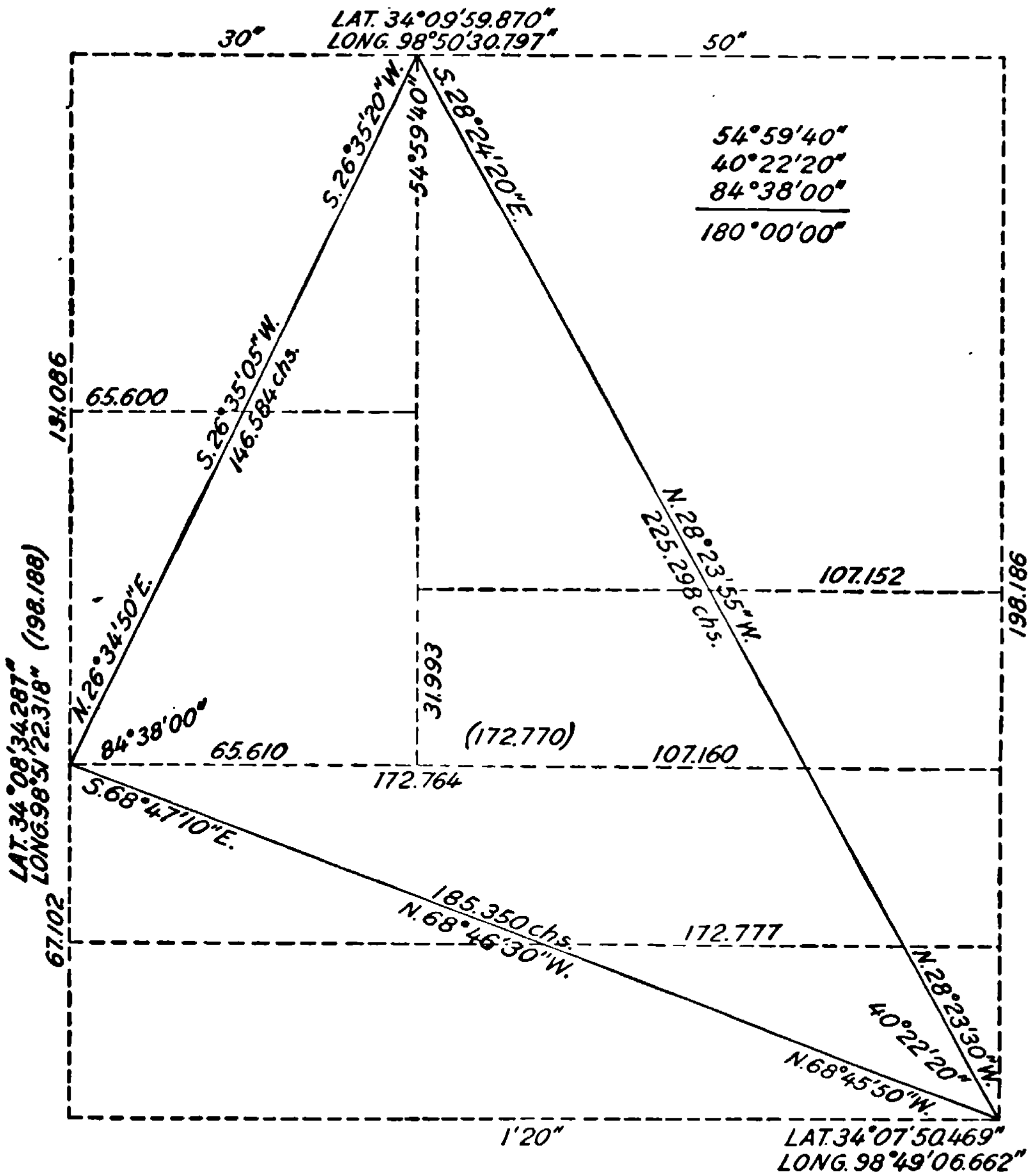
Where the transfer of azimuth is by triangulation, a check is secured by the closure of each triangle, and by the reductions of the lengths of the lines.

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° 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 $\pm 180°$ 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.




In checking the lengths of lines, the reduction of the longest line in northing or southing in any triangle should equal the sum of the northing or southing 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.

The 1-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 justification for the consequent needed increase in care. This will involve all necessary refinements in the observing, and in the line work, and that all calculations be carried to seconds, even though the final results may be shown only to the nearest 30″, 15″, or 10″.

A tolerance equal to the above limiting values should be allowed. Where the survey is executed with the 1-minute transit, including the due exercise of all necessary care, it is regarded as inappropriate to represent a final value closer than to the nearest 30″, 15″, or 10″, by the calculations. These limits are of course very small for verification by an equally competent observer, using an equally good one-minute transit, a comparable observing program, and the approved methods for all necessary steps.

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 measurement if those values are to be as good as the values required in the direction of lines. Section 234.

## The True Parallel of Latitude

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

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

### Solar Method

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

### Tangent Method

**127.** The tangent method of determination of the true latitude curve consists in establishing the true meridian at the point of beginning, from which a horizontal deflection angle of 90° is turned to the east or west, as may be required, and the projection of the line thus determined is called the tangent. The tangent is projected 6 miles in a straight line, and as the measurements are completed for each corner point, proper offsets are measured north from the tangent to the parallel, upon which line the corners are established.

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



700004°—47——11

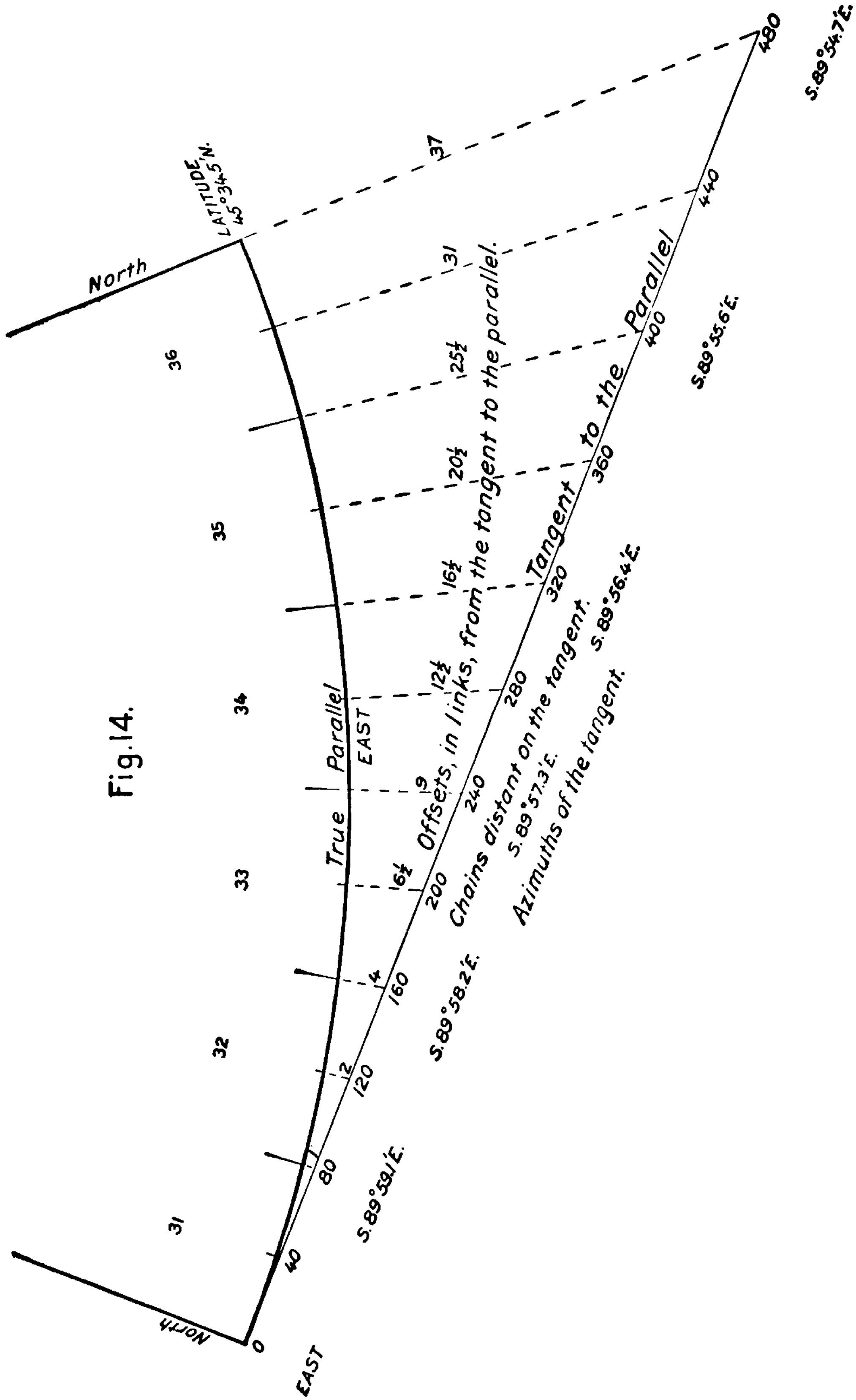

North
LATITUDE 45°34.5'N.
True Parallel
EAST
Tangent to the Parallel
Offsets, in links, from the tangent to the parallel.
Chains distant on the tangent.
Azimuths of the tangent.
31
32
33
34
35
36
0
40
80
120
160
200
240
280
320
360
400
440
480
1
2
4
6¼
9
12¼
16¼
20¼
25¼
31
37
S.89°59.1'E.
S.89°58.2'E.
S.89°57.3'E.
S.89°56.4'E.
S.89°55.6'E.
S.89°54.7'E.
North
EAST

Fig. 14.

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

The accompanying diagram illustrates the establishment of a standard parallel in latitude 45°34′.5 N., by the tangent method. See fig. 14. The form of record is shown in the specimen field notes, Manual Appendix VIII.

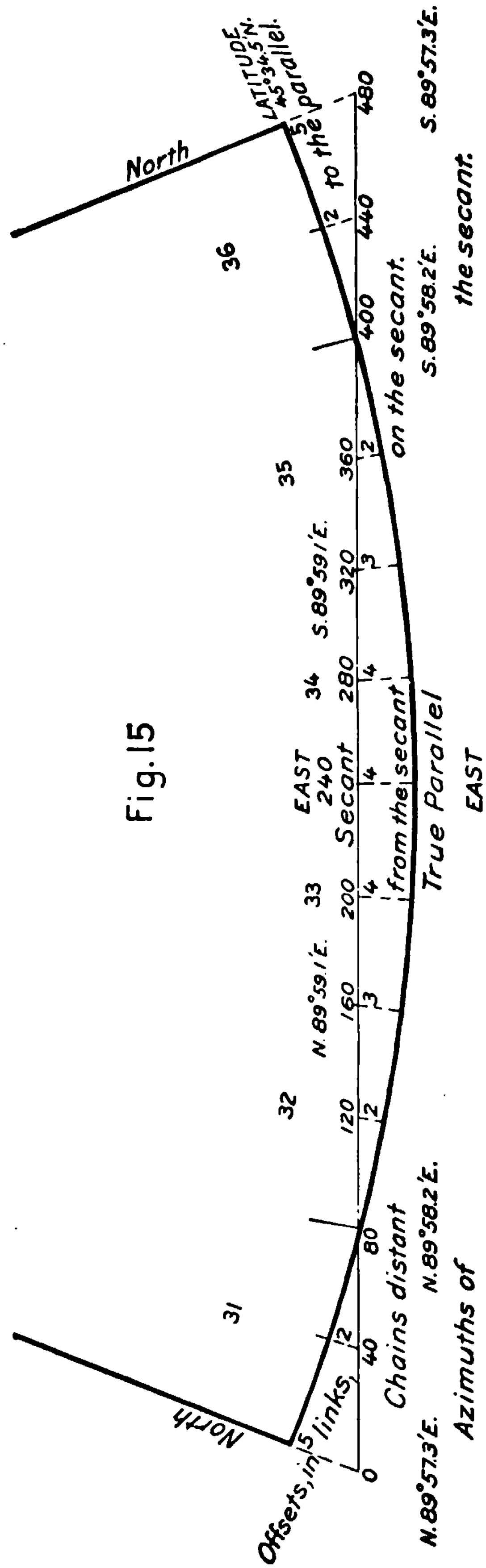
Objection to the use of the tangent method in a timbered country is found owing to the requirement that all blazing is to be made on the true surveyed lines. Also, all measurements to items of topography entered in the field notes are to be referred to the true established lines. These objections to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

## Secant Method

**128.** The designated secant is a great circle which cuts any true parallel of latitude at the first and fifth mile corners, and is tangent to an imaginary latitude curve at the third mile point. From the point of beginning to the third mile corner the secant has a northeasterly or northwesterly bearing; at the third mile corner the secant bears east or west; and from the third to the sixth mile corners the secant has a southeasterly or southwesterly bearing, respectively, depending upon the direction of projection, east or west. From the point of beginning to the first mile corner and from the fifth to the sixth mile corners the secant lies south of the true parallel, and from the first to the fifth mile corners the secant lies north of the true parallel. It will thus be seen that the secant method is a mere modification of the tangent method, so arranged that the minimum offsets can be made from the projected transit line to the established true parallel of latitude.

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

In table 14, Standard Field Tables, are given the bearing angles or azimuths of the secant, referred to the true N. point for the first 3 miles, and the same symmetrical bearing angles or azimuths referred



North
North
LATITUDE 45°34.5'N.
Offsets, in links to the parallel.
Chains distant from the secant on the secant.
Azimuths of the secant.
31
32
33
34
35
36
0
40
80
120
160
200
240
280
320
360
400
440
480
5
2
2
3
4
4
4
3
2
2
5
N.89°57.3'E.
N.89°58.2'E.
N.89°59.1'E.
EAST
Secant
S.89°59.1'E.
S.89°58.2'E.
S.89°57.3'E.
True Parallel
EAST


Fig. 15

to the true S. point for the last 3 miles, tabulated for any degree of latitude from 25° to 70° N., for the end of each mile from 0 to 6 miles.

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

The accompanying diagram illustrates the establishment of a standard parallel in latitude 45°34′.5 N. by the secant method. See fig. 15. The form of record is shown in the specimen field notes, Manual Appendix VIII.

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

## Convergency of Meridians

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

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

"$m_\lambda$": Measurement along the parallel.

"$m_\phi$": Measurement along the meridian.

"$a$": Equatorial radius of the earth=3963.3 miles.

"$e$": Factor of eccentricity, log $e$=8.915 2515.

"$dm_\lambda$": 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 | |

| | | |
|---|---|---|
| " $e^2 \sin^2 \phi$ | $=7.503\ 457$ | |
| nat " " " | = | 0.0031875 |
| " $(1-e^2 \sin^2 \phi)$ | = | 0.9968125 |
| log " " " | $=9.998\ 614$ | |
| " $\sqrt{1-e^2 \sin^2 \phi}$ | $=9.999\ 307$ | |
| " tan 43° 20′ | $=9.974\ 720$ | |
| " 24 | $=1.380\ 211$ | |
| " " | $=1.380\ 211$ | |
| " 80 [3] | $=1.903\ 090$ | |
| " product | $=4.637\ 539$ | |
| " 3963.3 | $=3.598\ 057$ | |
| " $dm_\lambda$ | $=1.039\ 482$ | |
| nat " | 10.9517 chs. | |

The convergency, measured on the parallel, of two meridians 24 miles apart and 24 miles long, in a mean latitude of 43° 20′, is therefore found to be 10.95 chains. The convergency of the east and west boundaries of a regular township in the same latitude would be equal to one-sixteenth of the convergency of the east and west boundaries of the quadrangle as computed above, or 68.44 links, which agrees with the value taken from table 11 of the Standard Field Tables.

**130.** In table 11, Standard Field tables, are tabulated the linear amounts of the convergency of meridians, 6 miles long and 6 miles apart, for each degree of latitude from 25° to 70° N., together with the angle of convergency of the same meridians. These amounts of linear convergency are at once the proper corrections to apply to the north boundary of a regular township in the computation of the closing error around a township, or other computation by which a theoretical length of a north or south boundary of a township is compared with the length of the opposite boundary; the tabulated linear amounts of convergency are equal to double the amounts of the offsets from a tangent to the parallel at 6 miles for the same latitudes. Simple interpolation may be made for any intermediate latitude, and the amount of the convergency for a fractional township or other figure may be taken in proportion to the tabulated convergency as the fractional area is to 36 square miles.

The tabulated angle of convergency represents at once the deviation in azimuth of the tangent from the parallel at 6 miles; and ⅙, ⅓, ½, ⅔, and ⅚ 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.

[3] This factor is introduced here for the purpose of conversion from the unit expressed in miles to the unit expressed in chains.

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

**131.** In the plan of subdivision of townships the meridional section lines are established parallel to the east boundary or other governing line; this necessitates a slight correction on account of the angular convergency of meridians. Meridional section lines west of the governing line are deflected to the left of the bearing of the governing line the amount shown in the second part of table 2, Standard Field Tables, which is entered under two arguments: (1) latitude, and (2) distance from the governing line. Meridional section lines east of a governing boundary are given the same amount of correction for bearing, but the deflection is made to the right.

## Lengths of Arcs of the Earth's Surface

**132.** All computations involving a difference of latitude for a given measurement along a meridian or the converse calculation, or other computations involving a difference of longitude for a given measurement along a parallel or a similar converse calculation, are readily accomplished by the use of the values given in table 16, Standard Field Tables; this table gives the lengths in miles and decimal part of a mile of one degree of longitude measured on the parallel, and the lengths in miles of one degree of latitude measured on the meridian, for any latitude from 25° to 70° N.

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

## Geographic Positions

**133.** A different method of computation is better suited to the determination of geographic position in the relatively short transfers from an established point to another station in the same vicinity. In this, the accepted values are the latitude and longitude of the geodetic station, currently referred to as those that are based upon the 1927 North American Datum, United States Coast and Geodetic Survey. The established stations of the United States Geological Survey are employed for the same purpose. The problem is to transfer those values to a monument of the public-land survey.

The reference may be by a direct tie or connecting line, by traverse lines, or by traverse coupled with one or more miles of the rectangular survey. In the great majority of cases (public land surveys) the most convenient method is by the reduction of the connecting line, or lines, to the equivalent latitudes and departures.

Some of the lines may be relatively short, with little difference between the forward and the back azimuth. Some may require correction for curvature. Some of them if taken from the field-note record for direction and length, just as run in the usual manner, may not have the high degree of accuracy that is required if the transfer of geographic position is to retain the refinement of the geodetic station. In practical application, however, the usual purpose is to ascertain a latitude and longitude for the monument of the public land survey that may be sufficiently good for mapping, reference, and other ordinary use excluding significance as a geodetic control station.

The tables best suited to the purpose are known as the "M" and "P" factors, relating as they do to the measurements along the meridian and along the parallel.[4]

The differences in latitude are computed first. The "M" factor of the table is taken out for the connecting line, or lines. The northing or southing of the connecting line, or lines, which is the reduced *distance in latitude*, measured in the chains unit, is multiplied by the "M" factor; the product is the number of seconds of arc in latitude, or the *difference in latitude* between the points. This result, added to, or subtracted from, the latitude of the geodetic station, gives the latitude of the monument to which the connection has been made.

The "P" factor, or factors, is then taken out with care as to the interpolation in latitude, as this factor changes rapidly. The "P" factor, or factors, should be interpolated in each case for the *mean latitude* of each important element of the connecting lines (explanation, next paragraph). The easting or westing of each element of the connecting lines, which is the reduced *distance in departure*, is multiplied by the "P" factor; the product is the number of seconds of arc in longitude, or the *difference in longitude*, between the points *of that element*. The sum of the reductions gives the whole *difference in longitude* between the initial and the closing point. The result, added to, or subtracted from, the longitude of the geodetic station, gives the longitude of the monument to which the connection has been made.

A meridional line, true north or south, or with small bearing angle from the meridian, may be regarded as relatively unimportant, in the

[4] Factors for the Interconversion of Latitudes and Departures in Feet and Differences of Latitude and Longitude in Seconds for Latitudes 25° to 50°: U. S. Geological Survey. A condensed form is proposed for inclusion in the Standard Field Tables, which will give the conversion from *ordinary latitudes and departures in chains measurement to seconds of latitude and longitude.*

sense that a meridian has no change in longitude. A line with a very small bearing angle from the meridian, such as the usual meridional lines of a township subdivision, themselves made parallel to the east boundary of the township, itself a meridian, has a departure that is measured in links only. If desirable, or convenient to do so, the latter may, for the purpose of computation, be added to the easting or westing of one of the adjoining lines. If that is done in combination as suggested, the "P" factor is taken out for the *mean latitude* of the principal easting or westing element, disregarding the difference in latitude of the meridional line.

East and west lines of any considerable length, such as miles and half-miles, should be computed as separate elements. Traverse courses that have the same general direction may be combined into one element, for which the "P" factor should be taken out for the *mean latitude of that element.*

Example: Manual Appendix II.

## Chapter III

# SYSTEM OF RECTANGULAR SURVEYS

## GENERAL SCHEME

**134.** For the purpose of administration or disposal of the public domain, the law provides generally that (*a*) the public lands of the United States shall be divided by lines intersecting true north and south at right angles so as to form townships 6 miles square, (*b*) the townships shall be marked with progressive numbers from the beginning, (*c*) the townships shall be subdivided into 36 sections, each 1 mile square and containing 640 acres as nearly as may be, and (*d*) 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. sec. 2395; 43 U. S. C. sec. 751).

In accordance with the foregoing legal requirements, the public lands of the United States are surveyed under the method known as 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 sufficiently near each other to maintain a practical workable adherence to the legal definition of the primary unit, the township 6 miles square.
4. The subdivision of the townships into 36 sections by running parallel lines through the township from south to north and from east to west at distances of 1 mile.

By law, (*a*) 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 (*b*) 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. sec. 2396; 43 U. S. C. sec. 752). From the foregoing it is evident that 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, and 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.

The extension of the rectangular system of public land surveys over the public domain in the United States, as the need developed, has been in progress over 150 years and is gradually approaching completion. This vast and comprehensive rectangular survey net provides a simple and certain form of land identification and legal description, and anchors in place the land of the public domain. Title to the public lands is based upon the rectangular system and should not be confused or obscured unnecessarily by supplemental records of surveys alien in character.

**135.** The townships will be numbered to the north or south commencing with number 1 at the base line, and with range numbers to the east or west beginning with number 1 at the principal meridian.

The 36 sections into which a township is subdivided are numbered commencing with number 1 in the northeast section of the township, proceeding thence west to section 6, thence south to section 7, thence east to section 12, and so on, alternately, to number 36 in the southeast section. In the case of townships containing less than 36 sections, the numbering of sections is accomplished as explained in sec. 213.

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

**137.** Section lines are usually surveyed from south to north and from east to west, in order to place the excess or deficiency of measurement on the north and west sides of the townships. In cases where the west or the north boundary of a township is within limits as to alinement (sec. 162) to serve as a basis for rectangular subdivision, and the opposite line is defective, the section lines may be run from the west or north when the procedure is approved by the appropriate administrative officer. For convenience, the satisfactorily surveyed lines on which subdivisions are to be based will be termed the governing boundaries of the township. In extreme cases an irregular township may be without a single governing boundary.

In the sections that follow the first explanations are with respect to ideal procedure in the rectangular plan. There follow then many explanations why the plan must be modified in various ways in order to begin new work, held to strict limits for rectangularity and closure, where the initial and closing lines already established by prior survey, are found not to qualify under the current specifications. The established lines can not now be changed because of the passing of titles based thereon. The purpose is to avoid the incorporation of the discovered discrepancies of the older lines in the running of new original surveys where the current specifications are to be adhered to. The further objective is to return to "normal" procedure in those many places of the older surveys where there were departures or exceptions made in the rectangular plan. Sec. 8. The explanations here are entirely apart from, and have no place in the Manual text on *resurveys*, chapter VI.

## INITIAL POINTS

**138.** The establishment of initial points, principal meridians and base lines from which the lines of the public surveys are extended, have been completed in the United States. Initial points will be established in Alaska, whenever necessary to control large areas within reasonable geographical limitations, under such special instructions as may be prescribed by the Director, Bureau of Land Management. Upon the establishment of an initial point, its position in latitude and longitude is to be determined by accurate field astronomical methods.

During the period since the organization of the system of rectangular surveys, numbered and locally named principal meridians and base lines have been established as shown by the accompanying tabular exhibit. These bases and meridians may be found by examining the large wall map of the United States published by the Bureau of Land Management; they are also shown upon the various official State maps, and upon a special map entitled "United States, Showing Principal Meridians, Base Lines, and Areas Governed Thereby."

**139.** The latitudes and longitudes given in the following table are based upon the best available information, having been derived from connections to nearby stations whose geographic positions are known. In some cases, notably the Fourth Principal, Illinois; Navajo; Second Principal; and Third Principal, the record of the subsisting public land surveys was adopted in computing the geographic values of the initial points. In such cases the tabulated values are reliable within the limits of accuracy of the record on which the computations are based. The coordinates of the several reference meridians governing the earliest public land surveys in Ohio can not be tabulated conveniently.

The following explanatory comments will clarify the tabulated statement.

As the result of contending claims of Ohio and Michigan as to the boundary between those states, the position of that boundary was not finally settled until Michigan was admitted into the Union in 1837. Prior to that time the surveys in the southern portion of the area governed by the Michigan Meridian had been executed and extended to the position for the state boundary as claimed by Michigan. Subsequent to the establishment of the state boundary the public land surveys were closed upon that boundary; the lands originally surveyed under the Michigan Meridian and situated south of the state boundary continue to be governed by the Michigan Meridian although administered within the State of Ohio.

A somewhat similar situation exists in southern Alabama where the surveys based upon the Tallahassee Meridian in Florida were closed upon the St. Stephens Base Line owing to uncertainty as to the position of the state boundary. The state boundary as originally surveyed by Andrew Ellicott in 1798 was later resurveyed and the necessary amended closings of the public land surveys on that line was accomplished. This has resulted in some lands governed by the Tallahassee Meridian being administered in the State of Alabama. The Tallahassee base line was extended west from the initial point to the west boundary of R. 18 W.; at this point the base line was offset north six miles and extended west from that point to avoid Choctawhatchee Bay and other bays and inlets of the Gulf of New Mexico.

The Navajo Meridian originally governed public land surveys in northwestern New Mexico and northeastern Arizona. However, only a few townships governed by that meridian were surveyed in the State of New Mexico and no disposals based on those surveys were made. The Navajo Meridian and the surveys based thereon in the State of New Mexico were canceled by letter of the Commissioner of the General Land Office dated July 28, 1936, in the interest of regularity and uniformity of surveying procedure in that state.

It will be noted that, in the tabulation of the principal meridians, a different value is assigned for the longitude of the initial point of the 4th Principal Meridian governing surveys in Illinois from that governing surveys in Minnesota and Wisconsin. This is accounted for by accumulated errors in the alinement of the 4th Principal Meridian as originally surveyed in 1831, particularly through that portion of the line which was carried as a blank line across a large bend in the Mississippi River. It is to be assumed that the longitude of the 4th Principal Meridian in the State of Illinois, north of the Mississippi River, is substantially the same as that published for Wisconsin.

The rectangular system of the survey of public lands was initiated in the State of Ohio. In its early stages the system was somewhat experimental and that State may well be referred to as the proving ground for the present rectangular system of surveys. The east

*Meridians and base lines of the United States Rectangular Surveys*

| Meridians | Governing surveys (wholly or in part) in States of— | Longitude of initial points west from Greenwich | | | Latitude of initial points | | |
|---|---|---|---|---|---|---|---|
| | | ° | ′ | ″ | ° | ′ | ″ |
| Black Hills | South Dakota | 104 | 03 | 16 | 43 | 59 | 44 |
| Boise | Idaho | 116 | 23 | 35 | 43 | 22 | 21 |
| Chickasaw | Mississippi | 89 | 14 | 47 | 35 | 01 | 58 |
| Choctaw | do | 90 | 14 | 41 | 31 | 52 | 32 |
| Cimarron | Oklahoma | 103 | 00 | 07 | 36 | 30 | 05 |
| Copper River | Alaska | 145 | 18 | 13 | 61 | 49 | 21 |
| Fairbanks | do | 147 | 38 | 26 | 64 | 51 | 50 |
| Fifth Principal | Arkansas, Iowa, Minnesota, Missouri, North Dakota, and South Dakota. | 91 | 03 | 07 | 34 | 38 | 45 |
| First Principal | Ohio and Indiana | 84 | 48 | 11 | 40 | 59 | 22 |
| Fourth Principal | Illinois [1] | 90 | 27 | 11 | 40 | 00 | 50 |
| Do | Minnesota and Wisconsin. | 90 | 25 | 37 | 42 | 30 | 27 |
| Gila and Salt River | Arizona | 112 | 18 | 19 | 33 | 22 | 38 |
| Humboldt | California | 124 | 07 | 10 | 40 | 25 | 02 |
| Huntsville | Alabama and Missisippi | 86 | 34 | 16 | 34 | 59 | 27 |
| Indian | Oklahoma | 97 | 14 | 49 | 34 | 29 | 32 |
| Louisiana | Louisiana | 92 | 24 | 55 | 31 | 00 | 31 |
| Michigan | Michigan and Ohio | 84 | 21 | 53 | 42 | 25 | 28 |
| Mount Diablo | California and Nevada | 121 | 54 | 47 | 37 | 52 | 54 |
| Navajo | Arizona | 108 | 31 | 59 | 35 | 44 | 56 |
| New Mexico Principal | Colorado and New Mexico | 106 | 53 | 12 | 34 | 15 | 35 |
| Principal | Montana | 111 | 39 | 33 | 45 | 47 | 13 |
| Salt Lake | Utah | 111 | 53 | 27 | 40 | 46 | 11 |
| San Bernardino | California | 116 | 55 | 17 | 34 | 07 | 20 |
| Second Principal | Illinois and Indiana | 86 | 27 | 21 | 38 | 28 | 14 |
| Seward | Alaska | 149 | 21 | 24 | 60 | 07 | 36 |
| Sixth Principal | Colorado, Kansas, Nebraska, South Dakota, and Wyoming. | 97 | 22 | 08 | 40 | 00 | 07 |
| St. Helena | Louisiana | 91 | 09 | 36 | 30 | 59 | 56 |
| St. Stephens | Alabama and Mississippi | 88 | 01 | 20 | 30 | 59 | 51 |
| Tallahassee | Florida and Alabama | 84 | 16 | 38 | 30 | 26 | 03 |
| Third Principal | Illinois | 89 | 08 | 54 | 38 | 28 | 27 |
| Uintah | Utah | 109 | 56 | 06 | 40 | 25 | 59 |
| Ute | Colorado | 108 | 31 | 59 | 39 | 06 | 23 |
| Washington | Mississippi | 91 | 09 | 36 | 30 | 59 | 56 |
| Willamette | Oregon and Washington | 122 | 44 | 34 | 45 | 31 | 11 |
| Wind River | Wyoming | 108 | 48 | 49 | 43 | 00 | 41 |

[1] The numbers are carried to fractional township 29 north in Illinois, and are repeated in Wisconsin, beginning with the south boundary of the State; the range numbers are given in regular order.

boundary of Ohio, north of the Ohio River, known as Ellicott's Line, in longitude 80°32′20″ was employed as the first reference meridian. From this meridian the ranges were numbered progressively westward, and the townships numbered progressively northward from the Ohio River in each range. Many other reference meridians and base lines were employed in the State of Ohio to govern particular areas for purposes of disposal. In determining the relative location of townships in Ohio difficulty may be anticipated by reason of the many base lines and meridians from which the respective townships and ranges are numbered. Careful study of the development, execution, and map of the public land survey in that State may be necessary to clarify the situation with respect to any given description.

## PRINCIPAL MERIDIAN

**140.** This line shall conform to the true meridian and will be extended from the initial monument, either north or south, or in both directions, as the conditions may require; regular quarter-section and section corners will be established alternately at intervals of 40 chains, and regular township corners at intervals of 480 chains; corner monuments designated as meander corners will be established at the intersection of the line with all meanderable bodies of water. Section 226.

**141.** In the survey of the principal meridian and the other standard lines (base lines, standard parallels, and guide meridians), hereinafter described, two independent sets of measurements will be employed, unless subdivisional closings thereon are provided in the same assignment with the standard line, in which case the closings will furnish a satisfactory verification of the length of the lines thus surveyed. Where two independent sets of measurements are employed, the measurement of each set will be noted in the field tablet, but the distance to the mean point only will be shown in the transcribed field notes; a form of record is given in the specimen field notes. Appendix VIII.

**142.** Should the difference between the two sets of measurements of any standard line, as above provided, exceed 14 links per 80 chains, it is required that the line be remeasured to reduce the difference, the final measurement of the line only to be shown in the field notes. Should the successive independent tests of the alinement of any standard line, or the average tests of the solar attachment employed in the projection thereof, indicate that the line has deflected from the true cardinal course to exceed 3′00″, the necessary corrections will be made to reduce the deviation in azimuth, the field notes of the true line only being shown. Every reasonable effort will be exercised to insure the accuracy of both the alinement and the measurement of the standard lines, and the stated discrepancies are the maximum that will be allowed in new surveys; corrective steps will be required where the differences are beyond the maximum.

## BASE LINE

**143.** From the initial monument the base line will be extended east and west on a true parallel of latitude; upon the true line standard quarter-section and section corners will be established alternately at intervals of 40 chains; and standard township corners at intervals of 480 chains; corner monuments designated as meander corners will be established at the intersection of the line with all meanderable bodies of water. Section 226.

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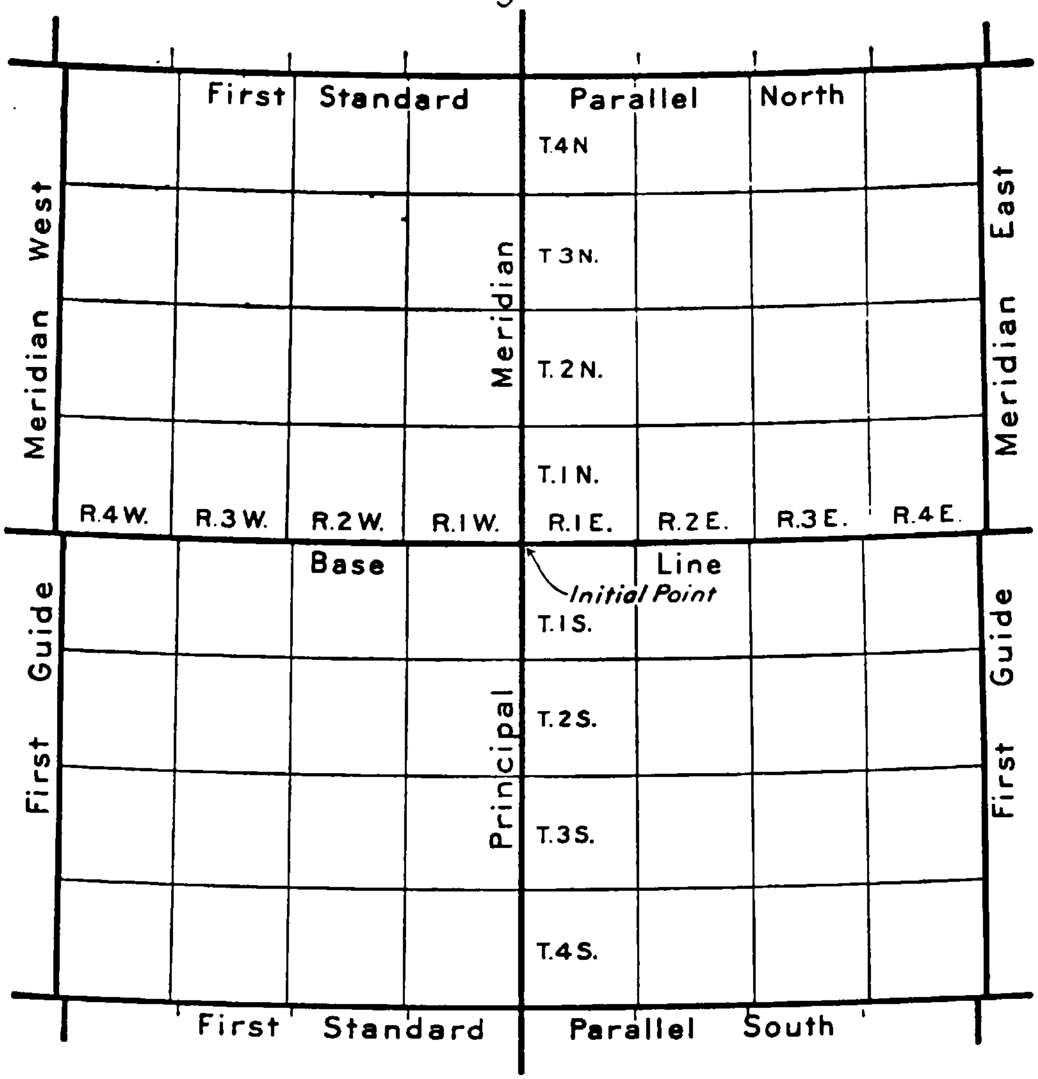
The manner of making the measurement of the base line and the accuracy of both the alinement and measurement will be the same as required in the survey of the principal meridian. Any one of the methods heretofore set forth (secs. 125, 126, 127, and 128) for the determination of the alinement of the true latitude curve may be used as existing conditions may require and the detailed process will be fully stated in the field notes. Appendix VIII.

## STANDARD PARALLELS

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

Fig. 16.




Illustrating the survey of quadrangles each embracing 16 townships bounded by standard lines, and showing the coördinate system of numbering the townships.

**145.** Where standard parallels have been placed at intervals of 30 or 36 miles, under practice then permissible, and present conditions require additional standard lines from which to initiate new, or upon which to close the extension of old surveys, an intermediate correction line should be established to which a local name may be given, e. g., "Fifth Auxiliary Standard Parallel North," or "Cedar Creek Correction Line," etc., and the same will be run, in all respects, like a regular standard parallel.

## GUIDE MERIDIAN

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

**147.** When existing conditions require that such guide meridians shall be run south from the base or correction lines, they will be initiated at the theoretical point for the closing corner of the guide meridian, which will be calculated on the basis of the survey of the line from south to north initiated at the proper standard township corner. At the theoretical point of intersection a closing township corner will be established.

**148.** Where guide meridians have been placed at intervals exceeding the distance of 24 miles, and new governing lines are required in order to limit the errors of the old or to control new surveys, a new guide meridian will be established, and a local name may be assigned to the same, e. g., "Twelfth Auxiliary Guide Meridian West," or "Grass Valley Guide Meridian," etc. These auxiliary guide meridians will be surveyed in all respects like regular guide meridians.

**149.** The above scheme covers the controlling lines contemplated under the rectangular system, and results regularly in the survey of quadrangles bounded on the north and south by true parallels of latitude, and on the east and west by true meridians, 24 miles apart. One exception may now be noted which will be found to depart from former practice, that is, where a guide meridian is carried forward at a time when uncertainty exists as to how the exterior and subdivisional surveys to the east may close upon it, the corners upon the same will be marked only for the surveys to the west.

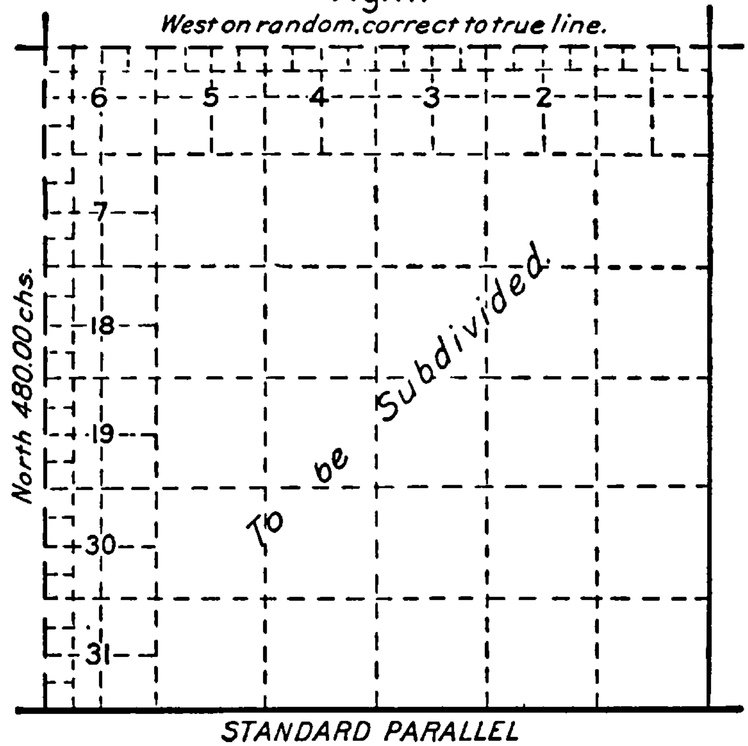
## TOWNSHIP EXTERIORS

### Regular Order

**150.** The controlling factors to be recognized in the establishment of new township boundary lines are found in the relation of these lines to the new subdivisional surveys which are to be executed. The south and east boundaries are normally the governing lines of the subdivisional surveys. Defective conditions which may be found in previously established exteriors cannot be eliminated where subdivisional lines have been initiated from or closed upon an old boundary, but the errors of the former surveys are not to be incorporated into the new, and where the previously established south and east boundaries 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 will be employed as expedient. Secs. 184, 185, 186. A new meridional township exterior is normally the governing boundary of the township to the west, and a new latitudinal township exterior is normally the governing boundary of the township to the north; any new boundary should therefore be established with full consideration for its control upon the subdivisional surveys thereafter to be executed.

**151.** Whenever practicable the township exteriors will be surveyed successively through a quadrangle in ranges of townships, beginning with the townships on the south. The meridional boundaries of the townships will have precedence in the order of survey and will be run from south to north on true meridians; quarter-section and section corners will be established alternately at intervals of 40 chains, and meander corners at the intersection of the line with all meanderable bodies of water; a temporary township corner will be set a distance of 480 chains, pending a determination of the controlling factor upon which its final position will be governed, whereupon the temporary point will be replaced by a permanent corner in proper latitudinal position. The latitudinal township boundary will be run first as a random line, setting temporary corners, on a cardinal course, from the old toward the new meridional boundary, and corrected back on a true line if ideal conditions are found to obtain. Where both meridional boundaries are new lines or where both have been previously established, the random latitudinal boundary will be run from east to west. In either case, if

Fig. 17.


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

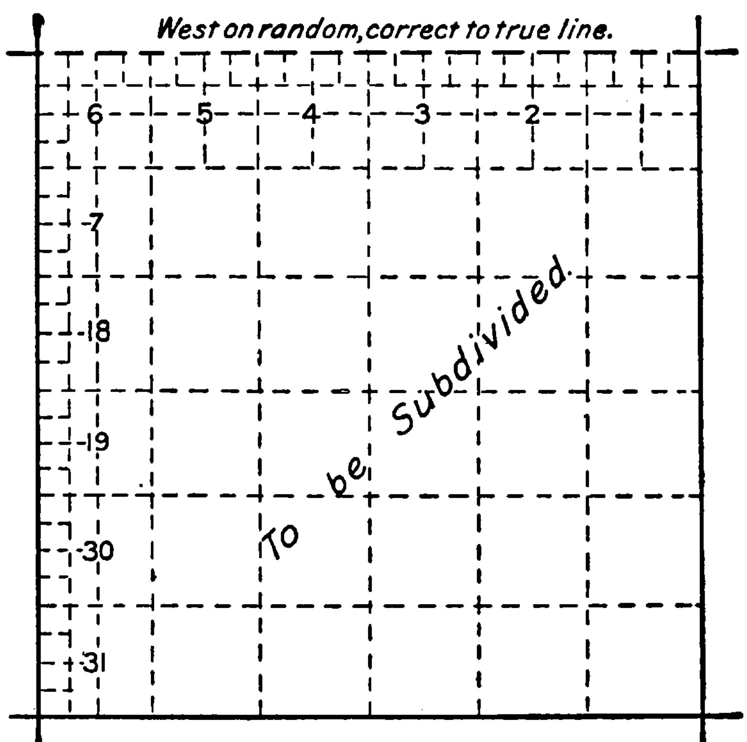
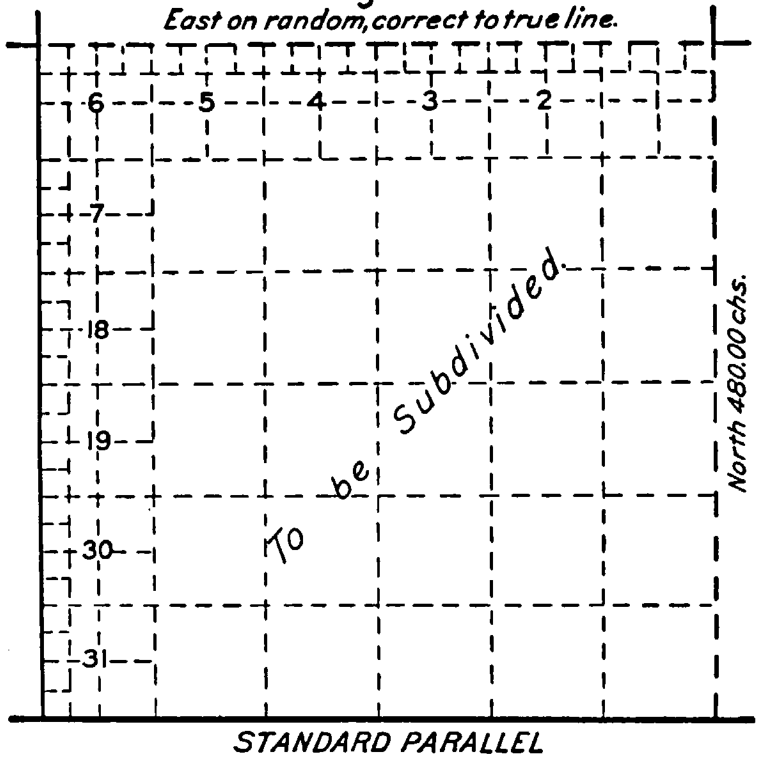

West on random, correct to true line.
6
5
4
3
2
7
18
19
30
31
To be Subdivided.

Fig. 18.

Fig. 19.


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

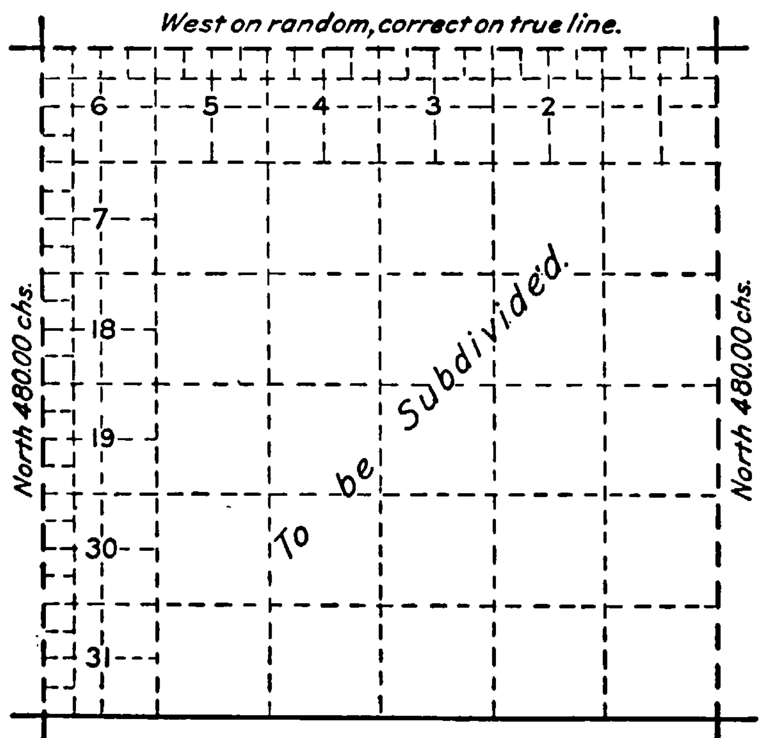
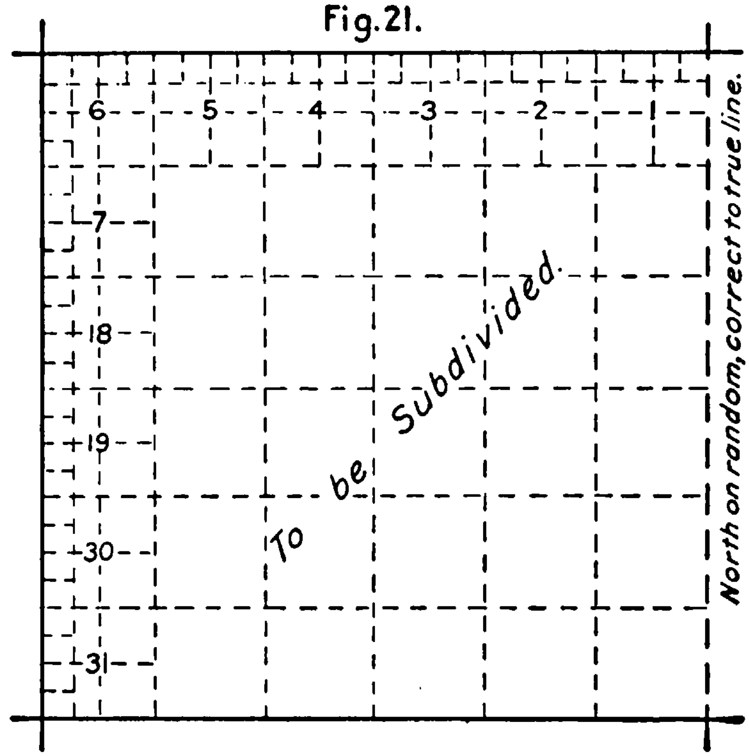

West on random, correct on true line.
6
5
4
3
2
7
18
19
30
31
To be Subdivided.
North 480.00 chs.
North 480.00 chs.

Fig. 20.

Fig. 21.




STANDARD PARALLEL

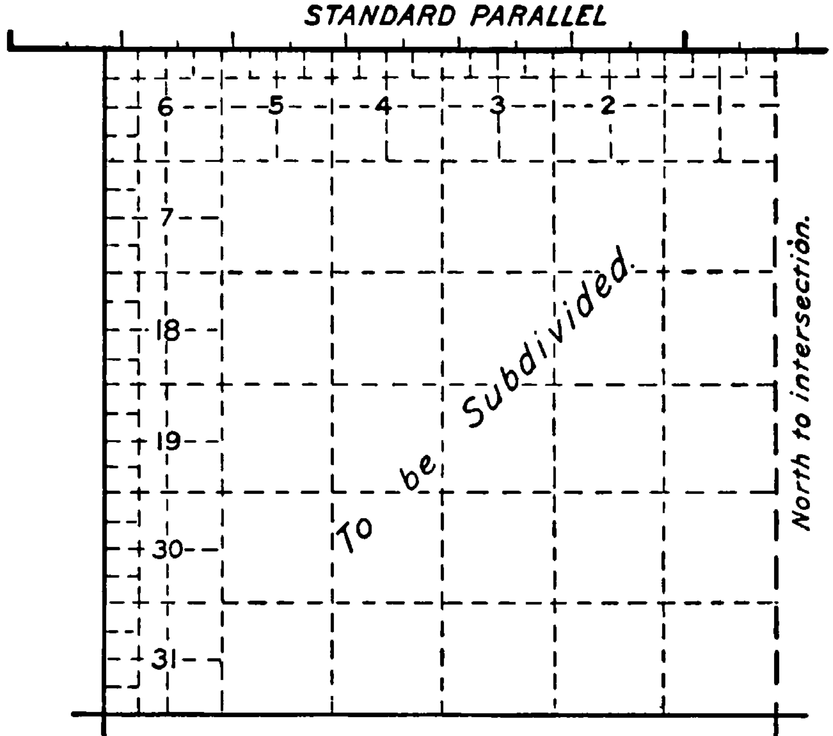



Fig. 22.

defective conditions are not encountered, the random line will be corrected back on a true line, upon which will be established regular quarter-section and section corners at intervals of 40 chains, alternately, counting from the east, and meander corners at the intersection of the true line with all meanderable bodies of water. The bearing of the true line will be calculated on the basis of the falling of the random, and the fractional measurement will be placed in the west half mile. A meridional township exterior will be terminated at the point of its intersection with a standard parallel, placing the excess or deficiency in measurement in the northernmost half mile. At the point of intersection of the meridional boundary with a standard parallel a closing township corner will be established; the parallel will be retraced between the first standard corners east and west of the point for the closing corner, in order to determine the exact alinement of the line closed upon, and the distance will be measured and recorded to the nearest corner on said standard parallel. Section 544.

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

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

**154.** The field notes will embrace a full and complete record of the manner in which the township exteriors are run and established. The field tablets will record all details, including the direction of the projection of the random latitudinal curve, the amount of the falling [1] left or right of the objective township corner, and the calculated return course or true line. The field notes will contain a prefacing statement that random lines are omitted except where necessary to record offsets, triangulations, stadia measurements, and important observations. The details of such measurements will be shown in

[1] The falling is the distance on the normal by which a line falls to the right or left of a corner on which the random line was intended to close.

the field notes only in those cases where the ground cannot be, or has not been, measured with the steel tape or where the line passes over corner points without monumentation. Section 544.

## Irregular Order and Partial Surveys

**155.** As the remaining unsurveyed public lands are found to contain less and less extensive areas it becomes necessary to depart from the ideal procedure in order more directly to reach the areas authorized for survey. The many possible combinations are entirely too numerous to state in detail, but where an irregular order appears to be necessary such departure from the ideal order of survey will be specifically outlined in the written special instructions. Such departure should always be based on the principle of accomplishing, by whatever plan, the same relation of one township boundary to another as would have resulted from regular establishment under ideal conditions.

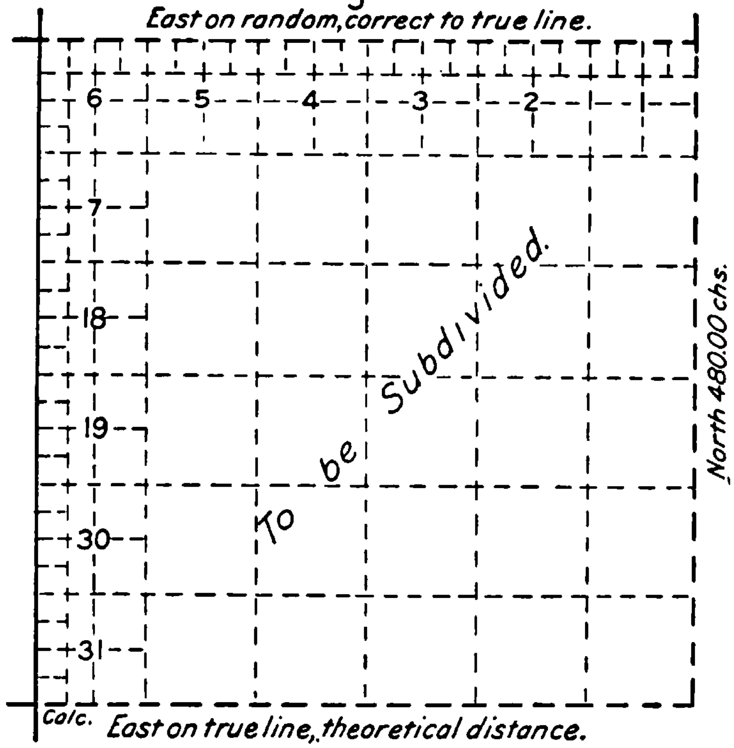
Where causes operate to prevent the establishment of the boundaries in full it is not imperative that the survey of the exterior lines be completed; under such conditions it may be found necessary to run section lines as offsets to township exteriors and such section lines will be run either on cardinal courses or parallel to the governing boundaries of such townships, or even established when subdividing, as existing conditions may require.

## General Exceptions

**156.** The above rules accord with former practice, except that in certain instances the random latitudinal boundaries will be run from west to east, instead of invariably from east to west, as heretofore required. It is also deemed advisable to incorporate other exceptions which will lessen the difficulties of subdivisional surveys frequently experienced in the past.

It is especially desirable that the alinement of a new latitudinal boundary (which becomes the governing south boundary of the township to the north) shall not depart more than 14′ from the true cardinal course; therefore the random line, run upon the cardinal course, may be made the true line where the falling would require a correction exceeding 14′ of arc. Where the random latitudinal boundary thus closes on a *new* meridional exterior the temporary township corner may be adjusted to the latitude of the opposite township corner; but where both meridional boundaries have been previously surveyed a closing township corner will be established at the point of intersection of the random latitudinal line with the meridional boundary, or its projection to the north or south as the case may be.

Fig. 23.


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

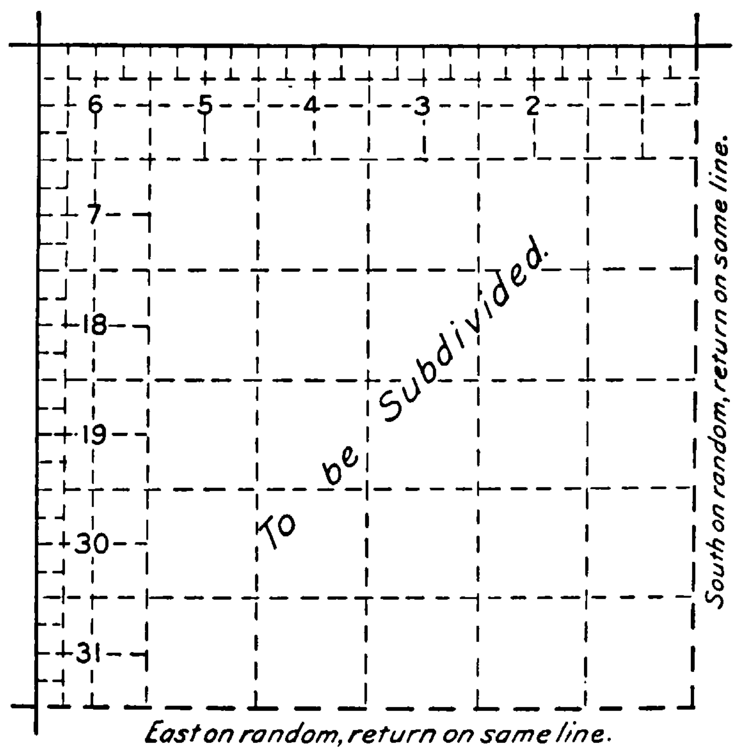
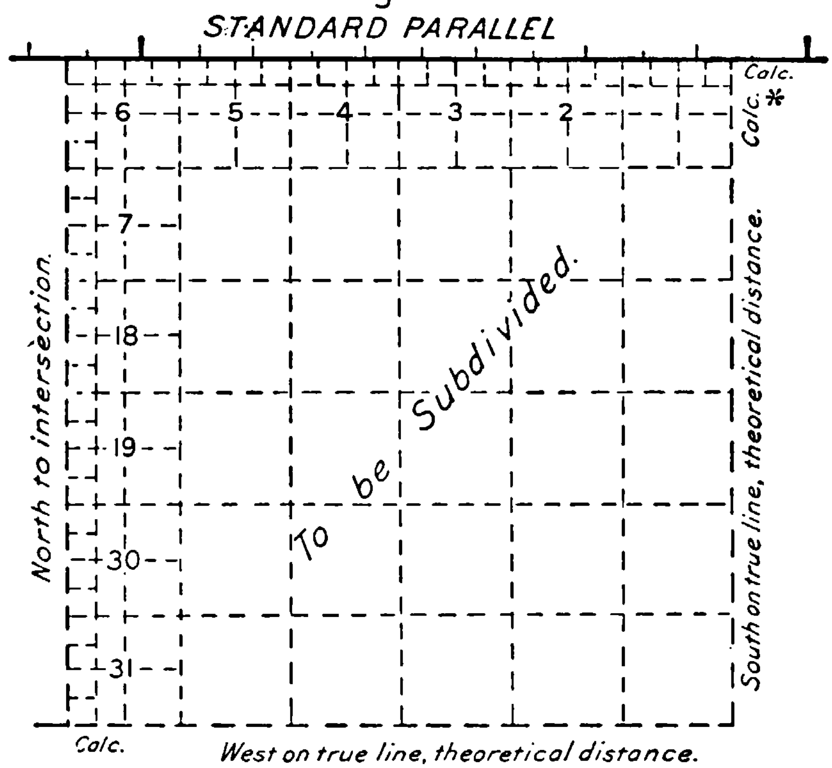

6
5
4
3
2
7
18
19
30
31
To be Subdivided.
South on random, return on same line.
East on random, return on same line.

Fig. 24.

Fig. 25.




* Exteriors initiated at a theoretical point for a closing corner.

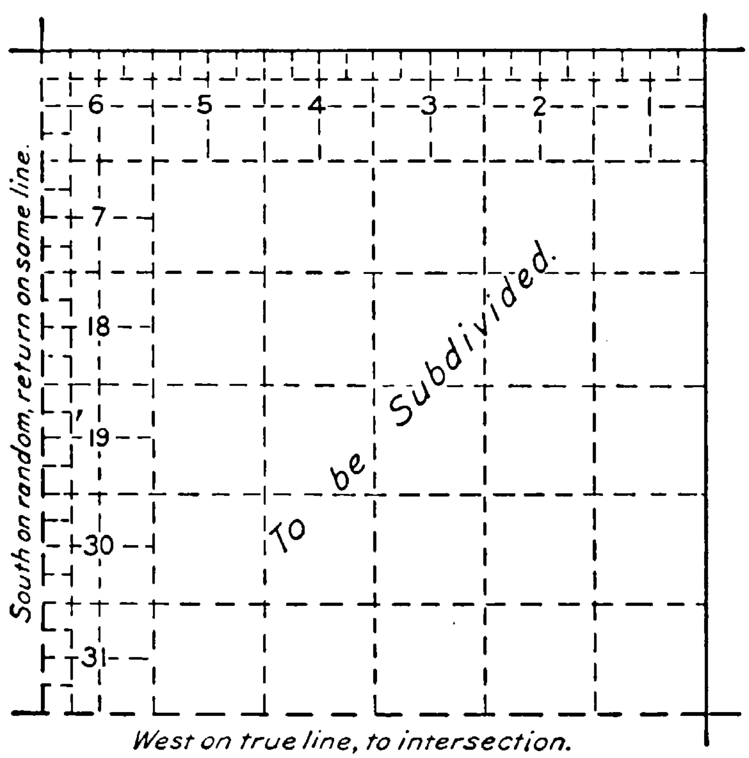
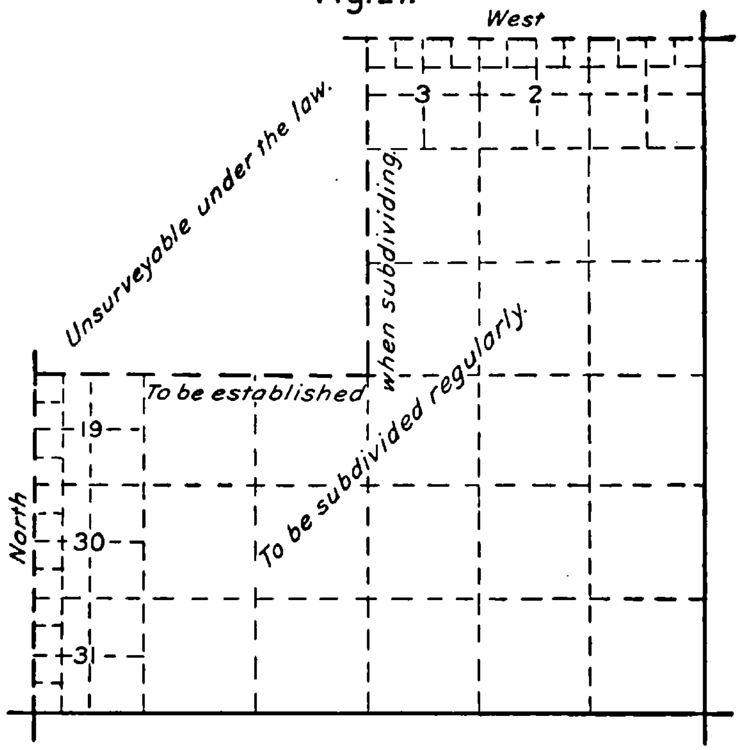



Fig. 26.

Fig. 27.


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

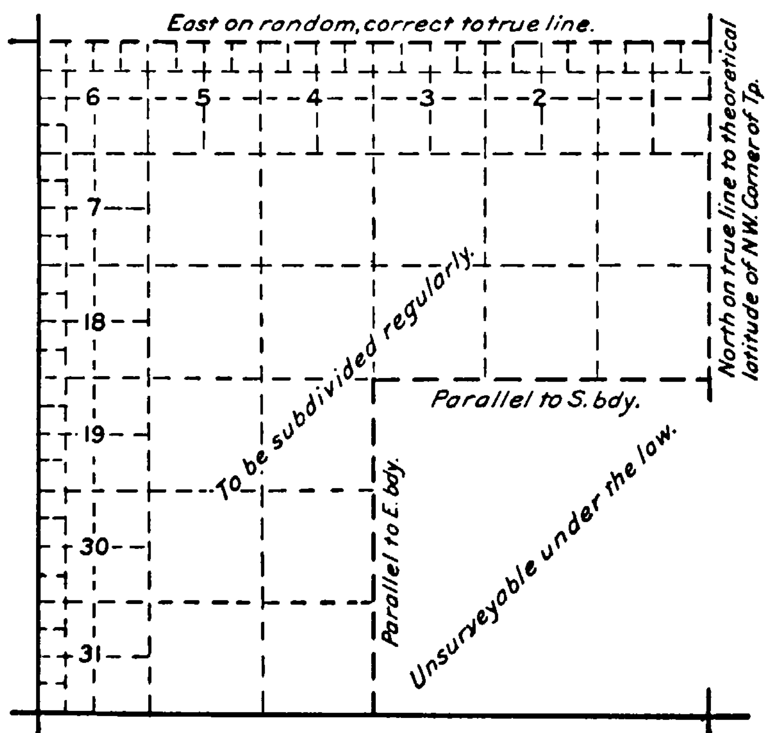
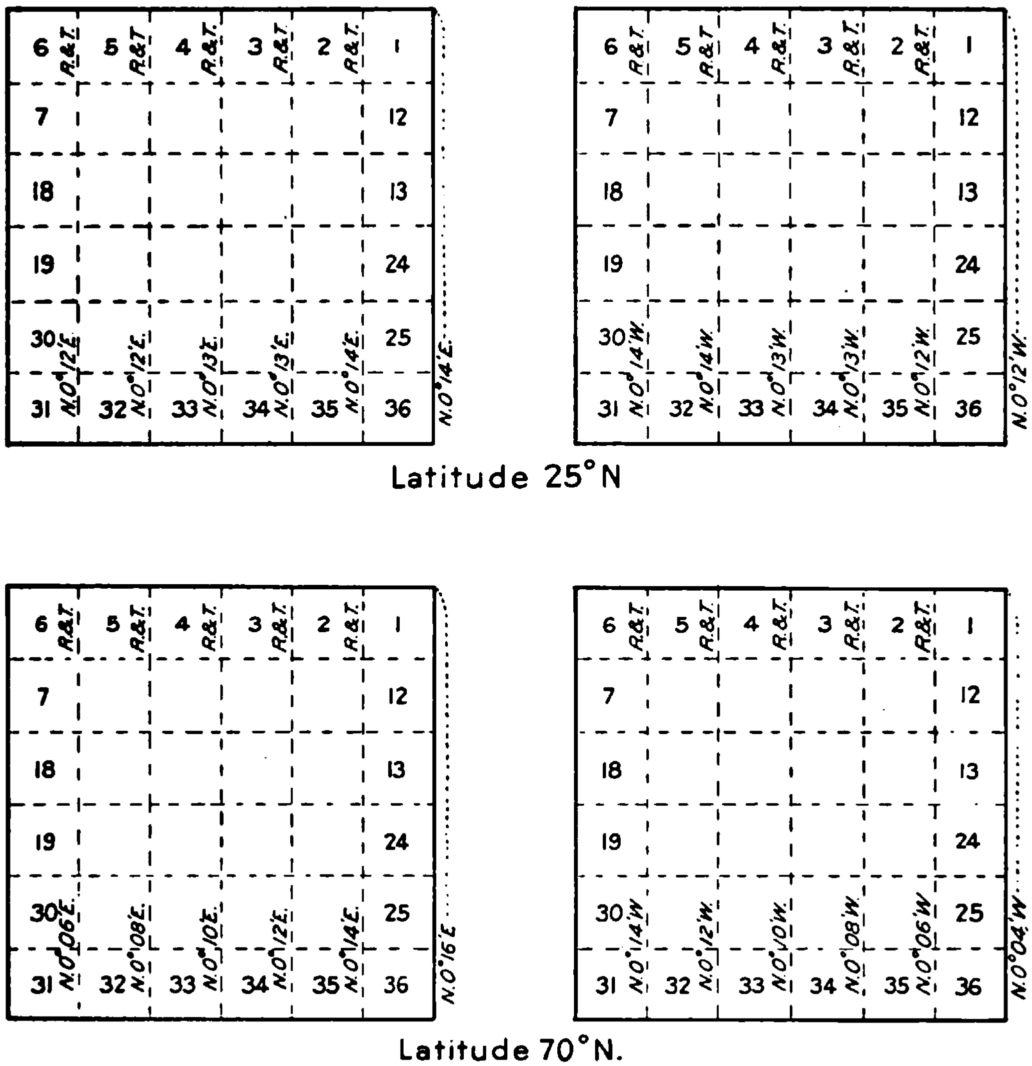

East on random, correct to true line.
6
5
4
3
2
7
18
19
30
31
To be subdivided regularly.
Parallel to S. bdy.
Parallel to E. bdy.
Unsurveyable under the law.
North on true line to theoretical latitude of N.W. Corner of Tp.

Fig. 28.

Likewise, where a meridional boundary is run as a random, the random will be made the true line if the adjustment for falling plus the usual correction to secure parallelism of the meridional sub-

Fig. 29




Illustrating the adjustment in the direction of the meridional lines of a subdivisional survey on account of convergency of meridians, also the 14′ limit of the rectangular "safety zone."

divisional lines (on account of convergency of meridians) would result in calculated bearings (in the northernmost miles of the latter lines) in excess of 14′ from cardinal. This margin for the alinement of the random and true meridional lines of the subdivisional survey calls for a governing east boundary whose bearing will fall within certain extremes suited to the latitude of the township, as for example (see second part of table 2, Standard Field Tables):

*Latitude 25° N.*

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

*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 | N. 0°16′ E. | E. bdy. may be | N. 0°04′ W. |

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

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

## Completion of Partially Surveyed Exteriors

**158.** Where the end portions of a township exterior have been previously surveyed and closed upon, the fractional unsurveyed middle part will be completed by random and true line, without offset regardless of the deviation from cardinal; the fractional measurements will be placed as a general rule in the north and west half miles, thereby permitting the subdivisional lines to be extended as usual from the south to the north and from the east to the west. In the case of a fractional part of an exterior remaining unsurveyed at either end of the line, the boundary will be completed by random line, initiated at the previously established terminal monument, which will be projected on a cardinal course in the direction of the objective township corner. The random will be corrected to a true line where the calculated bearing of any subdivisional line, governed by such exterior, comes within 14′ from cardinal, and the fractional

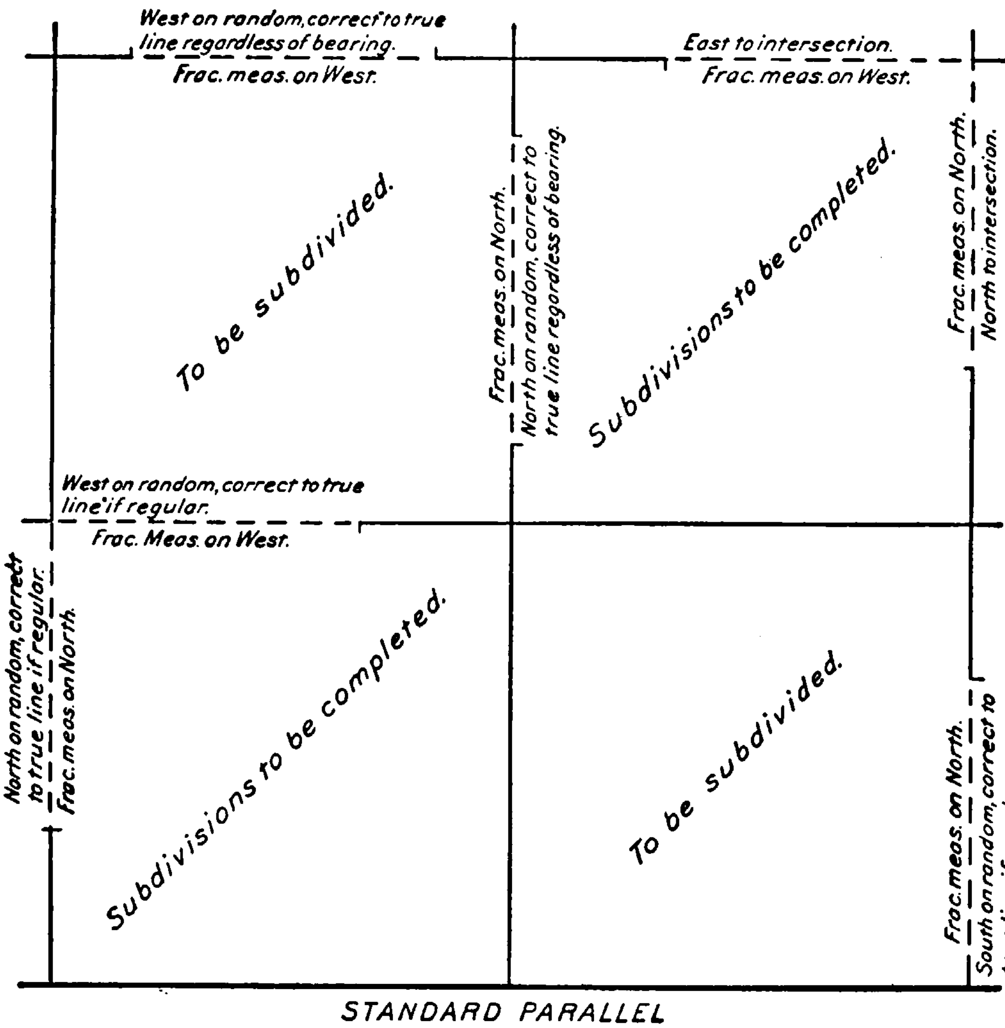



Fig. 30.

measurement will be placed generally in the north or west half miles. However, should irregularity be developed, or in the absence of a previously established objective township corner, the partially surveyed exteriors will be completed on cardinal courses beginning as above; and in either case the fractional measurements will generally be placed in the north and west half miles.

## Retracement and Resurveys Before Subdividing

**159.** If any part or all of the boundaries of a township which is to be subdivided have been previously surveyed, and the regional or public survey office has reason to question the accuracy of any portion of such exteriors, or the condition of the corner monuments thereon, the fact will be stated in the written special instructions, and the engineer will be authorized and required, as a condition precedent to beginning the subdivisional survey of such township to retrace such boundaries to verify the direction and length of lines and to identify the monuments of the prior survey, and to resurvey all or such portion of the boundaries as may be found necessary to accomplish the following purposes:

(*a*) To reestablish missing corners, (*b*) to remonument dilapidated corners, (*c*) to determine the direction and length of all lines, (*d*) to furnish all data necessary for the computation of the areas of all fractional lots, and (*e*) to provide a basis for an improved plan of the subdivision of the township. (Definitions of retracement and resurvey, sec. 387.)

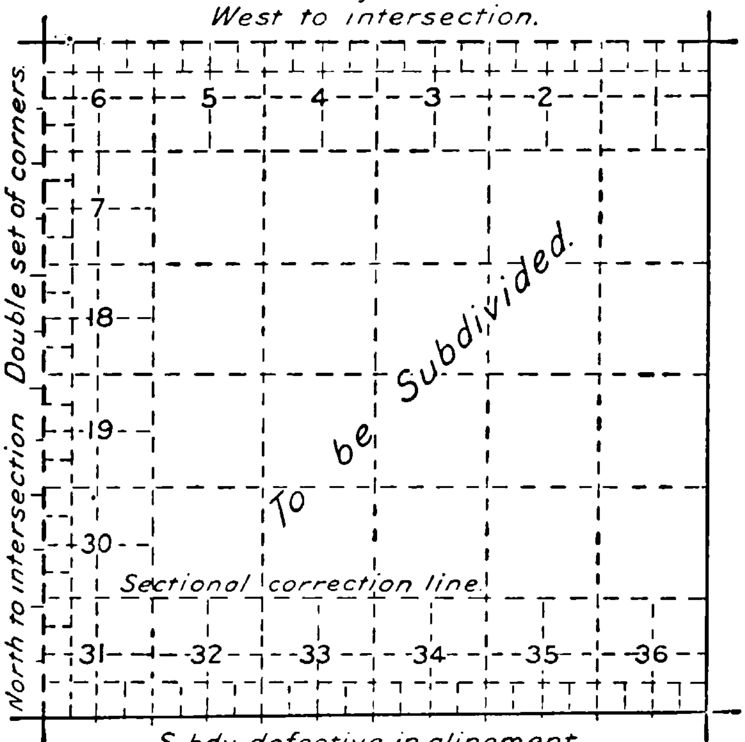
The retracements and resurveys as above will afford the data for a computation of the *total* coordinate latitude and departure of each and every previously established exterior corner, and a preliminary platting of their positions, all referred to a selected origin such as the southeast corner of the township. These will then be the basis for the required studies under the sections to follow.

**160.** All resurvey data will be embodied in the field notes and shown upon the plat of the survey. If the retracement results are substantially in agreement with the record of the original surveys, a general statement to that effect will be made in the field notes, and the original record will govern the data to be placed upon the plat.

## Rectangular Limits

**161.** Before approaching the subject of "subdivision of townships" it is necessary to consider the requirement of law relative to rectangular surveys, wherein the square mile, or section, is the unit of subdivision. The normal township will include 36 sections in all, 25 of which are returned as containing 640 acres each; 10 sections (on the north and west boundaries) each contain regular aliquot parts totaling 480 acres with 4 additional fractional lots in each section, each lot containing 40 acres plus or minus definite differences to be determined in the survey; and, section 6 containing regular aliquot parts totaling 360 acres with 7 additional fractional lots each containing 40 acres plus or minus certain definite differences to be determined in the survey, all as contemplated by law.

Fig. 31.



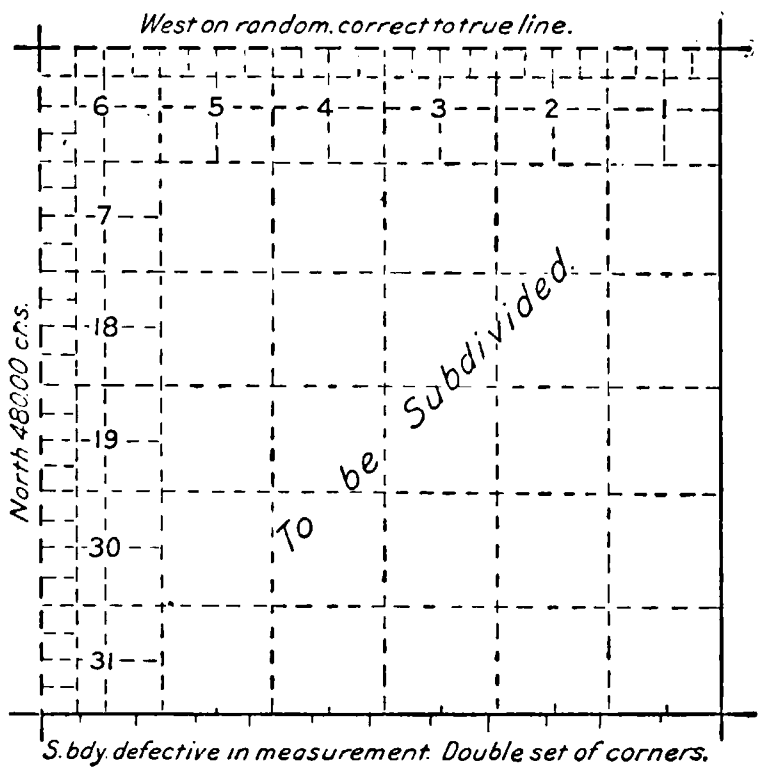




Fig. 32.



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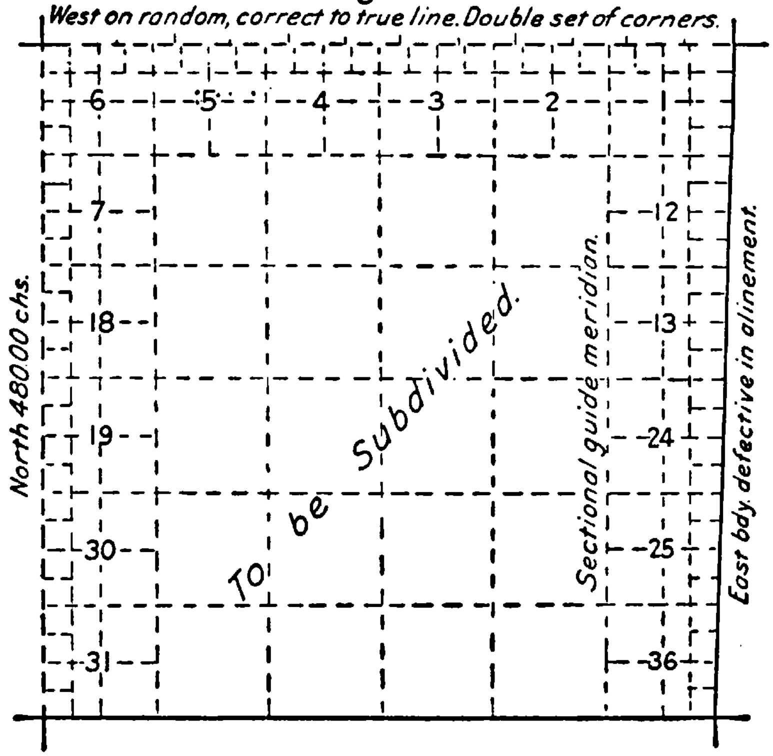
Fig. 33.


West on random, correct to true line. Double set of corners.
6
5
4
3
2
1
7
12
18
13
19
24
30
25
31
36
North 480.00 chs.
To be Subdivided.
Sectional guide meridian.
East bdy. defective in alinement.

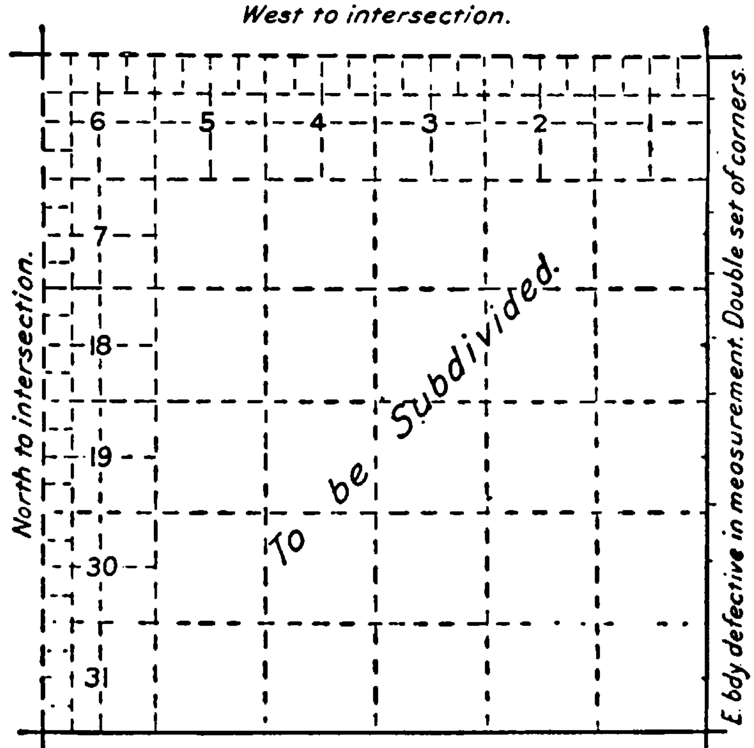

West to intersection.
6
5
4
3
2
1
7
18
19
30
31
North to intersection.
To be Subdivided.
E. bdy. defective in measurement. Double set of corners.

Fig. 34.

**162.** In the administration of the surveying laws it has been necessary to establish a definite relation between rectangularity (square miles of 640 acres, or aliquot parts thereof), as contemplated by law, and the resulting unit of subdivision consequent upon the practical application of surveying theory to the marking out of the lines on the earth's surface, wherein the ideal section is allowed to give way to one which may be termed "regular." Such relation, as applied to the boundaries of a section, has been placed at the following limits:

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

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

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

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

## Rectification of Defective Exteriors Before Subdividing and Method of Establishing New Governing Boundaries Where the Previously Surveyed Exteriors are Found to be Defective

**163.** Where subdivisional lines have been initiated from or closed upon an exterior prior to the subdivision of the adjoining township, the alinement of the exterior cannot be changed. A defective boundary not so closed upon may be obliterated after independently resurveying a new boundary and connecting the old with the new monuments. If known that a mineral survey, forest-homestead or small holding claim, railroad or canal right of way, reservoir site, etc., has been connected with any corner of an exterior subject to rectification, the fact will be specifically stated in the written special instructions, and in case the exterior is found to be defective, the cadastral engineer will add the letters "AM" (signifying "amended monument") to the markings of the original monument and accurately connect the old monument by course and distance with the new monument. A complete record of the connection from the new to the amended monument and a full description of the latter including the new markings and accessories will be included in the field notes, and where a special purpose is to be served the position of the old monument will be shown on the plat of the survey. Sections 258, 459.

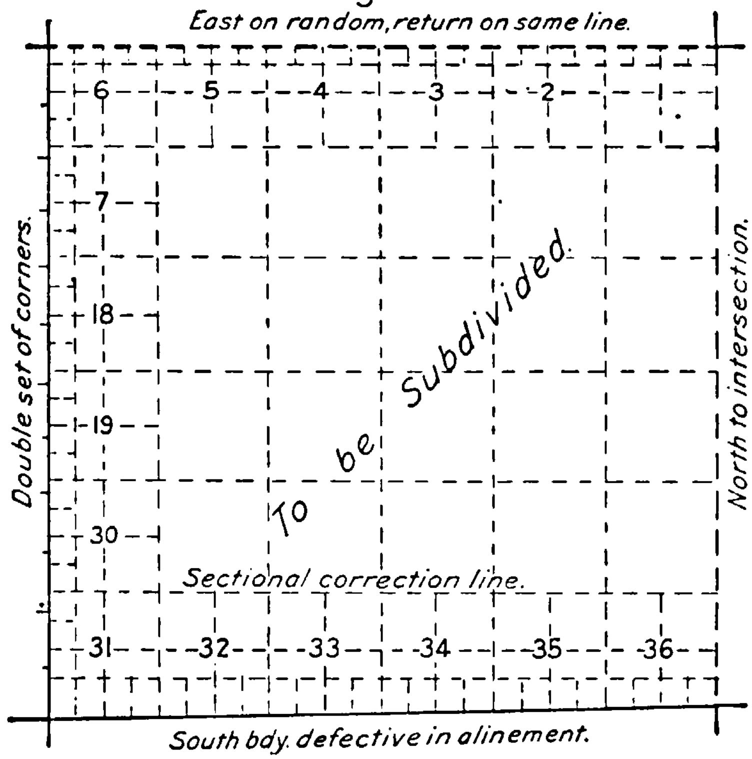
**164.** If a boundary is defective in measurement or position and is not subject to rectification, the location of the original corners will not be changed, but the marks on the monuments, and the marks upon or position of the accessories, may be appropriately altered to stand only for the sections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

**165.** Where subdivisional lines have been initiated from or closed upon one side of a portion of a township boundary prior to the subdivision of the township on the opposite side, while upon the remaining portion of the same such conditions do not interfere, said remaining portion may be obliterated, if found defective, whereupon a new line will be projected in accordance with regular independent resurvey methods.

**166.** The position of the new exteriors, or of new corners on defective township boundaries must be established by an actual rerunning of such lines; the data acquired in surveying subdivisional lines closing upon defective exteriors cannot be accepted in lieu of such retracement or resurvey.

**167.** Instances will occur both in closing subdivisional surveys upon regular exteriors and in the retracement of defective boundaries not subject to rectification where it will be developed that the original monuments have become lost or obliterated, or where such corner monuments may be identified in an advanced state of deterioration. All such exterior corners will be reestablished and remonumented in their correct original positions in strict accordance with the provisions of chapters IV and V, and a complete record thereof will be embodied in the field notes.

Fig. 35.


East on random, return on same line.
Double set of corners.
North to intersection.
6
5
4
3
2
1
7
18
19
30
To be Subdivided.
Sectional correction line.
31
32
33
34
35
36
South bdy. defective in alinement.

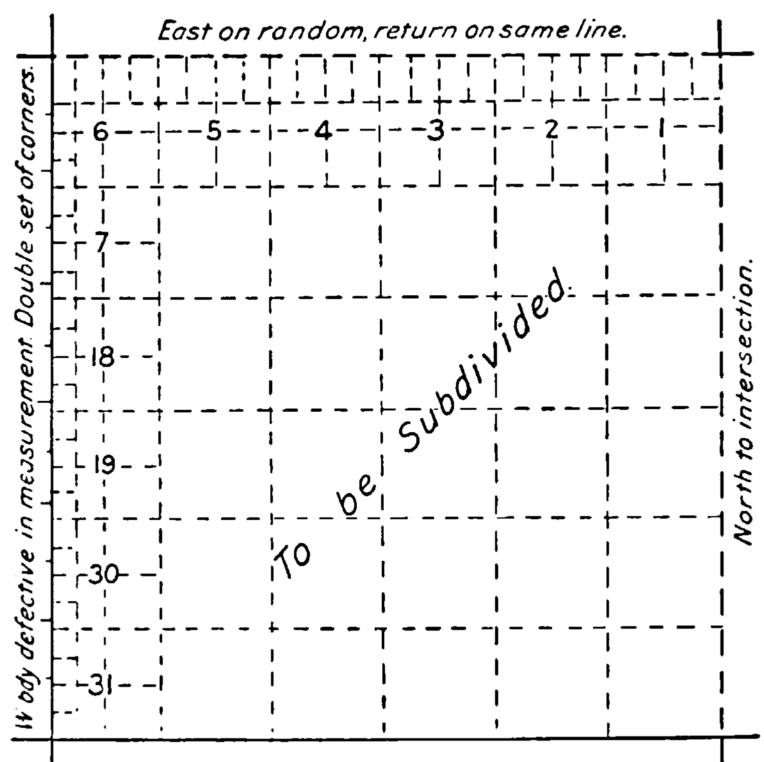
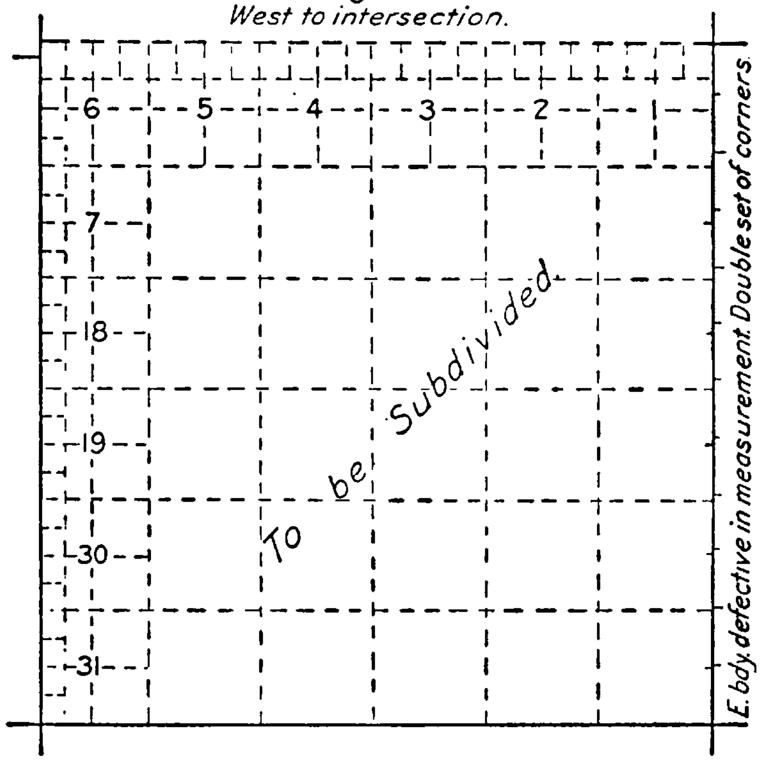

East on random, return on same line.
W. bdy defective in measurement. Double set of corners.
North to intersection.
6
5
4
3
2
1
7
18
19
30
31
To be Subdivided.

Fig 36.

Fig. 37.


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

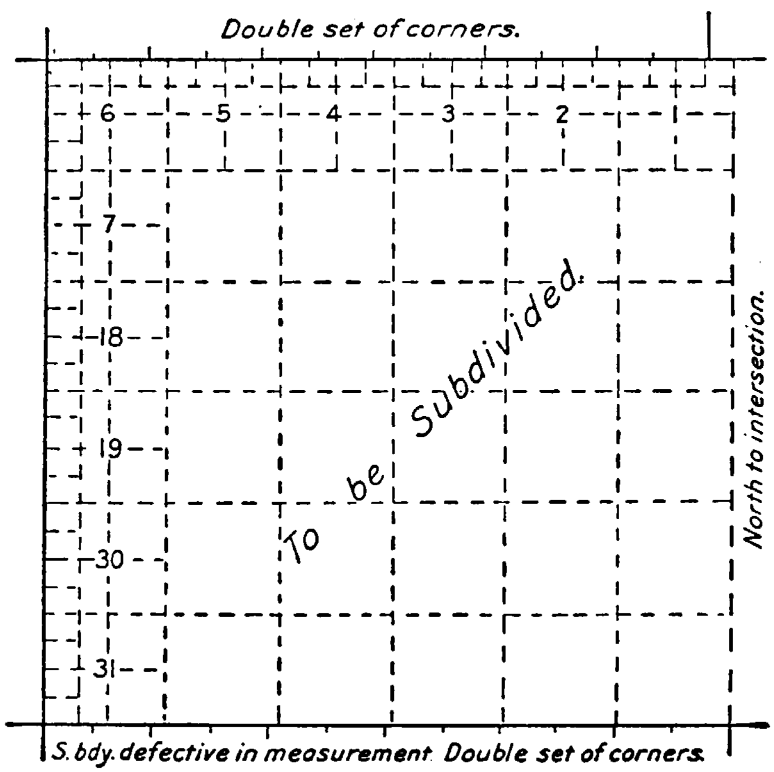

Double set of corners.
6
5
4
3
2
7
18
19
30
31
To be Subdivided.
North to intersection.
S. bdy. defective in measurement. Double set of corners.

Fig. 38.

**168.** The south boundary of a township is regularly the governing latitudinal boundary and will be used as such unless defective in alinement; if defective in measurement, and not subject to rectification, the position of the original corners will not be changed, but the marks on the monuments and the accessories will be appropriately altered to stand only for the sections of the township to the south; new corners of two sections and quarter-section corners common to the sections of the township to the north will be established at regular intervals of 40 chains, counting from the east, and the excess or deficiency in measurement placed in the west half mile. If the south boundary is defective in alinement, a sectional correction line will be required.

**169.** The east boundary of a township is regularly the governing meridional boundary and will be used as such unless defective in alinement; if defective in measurement, and not subject to rectifi-

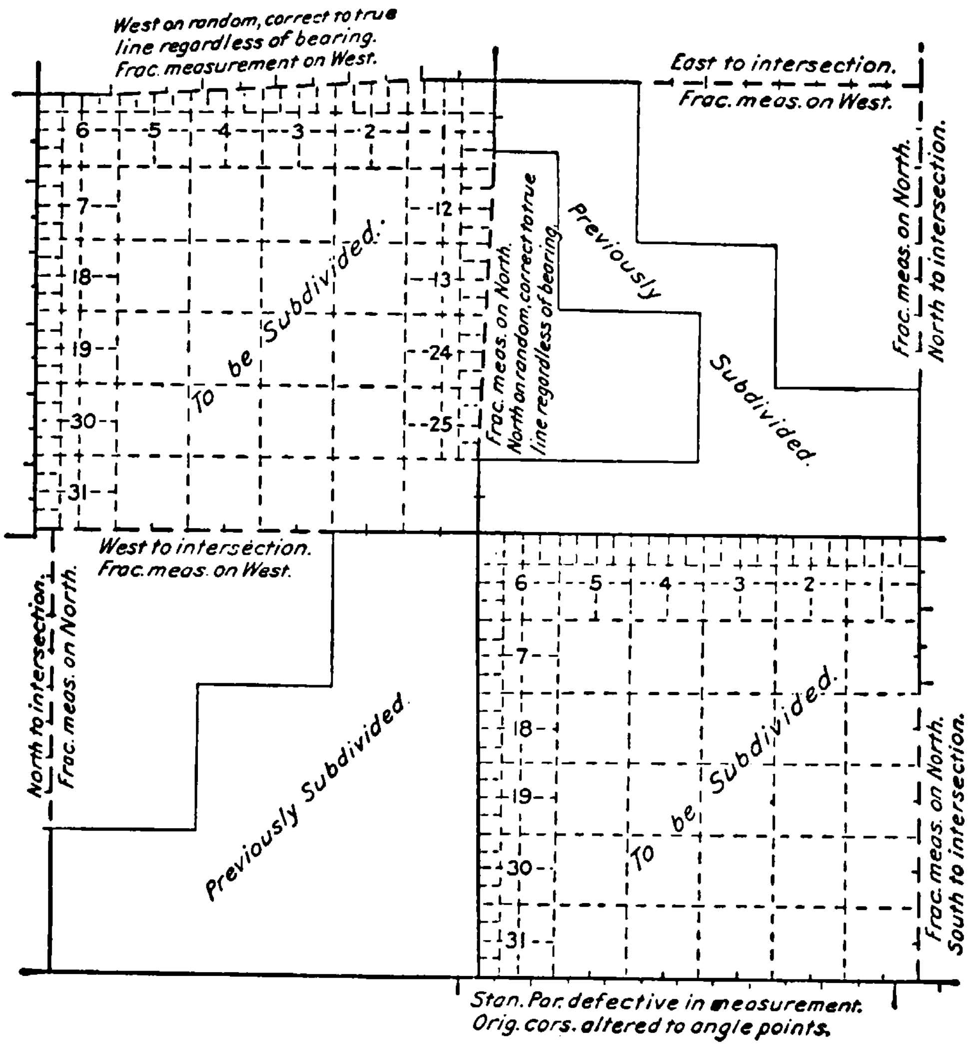



Fig. 39.

cation, the position of the original corners will not be changed, but the marks on the monuments and the accessories will be appropriately altered to stand only for the sections of the township to the east; new corners of two sections and quarter-section corners common to the sections of the township to the west will be established at regular intervals of 40 chains, counting from the south. If the east boundary is defective in alinement a sectional guide meridian will be required.

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

**171.** New east and south boundaries of a township become the closing meridional and latitudinal boundaries of the townships to the east and south, respectively, and where by peculiar necessity the ideal plan must be modified and doubt exists as to how unsurveyed lines may close upon same, the corners thereon may be established common only to the sections of the township of which the new lines are the governing boundaries. The corners appropriate to the sections upon the opposite side will be duly established as closing corners at the time of the survey of the subdivisional lines of the adjoining townships if the original corners are then found to be defective in position, and where regular connections can be made the marks upon the original corner monuments will be appropriately altered to corners of maximum control.

**172.** Where the previously established north or west boundaries are found to be defective in measurement or position and subdivisional surveys in the adjoining townships have been initiated upon the same, thereby preventing rectification, the marks upon the original corner monuments will be appropriately altered to corners of two sections and quarter-section corners common only to the sections of the townships to the north or west, respectively. Closing section corners will be established when subdividing and the distance measured to an original corner; new quarter-section corners, common to the sections of the township which is being subdivided, will be placed on the old line at the mean distances between the closing section corners, or at 40 chains from one direction, depending upon the plan of the subdivision of the section. Where such previously established north and west boundaries are defective in alinement, but not in measurement or position, no changes are required, and the section lines of the township which is being subdivided will be connected regularly to the original corners; the resulting fractional measurements will be placed uniformly in the north and west half miles.

**173.** The diagrams which accompany the text illustrate the guiding principles involved in the method of establishing new governing boundaries where the previously surveyed exteriors are found to be defective. Each diagram illustrates a simple condition affecting one boundary only, and the examples are taken only from the regular order of procedure. Combinations of two or more of the simple defective conditions are best solved by an analysis of the complex problem into its several parts of simple defective conditions. The same statement is applicable to the solution of complex defective conditions encountered in the establishment of township exteriors under an irregular order of procedure. The engineer will be expected to exercise skill and judgment in dealing with similar field problems, but where extraordinary conditions are encountered which will not admit of analysis and solution in harmony with the principles herein set forth he will report the facts to the proper administrative office which will issue appropriate instructions.

The rules set up in sections 163 to 173, inclusive, relating to the completion and rectification of township exteriors before subdividing are intended to secure the most direct return to normal procedure in those cases where these rules must be invoked. The preliminary retracements and the resurveys that are provided for may show that some modification will secure better results, this can be effected upon consideration of the problem, and approval of the plan by the proper administrative office. Each case should be treated on its own merits.

## Tables of Latitudes and Departures and Closing Errors

**174.** Upon the completion of the survey of one or more township exteriors closing the figure of either a full or fractional township, a table of latitudes and departures and closing errors will be prepared, wherein due allowance for convergency of meridians will be introduced. The closing errors will furnish an immediate guide to the accuracy of the lines included in the table and, in case the limit of closure ($\frac{1}{640}$ of the perimeter, in either latitude or departure) is exceeded, will serve to show what additional retracements or other corrective steps may be necessary in order to perfect the survey before leaving the field. The table of latitudes and departures and closing errors, including every part of any closed figure embracing township exteriors, based upon final field determination after all necessary retracements and final true lines have been completed, will be filed with the field tablets and computation sheets. The general subject of "limits of closure" will be amplified hereinafter. Section 234.

## SUBDIVISION OF TOWNSHIPS

### Regular Boundaries

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

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

**177.** The subdivision of a township may proceed in the normal order, where the above conditions are satisfied, as follows:

The meridional section lines will be initiated at the regularly established section corners on the south boundary of the township and will be run from south to north parallel to the governing east boundary, or, in case the east boundary is within limits, but has been found by retracement to be imperfect in alinement, the meridional section lines will be run parallel to the mean course of such east boundary. Regular quarter-section and section corners will be established alternately at intervals of 40 chains, as far as the northernmost interior section corner. The last miles of the meridional section lines will be continued as random lines without blazing through timber, each successive line being run parallel to the true east boundary of the section to which it belongs; a temporary quarter-section corner will be set at 40 chains, the distances will be measured to the points of intersection of the random lines with the north boundary of the township, and the fallings of the random lines east or west of the objective section corners will be noted. The randoms will then be corrected to true lines by returning to accomplish the required blazing through timber and markings between the section corners, including the permanent establishment of the quarter-section corners on the true lines at distances of 40 chains from the south, thus placing the fractional measurements in the north half miles. The bearings of the true lines will be calculated on the basis of the fallings of the randoms (table 3, Standard Field Tables). Where the north boundary of the township is a base line or standard parallel, the last miles of the meridional section lines will be continued as true lines parallel to the east boundary of the township, setting permanent quarter-section corners at 40 chains from the south and closing section corners at the points of intersection of the several lines with the base, standard, or correction line, where the distances will be measured to the nearest corners on said line; and new quarter-section corners, common to the sections of the township which is being subdivided, will be placed on the base line or standard parallel at the mean distances between the closing section corners, or at 40 chains from one direction, depending on the plan of the subdivision of the section. The adjustment of the bearing of all meridional section lines on account of convergency of meridians has already been explained in chapter II. Sections 129, 130, 131.

**178.** The latitudinal section lines, except in the west range of sections, will normally be run without blazing through timber from west to east on random lines parallel to the south boundaries of the respective sections, setting temporary quarter-section corners at 40 chains; the distances will be measured to the points of intersection of the random lines with the north and south lines passing through the objective section corners, and the fallings of the random lines north or south of said corners will be noted. Each random will be corrected to a true line by returning to accomplish the required blazing and marking between the section corners, including the permanent establishment of quarter-section corners at the *mid-points* on the true lines. The bearings of the true lines will be calculated on the basis of the fallings of the randoms (see Table 3, Standard Field Tables). In the west range of sections the random latitudinal section lines will be run from east to west, parallel to the south boundaries of the respective sections, and on the true lines the permanent quarter-section corners will be established at 40 chains from the east, thus placing the fractional measurements in the west half miles. Section 544.

**179.** Meander corners will be established at the points of intersection of the several true lines with all meanderable bodies of water.

**180.** The meridional section lines will have precedence in the order of execution, and these will be surveyed successively, beginning with the first meridional section line counting from the east. A meridional section line will not be continued beyond a section corner until after the connecting latitudinal section line has been surveyed, and in the case of the fifth meridional section line, both latitudinal section lines connecting east and west will be surveyed before continuing with the meridional line beyond a section corner. The successive meridional lines may be taken up at the convenience of the engineer at any time in order as previously stated, but none will be carried beyond uncompleted sections to the east. The field notes will be compiled in ranges of sections beginning with the easternmost, and the west two ranges will be compiled by alternating with the adjoining east and west sections. The specimen field notes exemplify the usual order of survey and the prescribed method of arranging the field notes. Appendix VIII.

181. Thus the subdivisional survey will proceed in accordance with instructions prescribed in sections 177 to 180, inclusive.

The field notes will embrace a complete record of the manner in which the subdivisional lines are run and established, and will include a prefacing statement that random line field notes are omitted except where necessary to record offsets, triangulations, stadia measurements, and important observations. Such measurements will be recorded in the transcribed field notes only where the ground has not been, or cannot be measured with the steel tape, or where the line passes over corner points without monumentation. Section 544.

The field tablets will contain all details of the survey, including 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.

The system of rectangular surveys places every means at the disposal of the engineer by which he may accomplish accurate results, and provides amply for the adjustment of all reasonable closing errors. Thus, a slight error in the alinement of the meridional section lines is taken up in the measurement of the latitudinal lines which, in order to come within the rectangular limit, must be within 50 links of 80 chains in length, except in the west range of sections where the convergency of the meridional lines is regularly provided for; the accumulated error in alinement for the 5 miles of true meridional line is taken up in the sixth mile, which is run random and true; here the true line must be within 21′ of cardinal in order to come within the rectangular limit. The slight, ordinary errors in the measurement of the meridional section lines are taken up by the adjustment of the bearings of the latitudinal section lines which, in order to come within the rectangular limit, must be within 21′ of cardinal; the accumulated error in measurement in running north is placed in the last fractional half mile; here the meridional distance will be checked by a calculated closing around the last section, and the latitudinal error must not exceed 50 links (or $\frac{1}{640}$) in order to come within the usual limits of closure. The accuracy of the subdivisional survey will everywhere be tested by the usual rules for limits of closure, hereinafter described. The engineer should discriminate carefully between the limits for subdivision and limits of closure and note with due respect that whereas the latter may admit of differences as great as 50 links in any one section, the former are controlled by the limit of rectangularity and will be exceeded if the accumulative error is greater than 3½′ in alinement, or 8½ links per mile in measurement. The accumulative error must ever be guarded against and avoided, and the order of survey is arranged with a view to furnishing continuous checks upon the accuracy of all lines.

**182.** Any random subdivisional line may be run for distance only where the objective section corner is in sight, but the bearing will be recorded, and the usual rules for running random and true lines will be duly observed in every other respect. The random latitudinal section lines, except in the west range of sections, will normally be run from west to east, thus always closing upon a previously established section corner; but when under the exigencies of the field work, in order to economize the time of his party, the engineer may elect to project the random from east to west (always parallel to the south boundary of the section), a temporary section corner (if the permanent corner has not already been established) will be set at 80 chains, and the true point for the section corner will be determined as usual at

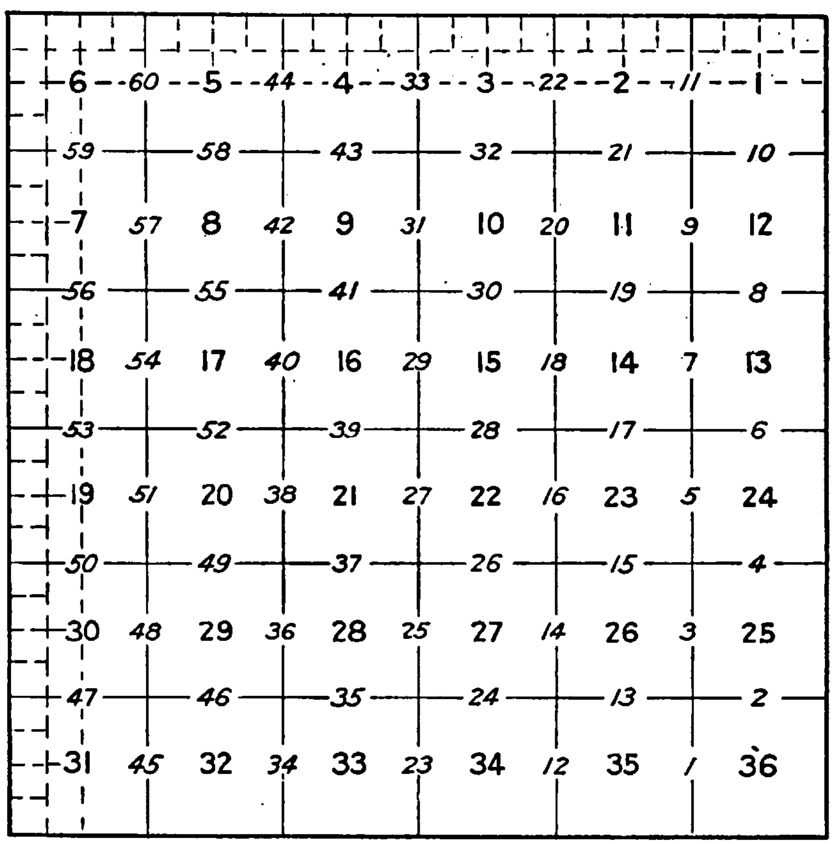



Fig.40.

FIGURE 40.—The numbers on the section lines indicate the normal order of subdivision and arrangement of the field notes.

the 80-chain point on the meridional section line, whereupon the connection of the random latitudinal line and the permanent marking of the true line will be completed as regularly provided. Examples of the authorized rules for running subdivisional lines will be found in the specimen field notes. Appendix VIII.

## Irregular Boundaries

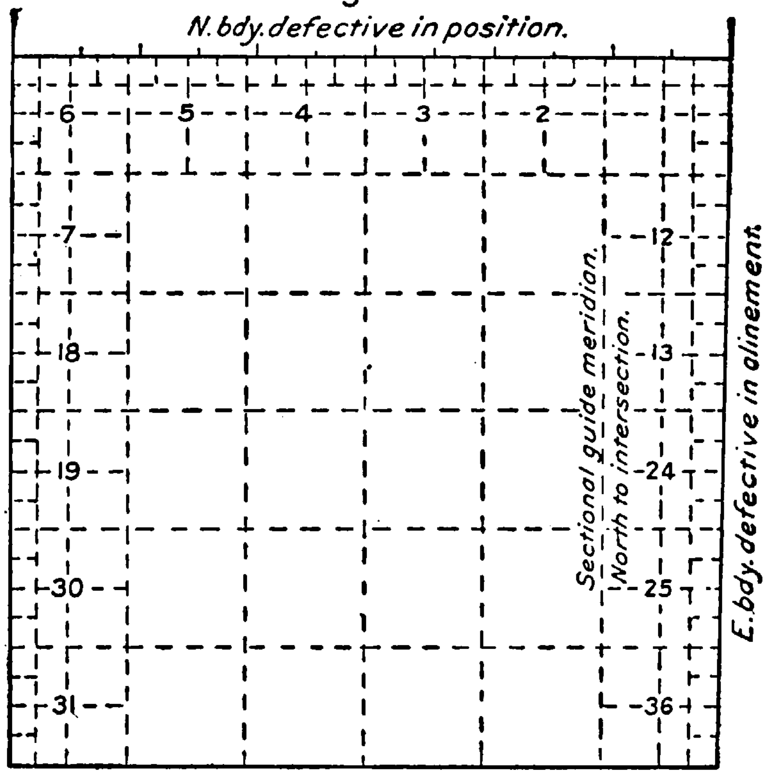
**183.** Where either of the governing boundaries of a township is disqualified as a controlling line upon which to initiate a subdivisional survey, the necessary retracements and resurveys or alterations will be accomplished before subdividing as previously explained under the subject of township exteriors; thus may be assured every possible provision for a correct subdivisional survey except as either the south or the east boundary may be defective in alinement and not subject to rectification.

The specific plan that is provided in secs. 184, 185, and 186, may be modified by the public survey office in those cases where due consideration has been given to the specific problem, and provision made for all basic requirements, and where the conditions present justify a change from the plan herein. The basic requirements are, adherence to the normal rectangular plan (sec. 8) where practicable; regard for the normal location and area of square miles of 640 acres each for the *granted lands* that are to be identified by the survey (the school sections); the maximum number of rectangular sections of 640 acres each, or aliquot parts thereof; avoiding two sets of corners when one set is ample for all needed subdivisional requirements; and, simplicity of survey, most readily understood by the public. The rules in these sections have no comparable application in the execution of those *resurveys* wherein prior rights have been acquired.

## Sectional Guide Meridian

**184.** If the east boundary of the township is defective in alinement, and can not be rectified, and the north boundary is thus made defective in position, the first meridional section line will be projected on a true meridian to an intersection with the north boundary of the township where a closing section corner will be established and the distance measured to the nearest regular corner. The intermediate quarter-section and section corners will be established alternately at regular intervals of 40 chains, counting from the south, unless the south boundary of the township is itself defective in alinement. Where the north boundary is not defective in position (nor within the danger zone) with reference to the section corners on the south boundary (by reason of the errors in the alinement of

Fig. 41.


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

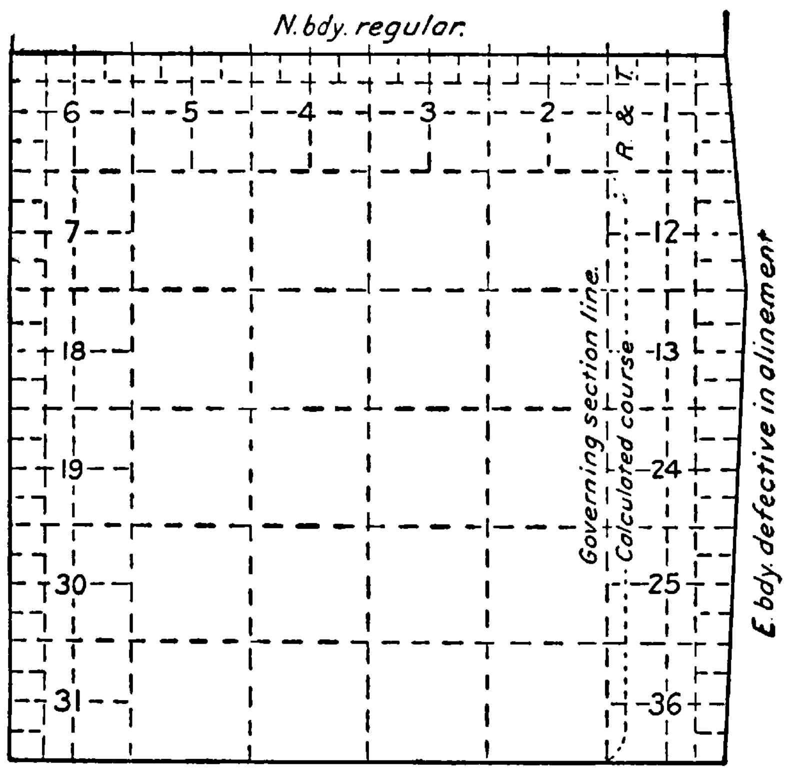

N. bdy. regular.
6
5
4
3
2
R. & T.
7
12
18
13
19
24
30
25
31
36
Governing section line.
Calculated course
E. bdy. defective in alinement.

Fig. 42.

the east boundary being compensating), the first meridional section line will be projected 5 miles as a true line on a bearing calculated to intersect the objective section corner on the north boundary, and the last mile will be run as a random line on the same course and corrected to a true line after the falling has been measured. The remaining meridional section lines will be run parallel to the one first established, in the usual manner, to closing section corners on the last mile or random and true as the case may be.

The fractional measurements of the latitudinal section lines in the first range of sections will be placed in the east half mile; elsewhere, unless the south boundary is defective in alinement, the latitudinal section lines will be run in the usual manner.

## Sectional Correction Line

**185.** If the south boundary of the township is defective in alinement, and can not be rectified, and the west boundary is thus made defective in position, a sectional correction line will be surveyed as a permanent line on a true latitudinal curve initiated at the first regular section corner on the east boundary and projected to an intersection with the west boundary of the township where a closing section corner will be established and the distance measured to the nearest regular corner. The intermediate quarter-section and section corners will be marked as temporary points at regular intervals of 40 chains, alternately, counting from the east. Where the west boundary is not defective in position (nor within the danger zone) with reference to the section corners on the east boundary (by reason of the errors in alinement of the south boundary being compensating), the first latitudinal section line will be projected 5 miles as a permanent line on a bearing calculated to intersect the objective section corner on the west boundary; temporary quarter-section and section corners will be marked at regular intervals of 40 chains, alternately, counting from the east.

The section corners on the sectional correction line will be established at the several points of intersection of the meridional section lines alined in the normal manner. Thereafter the quarter-section corners on the sectional correction line will be established at the usual mid-point positions except in the east and west ranges of sections. The quarter-section corner between secs. 25 and 36 will be established at 40 chains from the west if the east boundary is defective in alinement; otherwise it will be fixed at the usual mid-point position. The quarter-section corner between secs. 30 and 31 will be placed at 40 chains from the east, and if the sectional correction line has not been terminated at a closing section corner on the west boundary of the township (as previously provided), the line between secs. 30 and 31 will be run random and true in the normal manner. The quarter-section corners on the meridional section lines in the south tier of sections will be permanently established at 40 chains south from the corners on the sectional correction line. The balance of the subdivisional lines will be continued from the sectional correction line in the usual manner.

**186.** Where the south part of the east boundary, or the east part of the south boundary, is regular, and the balance of the exterior is found to be defective in alinement and not subject to rectification, the subdivisional survey will be made regular as far as possible. The initial point for the sectional guide meridian, or for the sectional correction line, will be determined by existing conditions, and the subdivisional survey continued in harmony with the principles already outlined. Thus the first meridional section line would be continued as a sectional guide meridian if the north part of the east boundary is defective in alinement and the north boundary is thereby made defective in position, but if the north boundary is not defective in position (nor within the danger zone) the first meridional section line should be continued on a course calculated to intersect the objective section corner on the north boundary. The same principle would be observed if the west part of the south boundary is defective in alinement and the west boundary is not defective in position (nor within the danger zone), but if the west boundary is thus made defective in position the sectional correction line should be established on the true latitudinal curve.

Under the provisions of the above paragraph it will be seen that the maximum number of normal sections are to be secured where the condition of the governing boundaries warrants a combination of the several general plans of subdivisional surveys. The sections adjoining the east boundary may be considered regular to the full extent of their conformity with the usual rectangular limits, and where such agreement obtains the quarter-section corners on the latitudinal section lines will be placed at the normal mid-point position. The sections adjoining the south boundary of the township can not be considered regular unless the meridional lines are established at 80 chains in length, and the sections are otherwise in conformity with the usual rectangular limits; certain exceptions to this rigid requirement will be noted under the subject of "fractional subdivision."

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



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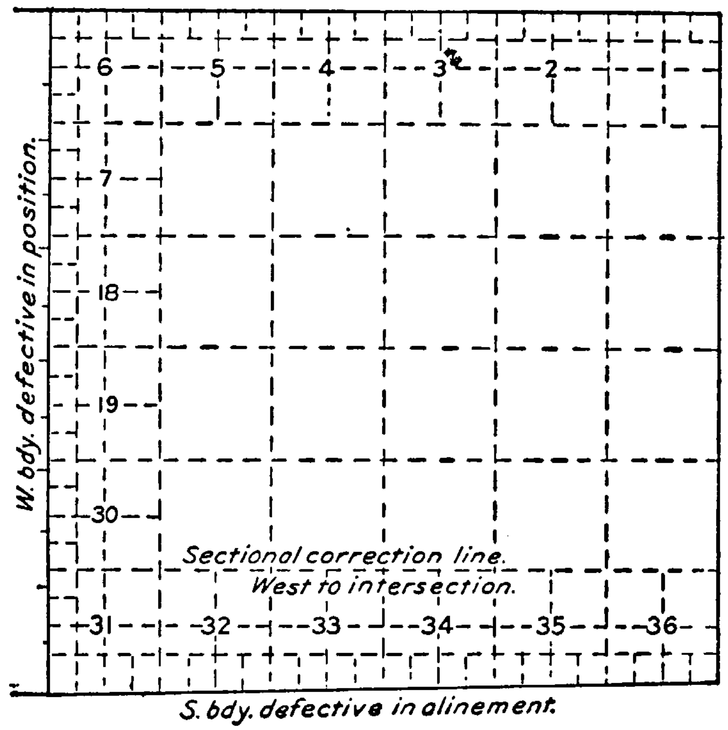
Fig. 43.


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

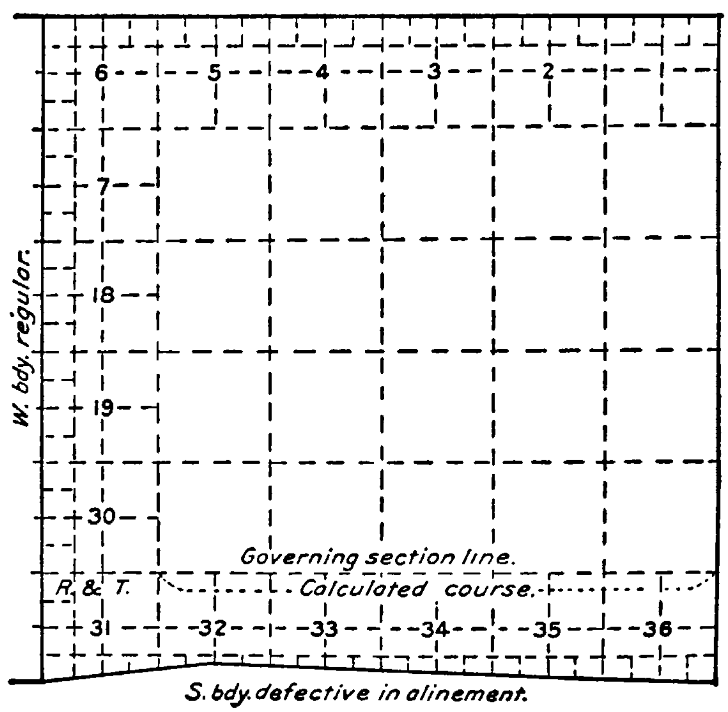
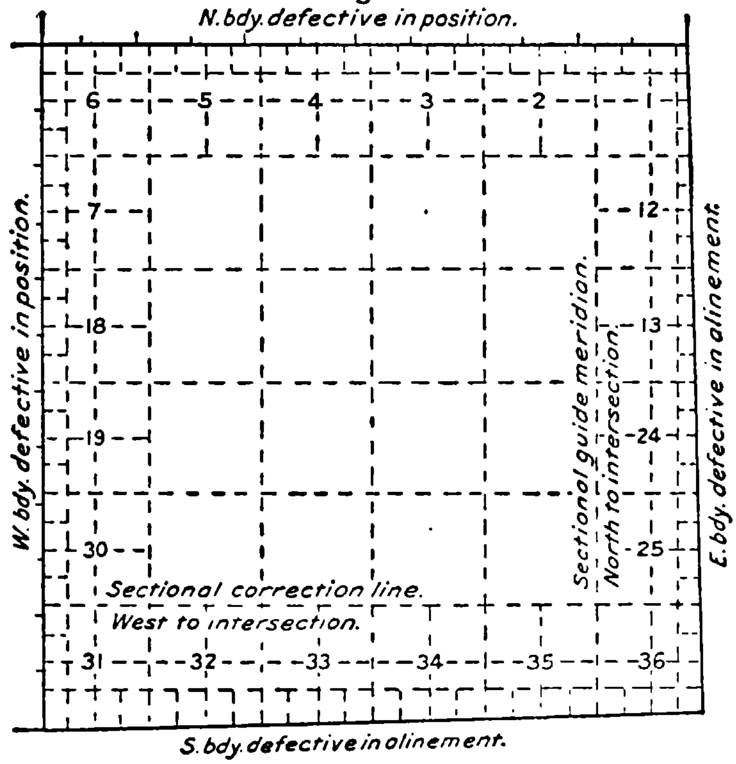

6
5
4
3
2
7
18
19
30
31
32
33
34
35
36
W. bdy. regular.
Governing section line.
R. & T.
Calculated course.
S. bdy. defective in alinement.

Fig. 44.

Fig. 45.


N. bdy. defective in position.
W. bdy. defective in position.
E. bdy. defective in alinement.
S. bdy. defective in alinement.
Sectional guide meridian. North to intersection.
Sectional correction line. West to intersection.
6
5
4
3
2
1
7
12
18
13
19
24
30
25
31
32
33
34
35
36

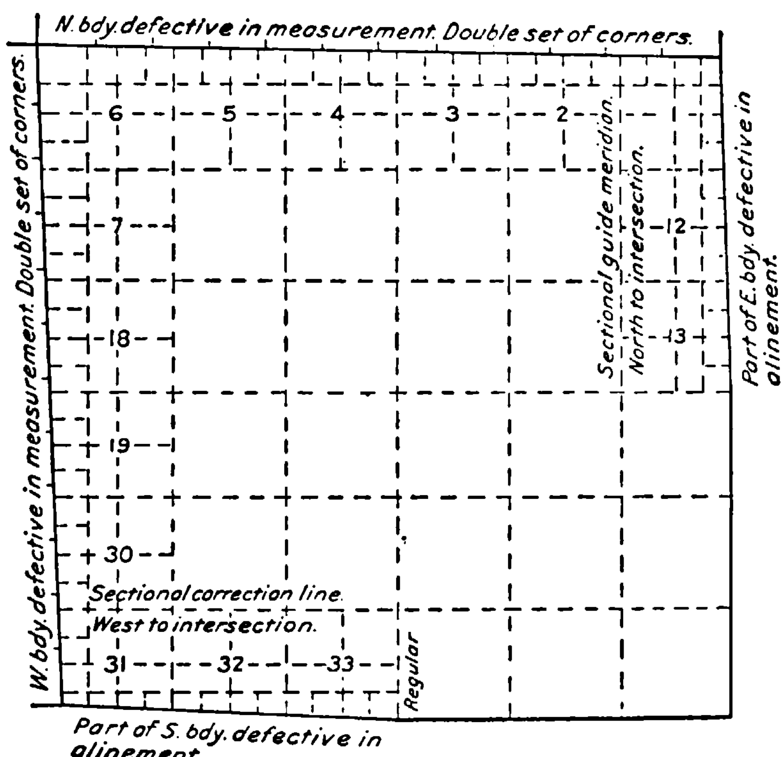

N. bdy. defective in measurement. Double set of corners.
W. bdy. defective in measurement. Double set of corners.
Part of E. bdy. defective in alinement.
Part of S. bdy. defective in alinement.
Sectional guide meridian. North to intersection.
Sectional correction line. West to intersection.
Regular
6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

Fig. 46.

## Closing Section Lines

**188.** In the event of defective north or west boundaries, not subject to rectification, where the subdivisional lines cannot be connected with the previously established exterior section corners, regularly by random and true lines not exceeding 21′ from cardinal and at the same time not deviating more than 21′ from a line parallel to the opposite (regular) boundary of the section, the normal positions of the randoms will be made the true lines; a closing section corner will then be established at the point of intersection of the section line with the original boundary, and the distance will be measured to the nearest original corner. The quarter-section corners on the closing section lines will be placed uniformly at 40 chains from the south or east as the case may be. If not already accomplished, the defective boundaries of the township will be retraced as may be necessary, and the marks upon the original corners appropriately altered as previously provided under the subject of rectification of defective exteriors, whereupon new quarter-section corners, common to the sections of the township which is being subdivided, will be established on the original defective boundaries at the mean distance between the closing section corners, or at 40 chains from one direction, depending upon the plan of the subdivision of the section to which a particular quarter-section corner belongs. In a like manner, quarter-section corners between closing section corners will be established for sections closing on a State, reservation, or other irregular boundary, or on a standard line. Sections 205 and 225.

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

**190.** Where a section is invaded by a surveyed State or reservation or grant boundary, whose boundaries are at variance with the lines of legal subdivisions, the distance on the township boundary or section line to the point of intersection with the irregular boundary will be carefully measured, likewise the exact bearing of the irregular boundary will be determined and the distance will be measured to the nearest corner on such irregular boundary. A closing township or section corner will or will not be established depending on the conditions set forth in section 191.

Surveyed mineral claims, forest-homestead claims, small holding claims, etc., intersected by or located entirely within the boundaries of a section will be connected to a regular corner on one of the boundaries of the section either by a connection from a corner of the claim or from the mineral, location, or other corner monument to which the claim was originally connected. The bearings and lengths of all connecting lines will be carefully determined. A connecting traverse line will be recorded, if one is run, but it will also be reduced to the equivalent direct course and distance, all of which will be recorded in the field tablets, and the course and length of the direct connecting line will be stated in the field notes and will be shown upon the plat of the survey.

**191.** If a survey is to be concluded upon an irregular boundary at variance with the lines of legal subdivision, or if the survey is to be continued on a blank line to acquire a definite location upon the opposite irregular boundary, but without monumenting the rectangular survey between such irregular boundaries, a closing township or section corner, as the case may be, will be required at the point of intersection of the regular with the irregular line. On the other hand, if the survey is not to be so concluded, but is to be continued for the purpose of establishing a full complement of section and quarter-section corners for the control of the subdivision of a section so invaded by a private claim, no closing corner will be required.

**192.** In every case where a closing township or section corner is to be established upon a standard parallel, State, reservation, grant, or claim boundary, or upon an irregular section line or exterior, the line closed upon will be retraced between the first corners to the right and left of the point for the closing corner, whenever such retracement is necessary to insure that the closing corner is established at the precise point of intersection of the two lines. The distance from the closing corner to the nearest corner on the line closed upon will always be measured and recorded.

## SUBDIVISION OF SECTIONS

**193.** Revised Statutes, secs. 2396, 2397 (43 U. S. C., secs. 752, 753), contain the fundamental provisions for the subdivision of sections into quarter sections and quarter-quarter sections. The principles recognized by law have already been stated in chapter I. The sections are not subdivided in the field by Bureau of Land Management cadastral engineers unless provision therefor is specifically mentioned in the written special instructions, but certain subdivision-of-section lines are always protracted upon the official plats. When surveying subdivision-of-section lines in the field, the local surveyor must correlate the conditions as found upon the ground with those shown upon the approved plat. The Bureau of Land Management cadastral engineer is required so to establish the official section boundary monuments that a proper foundation is laid for the subdivision of the section, whereby the officially surveyed lines may be identified and the subdivision of the section controlled as contemplated by law.

**194.** The rectangular system provides for the unit of administration under the general land laws, broadly, the quarter-quarter section of 40 acres, upon a plan in which the square mile, or section of 640 acres, is the unit of subdivision, while the unit of survey is the township of 36 sections. The function of the cadastral engineer of the Bureau of Land Management has been fulfilled when he has executed and monumented his survey properly and returned an official record thereof in the form of complete detailed field notes and a plat. The plats are constructed in harmony with the official field notes returned by the engineer. The lands surveyed are identified on the ground by fixed monuments established in the survey. A United States patent conveys the title to a tract defined by those fixed monuments and related by description and outline to the official plat.

The function of the local surveyor begins when he is employed as an expert to identify the lands which have passed into private ownership; this may be a simple or a most complex problem, depending largely upon the condition of the original monuments as affected principally by the lapse of time since the execution of the official survey. The work of the local surveyor usually includes the subdivision of the section, already mentioned as the official unit of subdivision, into the fractional parts shown upon the approved plat. In this capacity the local surveyor is performing a function contemplated by law, and he 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 cannot hope effectively to recover said corners without a full understanding of the record concerning their original establishment, nor can the surveyor hope legally to restore the same until he has mastered not only the principles observed in the execution of the original survey, but the principles upon which the courts having jurisdiction over such matters have based their rulings.

**195.** The 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, and the Bureau desires that the rules controlling the acts of its own cadastral engineering service be considered by all other surveyors as merely advisory and explanatory of the principles which should prevail in performing such duties.

The subject of restoration of lost corners will be treated in chapter V, as the purpose here is to outline the principles concerning the subdivision of sections.

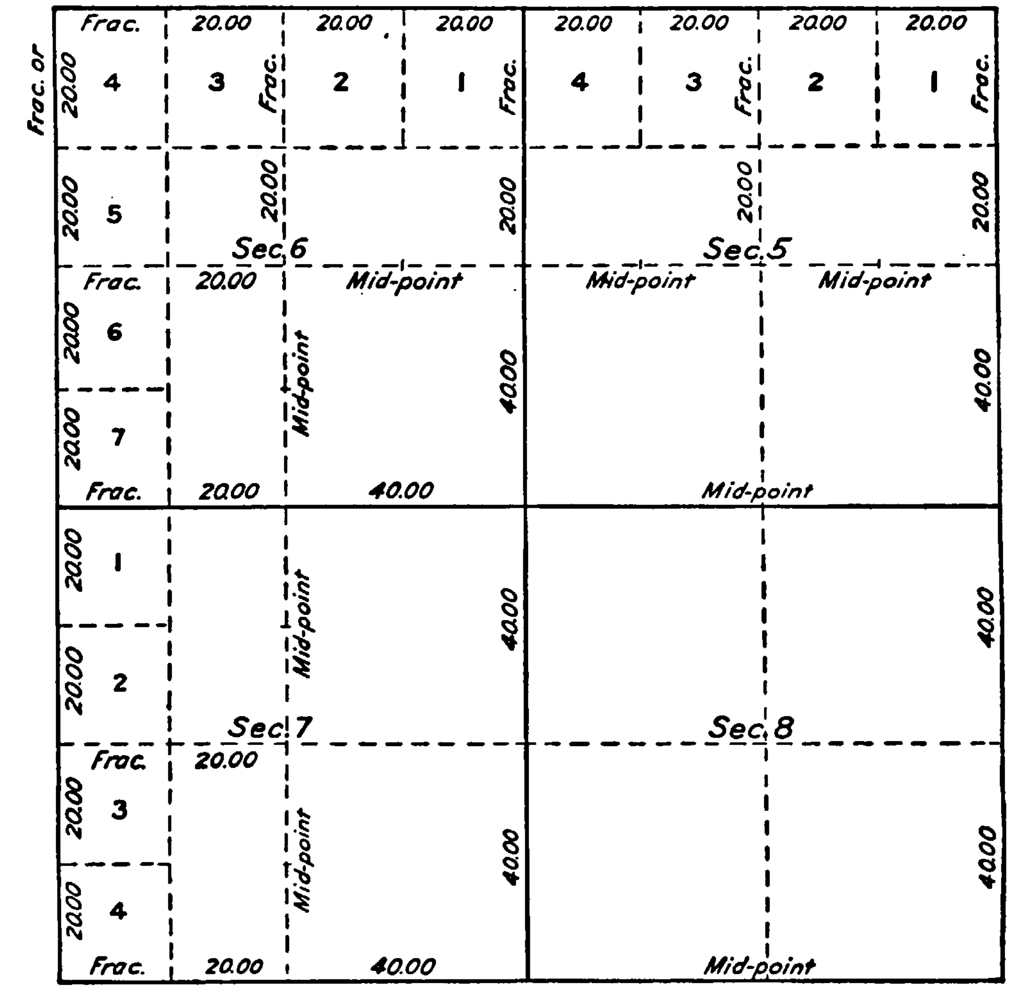
## Subdivision by Protraction

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

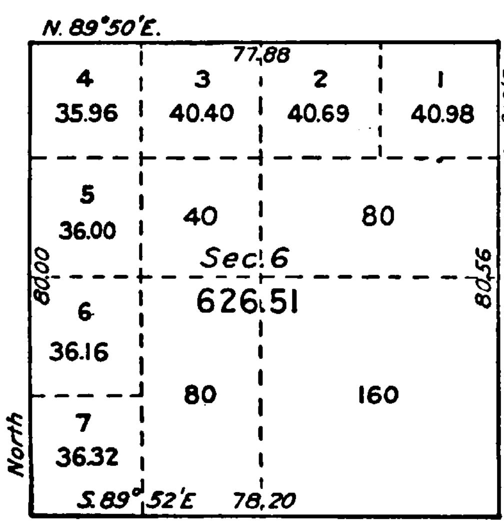
The regular quarter-quarter sections are aliquot parts of quarter sections based upon mid-point protraction; it is not deemed necessary to indicate these lines upon the official plat.

**197.** Sections which are invaded by meanderable bodies of water, or by approved claims at variance with the regular legal subdivisions, are subdivided by protraction into regular and fractional parts as may be necessary to form a suitable basis for the administration of the public lands remaining undisposed of, and to describe the latter separately and apart from the segregated areas.

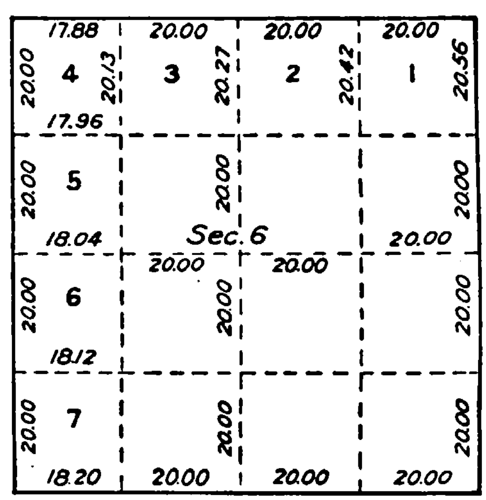
Fig. 47.




Showing normal subdivision of sections.



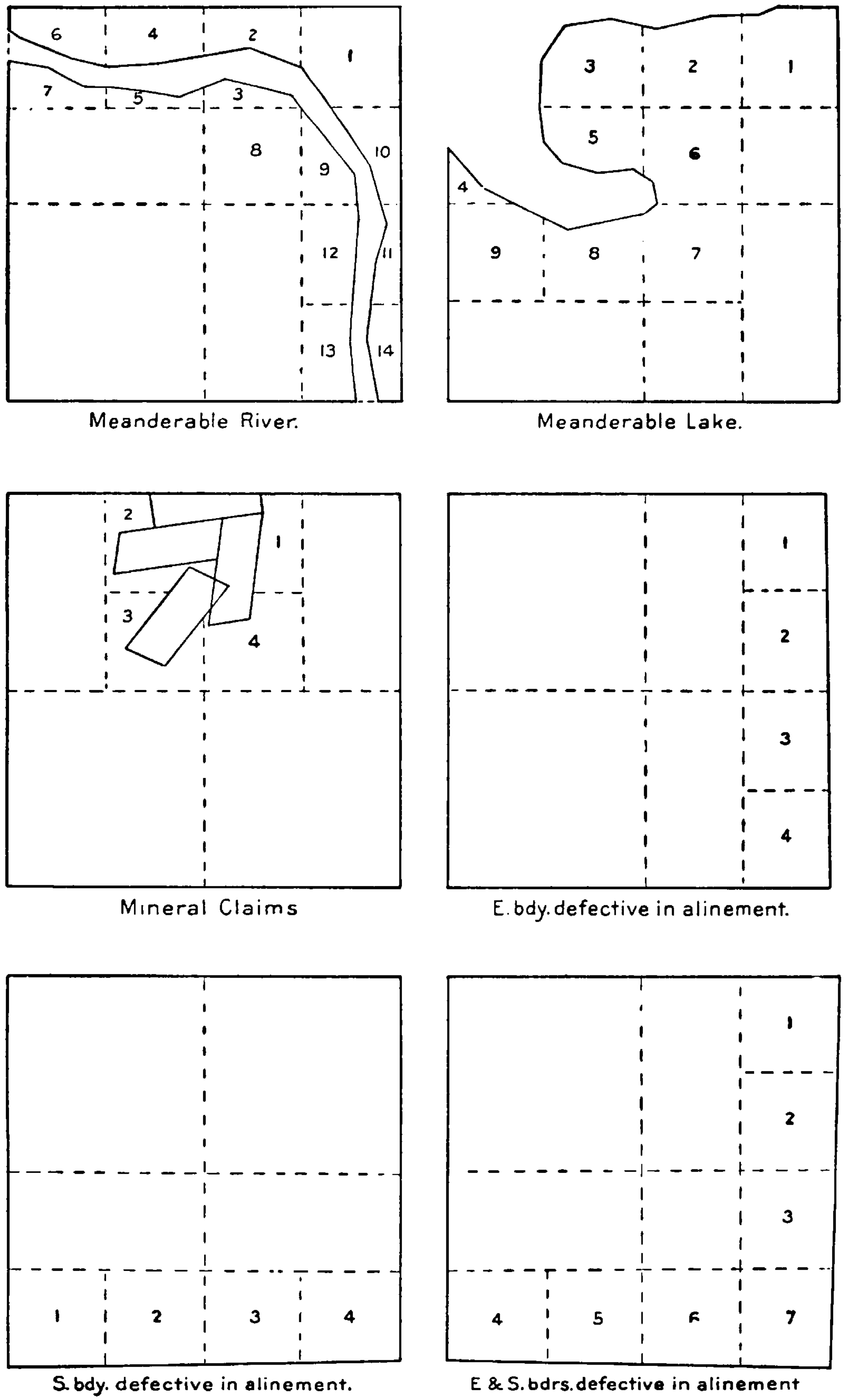

Showing areas.




Showing calculated distances.

**Examples of subdivision by protraction.**

Fig. 48.




**Examples of subdivision of fractional sections.**

The meander line of a body of water and the boundary lines of private claims are platted in accordance with lines run or connections made in the field; thereupon the sections so invaded are subdivided as nearly as possible in conformity with the uniform plan already outlined. The subdivision-of-section lines are terminated at the meander line or claim boundary, as the case may be, but the position of the subdivision-of-section lines is controlled precisely as though the section had been completed regularly. In the case of a section whose boundary lines are in part within the limits of a meanderable body of water, or within the boundaries of a private claim, the said fractional section lines are, for the purpose of uniformity, completed in theory, and the protracted position of the subdivision-of-section lines is controlled by the theoretical points so determined.

**198.** In the subdivision of fractional sections as many regular parts should be secured as possible, except to avoid thus creating poorly shaped fractional lots. Skill and judgment must be exercised to accomplish a subdivision which embraces simplicity of platting as well as a form to each and every lot that will prove to be equitable to the entryman. In the case of fractional lots along the north and west boundaries of a township, and in other similar cases where a lot has a full normal width of 20 chains in one direction, it is generally advisable to avoid areas of less than 10 or more than 50 acres, but in the instance of fractional lots along a meander line or other irregular broken boundary, where the width of the lot in both directions may be considerably less than 20 chains, resulting in tracts of more compact form, it is generally better to avoid an area of less than 5 or more than 45 acres. Extreme lengths or narrow widths should be avoided; the longer direction should extend back from a meander line or claim boundary rather than along the same. It is inconsistent that a fractional lot lie partly in two sections, and it is generally better, when consistent with other rules, to avoid fractional lots extending from one into another fractional quarter section.

**199.** To secure a uniform system for numbering lots of fractional sections, including those above specified, imagine the section divided by parallel latitudinal lines into tiers, numbered from north to south; then, beginning with the eastern lot of the north tier, call it No. 1, and continue the numbering west through the tier, then east in the second, west in the third, east in the fourth tier, etc., until all fractional lots have been numbered. These directions will be maintained even though some of the tiers contain no fractional lots. A lot extending north and south through two, or part of two tiers, will be numbered in the tier containing its greater area. This method of numbering will apply to any part of a section. A section that has been partly surveyed at different times should have no duplication of lot numbers.

**200.** When, by reason of irregular surveys or from other causes, the length of a township from south to north exceeds the regular length of 480 chains, or the width from east to west exceeds 480 chains, to such an extent as to require two or more tiers of lots along the north boundary, or two or more ranges of lots along the west boundary, as the case may be, the entire north or west portions of said sections beyond the regular legal subdivisions usually provided in these sections, will be suitably lotted, and to each lot will be assigned a proper number. Certain exceptions to this rule will be found in chapter VII, in the instance of townships which possess abnormal dimensions in one or both directions.

**201.** If the first meridional section line of a township has been established as a sectional guide meridian, or the first latitudinal section line has been established as a sectional correction line, fractional lots will result along the east or south boundary of the township, as existing conditions may necessitate. Thus, where either the east or south boundaries of a township are defective in alinement (and not subject to rectification before subdividing) the sections bordering such defective boundaries will be subdivided by protraction in accordance with rules similar to those which operate in regard to sections bordering the north and west boundaries of a normal township. Other examples of subdivision of sections will be found under the general subject of "fractional subdivision."

## Subdivision by Survey

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

**203.** *Preliminary to subdivision it is essential to identify the boundaries of the section, as it can not be subdivided until the section corners and quarter-section corners have been found, or restored by proper methods, and the resulting courses and distances determined by survey.*

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

## Subdivision of Sections Into Quarter Sections

**205.** *The method to be followed in the subdivision of a section into quarter sections is to run straight lines from the established quarter-section corners to the opposite quarter-section corners; the point of intersection of the lines thus run will be the corner common to the several quarter sections, or the legal center of the section.*

Upon the lines closing on the north and west boundaries of a regular township the quarter-section corners were established originally at 40 chains to the north or west of the last interior section corners, and the excess or deficiency in the measurement was thrown into the half mile next to the township or range line, as the case may be. If such quarter-section corners are lost they should be reestablished by proportionate measurement based upon the original record.

Where there are double sets of section corners on township and range lines, the quarter-section corners for the sections south of the township line and east of the range line have not usually been established in the original surveys; in subdividing such sections new quarter-section corners are required, to be so placed as to suit the calculations of the areas that adjoin the township boundary, as expressed upon the official plat, adopting proportional measurements where the new measurements of the north or west boundaries of the section differ from the record distances.

### Subdivision of Fractional Sections

**206.** *The law provides that where opposite corresponding quarter-section corners have not been or can not be fixed, the subdivision-of-section lines shall be ascertained by running from the established corners north, south, east, or west lines, as the case may be, to the water course, reservation line, or other boundary of such fractional section, as represented upon the official plat.*

In this the law presumes that the section lines are due north and south, or east and west lines, but this is not usually the case. Hence, in order to carry out the spirit of the law, it will be necessary in running the 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. Section 197.

### Subdivision of Quarter Sections

**207.** *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.* Sections 209, 468.

*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.* Section 468.

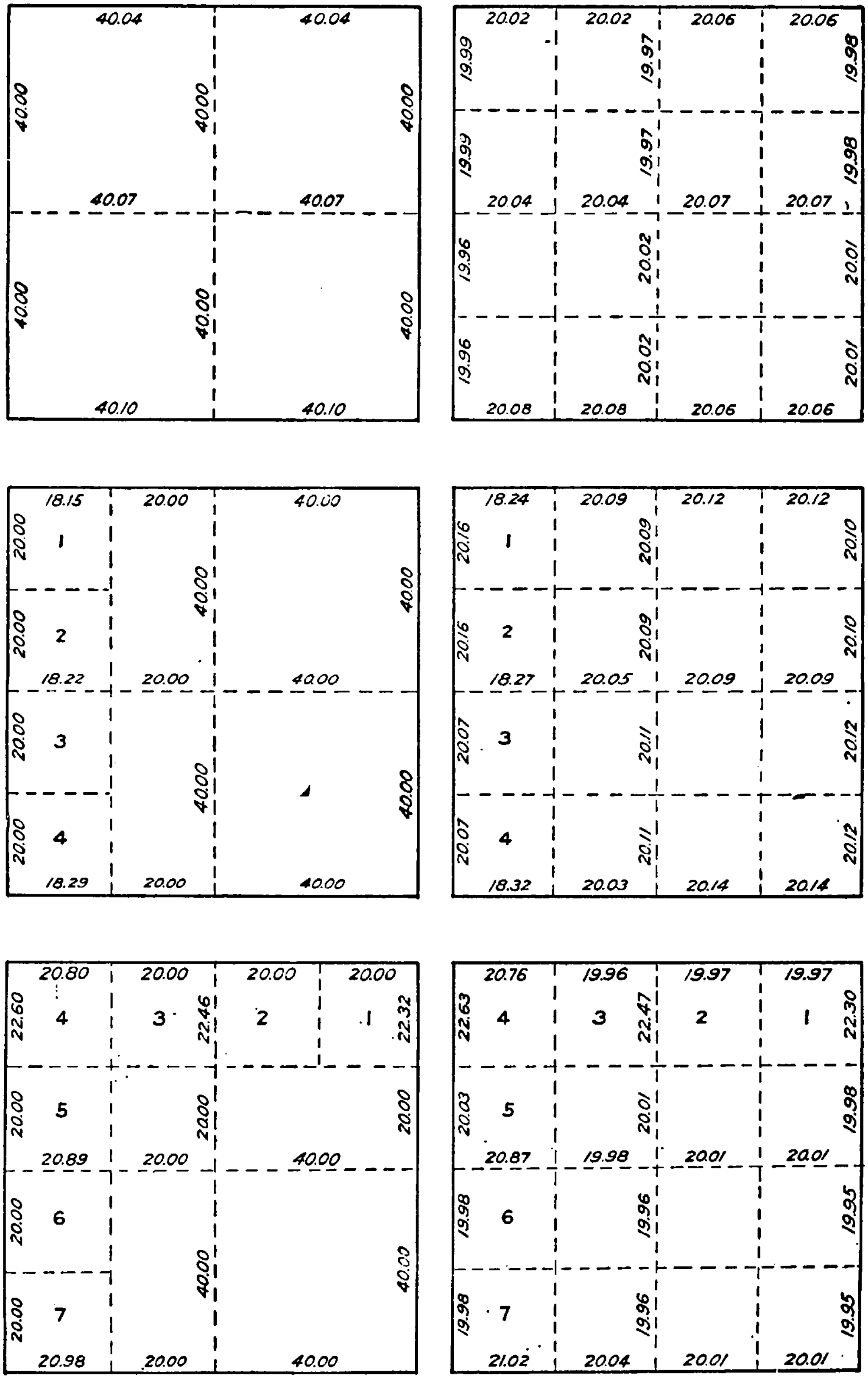
### Subdivision of Fractional Quarter Sections

**208.** *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.* Section 197.

**209.** By "proportionate measurement" is meant a measurement having the same ratio to that recorded in the original field notes as the length of the line by re-measurement bears to its length as given in the record. Reasonable discrepancies between former and new measurements may generally be expected. Errors may occur through many causes and should be as carefully avoided in re-measurements as in original surveys. Instead of the old practice of "adjusting the chain" to suit the former measure, the distance obtained by a precise method is compared with that of the record, and the shortage or surplus is distributed by proportion, producing the same result in a more reliable manner. For example: The length of the line from the quarter-section corner on the west boundary of section 2 to the north line of the township, by the official survey was reported as 43.40 chains, and by the county surveyor's measurement was found to be 42.90 chains; then the distance which the quarter-quarter- or sixteenth-section corner should be located north of the quarter-section corner would be determined by proportion as follows: As 43.40 chains, the official measurement of the whole distance, is to 42.90 chains, the county surveyor's measurement of the same distance, so is 20 chains, original measurement, to 19.77 chains by the county surveyor's measurement, showing that by proportionate measurement in this case the quarter-quarter- or sixteenth-section corner should be set at 19.77 chains north of the quarter-section corner, instead of 20 chains north of said corner, as represented on the official plat. In this manner the discrepancies between original and new measurements are equitably distributed.

**210.** By way of recapitulation it should be emphasized that when entrymen have acquired title to certain legal subdivisions they have

Fig. 49.




Official measurements. Remeasurements.

The above examples of subdivision by survey show the relation of the official measurements and calculated distances to the remeasurements, and indicate the proportional distribution of the differences.

become the owners of the identical ground area represented by the same subdivisions upon the official plat. It is a matter of expert or technical procedure to mark out the legal subdivisions called for in a patent, and entrymen are advised that a competent surveyor should be employed. The surveyor must necessarily identify the section boundaries and locate the legal center of the section in order to determine the boundaries of a quarter section. Then, if the boundaries of quarter-quarter sections, or fractional lots, are to be determined on the ground, the boundaries of the quarter section must be measured, and the sixteenth-section corners thereon should be fixed in accordance with the proportional distances represented upon the approved plat, thereupon the legal center of the quarter section may be duly located. Thus will be produced in the field the figure represented upon the plat, every part of the former in true proportion to the latter, where the elements of absolute distance and area have given way to corresponding proportional units as defined by fixed monuments established in the original survey.

## FRACTIONAL SUBDIVISION OF TOWNSHIPS

**211.** In the preceding sections covering the subject of subdivision of townships every assumption was based upon initiating the subdivisional survey upon regularly established exteriors, or, when necessary, a sectional guide meridian or a sectional correction line, or both, were to be established, upon which rested the control of the subdivision of the township. The subdivision of every full township may always be governed by the aforestated rules, but many other factors operate in determining the method and order of procedure to be adopted in the instance of fractional townships which have no linear south or east boundary, or in the case of continuing with the survey of partially subdivided townships, where one or more of the previously established section lines may be found to be defective in respect to the rectangular limit, or where partially surveyed sections, or sections containing outlying areas protracted as surveyed, are to be completed. The cadastral engineer can not hope to master the subject of fractional subdivision of townships until he has become thoroughly familiar with every question relating to the subdivision of sections, nor is it possible to give in the Manual an example of every intricate problem which may be encountered in the field; thus the following discussion deals primarily with the principles, which must be considered in the field, operating to control the engineer's method and order of procedure. It is possible, however, that cases may arise so complex in their character as to produce a feeling of doubt relative to the proper solution of the problem; in which case the engineer will at once communicate with the regional or public survey office, submitting information, by letter and diagram, of the exact condition as found by him, and the necessary instructions will be forwarded.

## FRACTIONAL TOWNSHIPS

**212.** Where by reason of the presence of a large meanderable body of water, impassable objects, a State or reservation or grant boundary, or for other similar reasons a township is made fractional and is without a full linear south or east boundary, and it has been found advisable to run section lines as offsets to the township exteriors, the fractional section lines south and east of said controlling lines will be projected opposite to the usual direction; the fractional measurements on said lines and the resulting fractional lots will be placed against the irregular boundary. If similar conditions obtain throughout the north or west part of a fractional township no departure from the regular order of subdivision becomes necessary; in all such cases the fractional measurements on the exterior and subdivisional lines, and the resulting fractional lots, will be placed to the north and west against the irregular boundary.

**213.** Where on account of impassable objects or for other reasons no part of the south boundary of a township can be regularly established, the subdivision thereof may proceed from north to south and from east to west, thereby throwing all fractional measurements and areas against the west boundary and the meanderable stream or other boundary limiting the township on the south; if the east boundary is without regular section corners and the north boundary has been run eastwardly as a true line, with section corners at regular intervals of 80 chains, the subdivision of the township may be made from west to east, in which case the fractional measurements and areas will be thrown against the irregular east boundary; on the other hand, if the north boundary of sec. 6 is fractional, a sectional guide meridian will be initiated at the easternmost regular section corner on the north boundary of the township, which will be projected to the south to take the place of a governing east boundary, thus the subdivisional survey would be projected from north to south and from east to west, with fractional measurements, and resulting fractional lots, on the east, south and west boundaries of the township. The accompanying diagrams are illustrative of the principles which operate to control the subdivision of partial townships.

It will be observed that in the case of fractional townships, the sections bear the same numbers they would have had if the townships were full, that is to say the section numbers are employed which are the proper section numbers relating to the sides which are the governing boundaries, leaving any deficiency to fall on the opposite sides.

**214.** A very considerable class of surveys now coming before the Bureau of Land Management embraces the continuation of the subdivisional survey of townships previously subdivided in part only, frequently including the completion of partially surveyed sections or of sections containing outlying areas protracted as surveyed. If defective conditions are encountered in the previously established surveys, the problems concerning the procedure to be adopted multiply rapidly and require the greatest skill on the part of the engineer. In the construction of new township plats the former parctice of showing certain outlying areas of sections protracted as surveyed has been abandoned as unsatisfactory and inconsistent with the surveying laws. Section 583.

**215.** Most original surveys which are to be extended were executed many years ago when the remaining areas now to be surveyed were considered waste lands. Due to the ravages of time and the inferior monumentation of the early surveys, obliteration is so far advanced in the majority of cases that usually resurveys are required to identify and remonument the limiting boundaries of the area to be surveyed so far as the section or subdivision-of-section lines controlling the new areas may depend upon the position of the previously established corners. In order properly to determine the position of a lost corner, the engineer often will be required to retrace additional lines which are not the boundaries of sections containing the new areas to be surveyed, but no reestablishments of original corners on such lines are required. The theoretical position of a lost corner on such lines may be at variance with an unofficial corner established by local survey, accepted and recognized by the owners of the private lands affected; thus much controversy between landowners is avoided if the reestablishments are confined strictly to those corners which control the position of the section boundaries or the subdivision-of-section lines affecting the public lands to be surveyed. Identified original corners which are adopted as a basis from which to control the reestablishments bordering the public land sections will be rehabilitated but not remonumented. All restorations of lost corners will be made in strict accordance with the provisions of chapter V.

The field notes of such resurveys should include an explanation of their purpose and extent preliminary to proceeding with the running of the new lines as set out in the special instructions, giving all needed historical references to the related prior surveys. The detail will be written in the usual field note record form, following the introductory statement.



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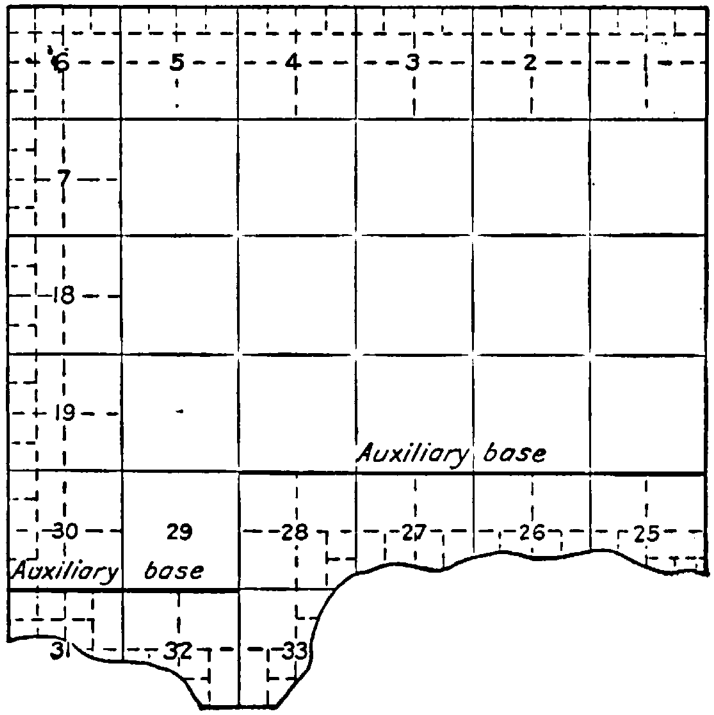
Fig. 50.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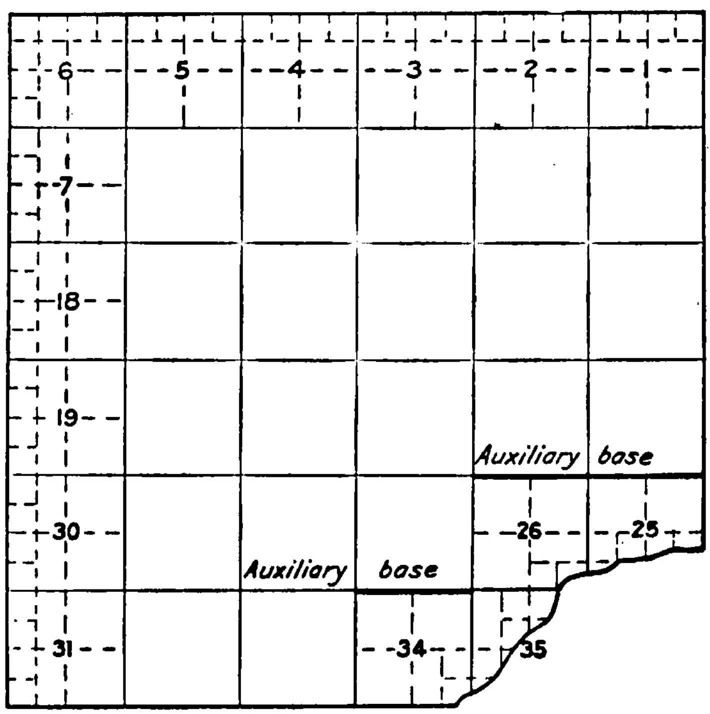
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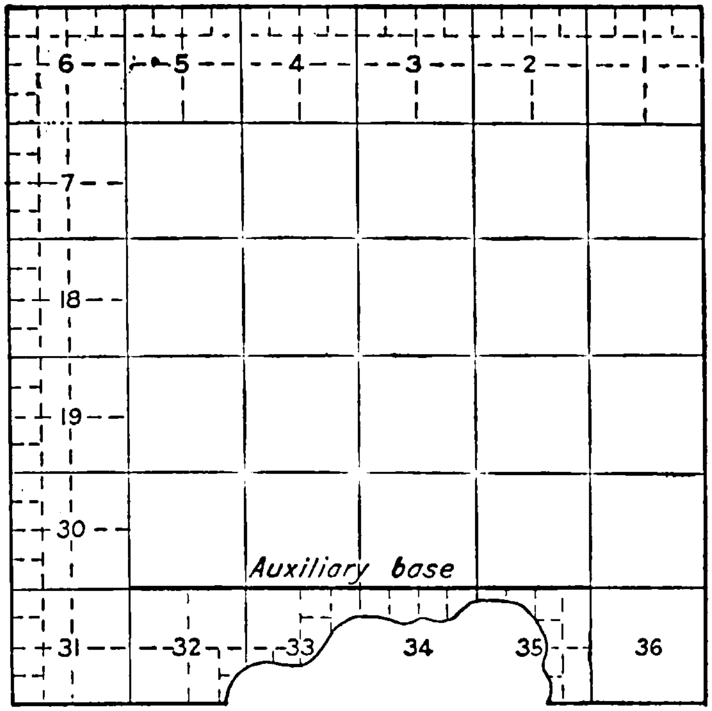
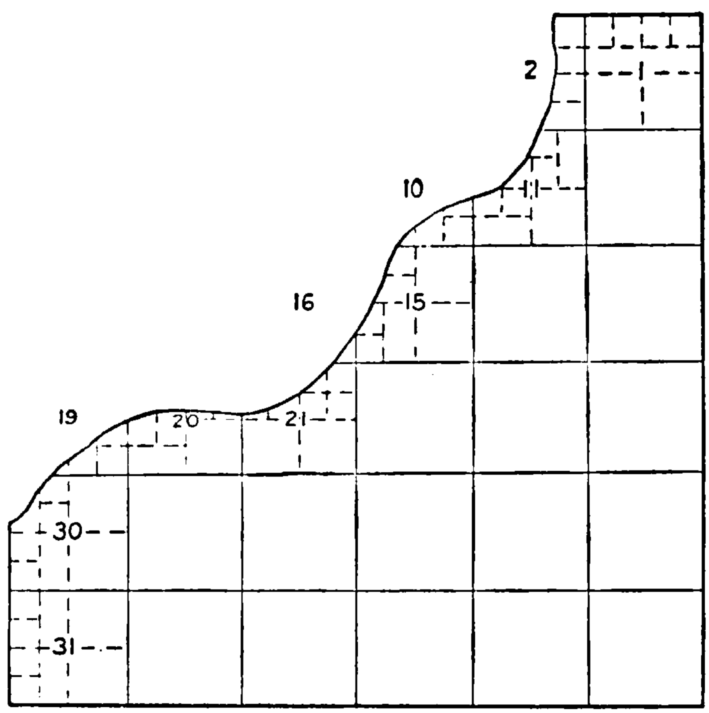
Fig. 51.

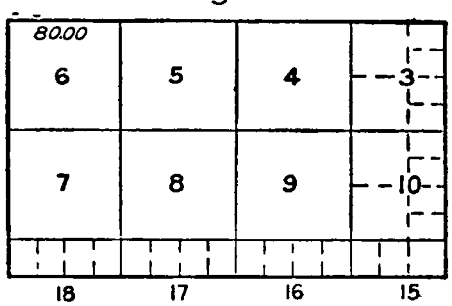
Fig. 52.



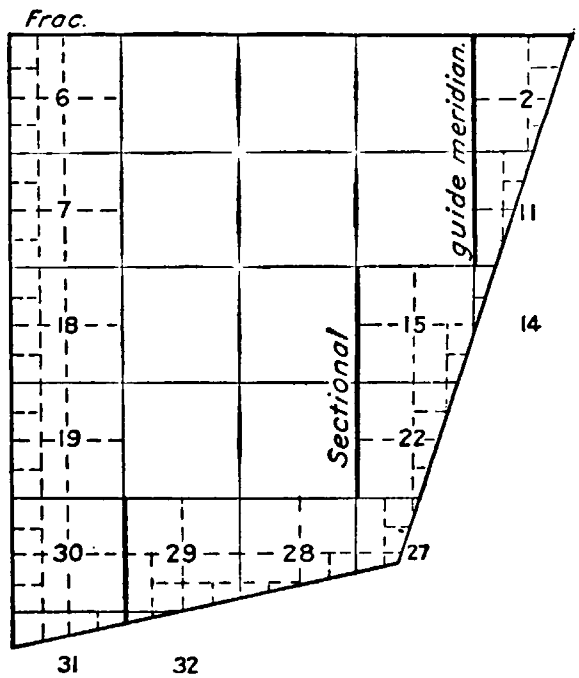




Subdivide Regularly.
Fig. 53.

Fig. 54.




Subdivide from north to south, and from west to east.




Subdivide from north to south, and from east to west.

Fig. 55.

The plat, in addition to the usual data, may if desirable carry a marginal memorandum (or diagram) that makes it clear what lines of the prior survey have been retraced as a basis for extending the new lines. If no changes in the former lottings and areas in the resurveyed portion are to be made it will be stated that the lottings and areas remain as shown on the plat (or plats) approved ---------- (date or dates).

## Completion of Partially Surveyed Sections

**216.** Many assignments for fragmentary surveys require the completion of the survey of portions of boundaries of sections heretofore unsurveyed, in which sections are contained areas fixed in position by less than the regular complement of corners usually established for the identification of the legal subdivisions of the section. In the completion of such partially surveyed sections, the engineer will be expected to give full consideration to the manner of protecting acquired rights based upon the former approved plats. Section 583.

The following 10 principles are distinctly applicable to the subject:

1. The legal procedure governing the subdivision of any normal section into quarter sections is based broadly on the principle that the partition lines may be definitely fixed by four opposite quarter-section corners established on its boundaries; the intersection of the true center lines thus controlled is the legal point for the interior quarter-section corner of a section.
2. The legal procedure governing the subdivision of regular quarter sections into quarter-quarter sections is based broadly on the same principle of controlling lines projected between opposite sixteenth-section corners of the quarter section, the latter corners established at mid-points on the true lines bounding the quarter section; the intersection of the true center lines of the quarter section is the legal point for the interior sixteenth-section corner of such regular quarter section.
3. The legal procedure governing the subdivision of sections containing fractional lots into their component regular quarter-quarter sections and fractional lots is based on the same principle with the simple modification that the sixteenth-section corners on the boundaries of such quarter sections are themselves established at distances conformable to the proportions shown on the official plat.
4. The fact that the full complement of four section corners of the section and all of the four opposite quarter-section corners has not been established in an accepted survey does not impair the validity of any areas shown upon the approved plat, and the legal procedure to be adopted in the extension of the boundaries of such sections must be such as to fix, within reasonable limits, the remaining quarter-section corners in a position which will protect the integrity of the original areas by controlling center lines connecting the old and new quarter-section corners.
5. In the rectangular system the section is recognized as the unit of subdivision, and in proceeding with the extension of fragmentary surveys first consideration must necessarily be given to the completion of the survey of fractional sections. No invasion of the original unit is tolerable if any portion of such unit has been surveyed, or if outlying areas have been shown protracted as surveyed.
6. "Reasonable limits" for the fixation of the remaining quarter-section cor-

ners of a section in a position which will protect the integrity of the original areas of such section may be considered such as for alinement when not to exceed 21′ from a cardinal course, and for measurement when not to exceed 25 links from 40 chains where the opposite portion of the section boundary is shown as 40 chains, or in proportion as a limiting difference when the opposite portion of the section is more or less than 40 chains. This concession as to limits is made in the interest of simplicity, where by such concession rectangularity of both the old and new surveys may be maintained if so harmonized.

7. The position of the new quarter-section corner which is to be established on the new opposite boundary of a fractional section will be controlled from one direction only if the old opposite distance has been made to count from one direction only, and the controlling measurement will be made to harmonize with the length of the opposite portion of the section, but if the old opposite distance has been made to count from two directions the position of the new quarter-section corner will be controlled from the two directions and the proportional lengths of the two portions of the new line will be made to harmonize with the proportional lengths of the two parts of the old opposite boundary, all as indicated by the distances and areas shown on the original approved plat.

8. The underlying principles governing the rectangular surveying system are equally applicable to the completion of the survey of fractional sections, and given a condition in an original survey which in all its various elements is "within limits" within the meaning of the rectangular surveys, the simple plan of continuing in the same manner and order as would have been adopted in the original survey, if the same had not been discontinued, will accomplish usually in its simplest form the completion of the survey of fractional sections; this becomes the first duty of the engineer before proceeding with the survey of additional sections, so that should irregularity be developed, no invasion of partially surveyed sections can result from the irregularities of other sections. It follows in principle, when irregularity is developed, that the engineer will be best prepared to determine the proper method of survey adapted to procure simplicity of correction of existing irregularities and an early resumption of regularity, when he is in possession of full data concerning the conditions of all the old lines limiting the fragmentary surveys and upon which the new lines are to be initiated or closed, his knowledge being based upon the results of actual retracement of such irregular old lines. It must be granted that a skillful exercise of judgment by the engineer based upon his knowledge of the facts is far more desirable than to restrict him to the application of empirical rules devised to cover possible but innumerable combinations of irregularity.

9. The completion of the survey of the partially surveyed sections will be made as nearly as possible in accordance with the regular rules for subdividing when the original lines are found to be within limits; otherwise, such sections will be completed by surveying all lines in such a manner that each and every section (excepting in cases of unavoidable hiatus or overlap) shall have four regular boundaries without offsets, with four governing section corners and four controlling quarter-section corners in such positions as to maintain the integrity of the fractional areas already shown upon the original plat. The subdivision thereof may then be made by connecting the opposite quarter-section corners in the regular manner with resulting locations agreeable to the legal subdivisions shown upon the original plat. If an hiatus or overlap is unavoidable, the position of the new quarter-section corner or corners will be carefully determined for latitude on a meridional line or for departure on a latitudinal line on the same plan as would have resulted in the regular survey of a new boundary extending in full from

the one or two directions which control the position of the new quarter-section corner or corners.

10. Adjoining sections must be considered separately when placing the new quarter-section corners, and the new corner need not be common to the four quarters of the two adjoining sections unless the theoretical position for each section falls within 25 links of a common point; in which case the difference may be adjusted in such a manner as to secure maximum regularity.

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).

Examples: Manual Appendix III.

**217.** The meridional line out of limits in measurement.

**218.** The meridional line out of limits in alinement.

**219.** Combinations of the discrepancies.

**220.** Half sections protracted as surveyed.

**221.** Fractional parts of sections protracted as surveyed.

**222.** The application of the rules for the completion of the boundaries of irregular sections which contain outlying areas protracted as surveyed will not usually permit the complete establishment of the lines, and the marking of the monuments, until all directions and lengths of the lines, and the exact situation with respect to the units of the adjoining sections, have been determined on the ground, and represented by diagram.

**223.** A distinctly different class of partially surveyed sections is found along erroneous meander lines shown upon approved plats of fractional townships. Such sections are never subject to completion except as definitely authorized in the written special instructions furnished to the engineer, as the approved plat must be held to represent correctly a true meanderable body of water until proven otherwise to the satisfaction of the Bureau of Land Management, as intimated in section 3, chapter I. Numerous instances are on record, however, where the evidence submitted to the Bureau is conclusive that surveyors have erroneously classified overflowed lands as meanderable, or where the recorded meander line does not and never did conform to the mean high-water elevation of an actual meanderable body of water, thus erroneously omitting considerable areas of land. The questions of title to such areas are extremely intricate, and the original surveys will be extended only under definite authorization by the Bureau of Land Management. The surveying problems arise only when the extension of the original survey beyond the meander line shown upon the approved plat has been duly authorized. Sections 521–529, inclusive.

The reestablishment of the original meander line with a suitable monument at each angle point is a usual accompaniment of the above class of surveys, the purpose being to segregate definitely the previously surveyed areas from the unsurveyed public lands; it is more appropriate to consider the surveying questions thus involved along with other problems relating to the reestablishment of broken boundaries, where the subject will be found in section 380, chapter V. The next step in the field is to complete the partially surveyed sections and the procedure in practically every instance will be controlled by the rules already outlined in respect to the completion of the survey of sections containing outlying areas protracted as surveyed; it seems unnecessary to repeat the governing principles in such closely related cases.

## Subdivision of Fractional Sections Resulting From Fractional Surveys

**224.** The one best test of the fitness of a proposed method incident to the completion of partially surveyed sections will be found in platting the section for subdivision by protraction; thereupon the regular rules for subdivision of sections should be applicable. Thus the position of the new quarter-section corners, established to control the subdivision of a particular section in question, must be such as to permit the center lines from said points to the opposite original quarter-section corners to be connected in strict harmony with the conditions represented upon the original approved plat, disregarding the effect upon the subdivision of the newly surveyed public land. Likewise the lines connecting the sixteenth-section corners on the opposite boundaries of a quarter section must conform to the conditions represented upon the original plat. When the subdivision-of-section lines are thus platted the section may be considered satisfactory if the integrity of the original areas is in no way violated. When the subdivision-of-section lines are platted as suggested, the permanent conditions affecting the new areas may be considered, and should be harmonized with the following additional rules:

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. The same meridional limit may be permitted, in the interest of regularity and simplicity of platting, as is ordinarily allowed in

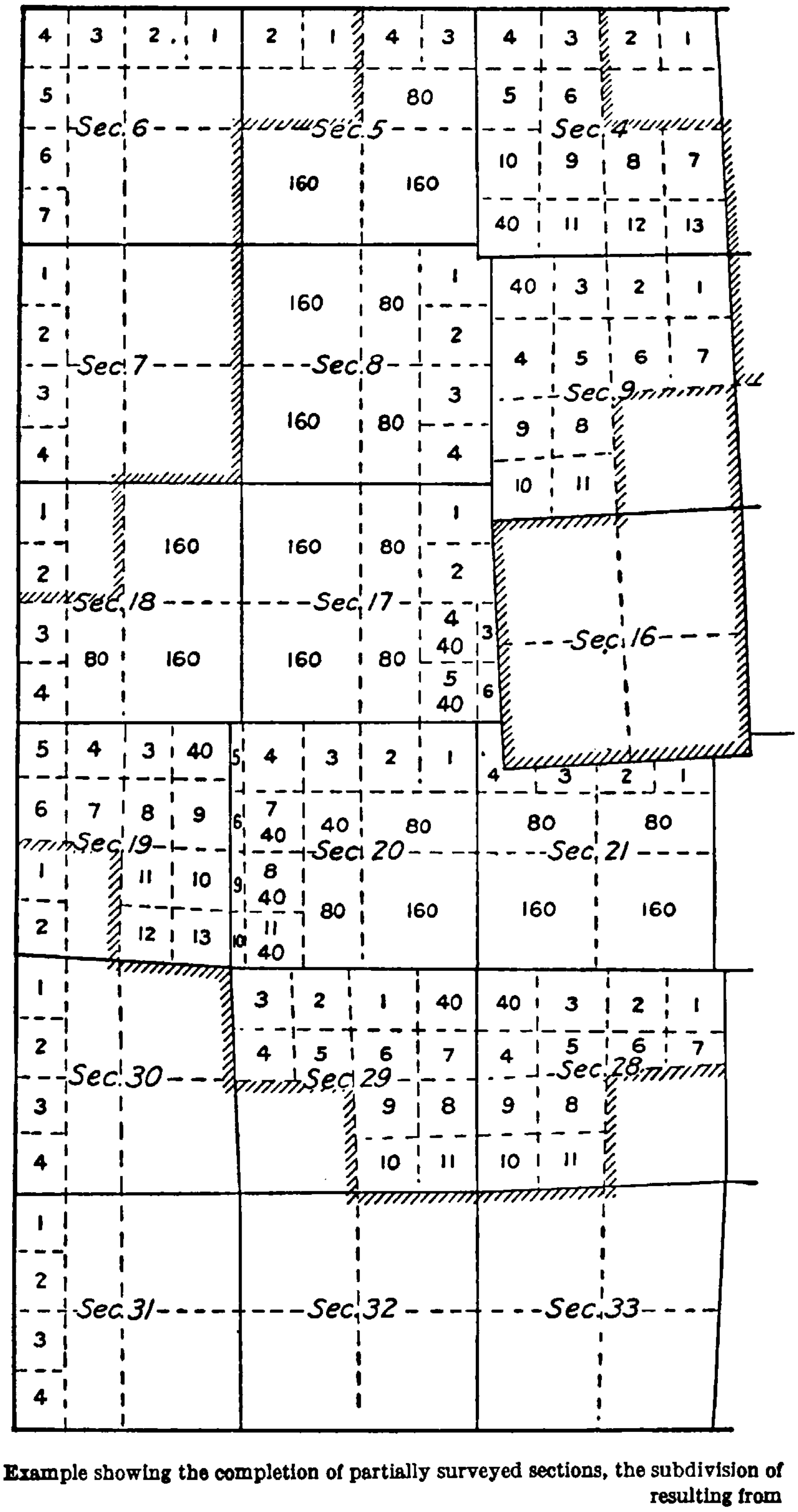
latitudinal section lines; i. e., a section may be considered regular whose boundary lines are all for alinement when not to exceed 21′ from a cardinal course, and for measurement when not to exceed 25 links from 40 chains between the section and quarter-section corners. Such regular sections may be subdivided into regular quarter sections and quarter-quarter sections as far as possible. A section having three regular boundary lines may be subdivided in accordance with the usual rules for subdividing sections along the north and west boundaries of a normal township. A section having two adjacent regular boundary lines may be subdivided similarly to the manner in which sec. 6 of a normal township is treated. All other sections should be treated as irregular, with subdivision-of-section lines protracted to mid-points on the boundaries of the quarter sections, except as a calculated proportional position for a sixteenth-section corner is made necessary by reason of conditions relating to the complementary area shown upon the original plat.

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

## Completing the Subdivision of a Partial Township Resulting From Fragmentary Surveys

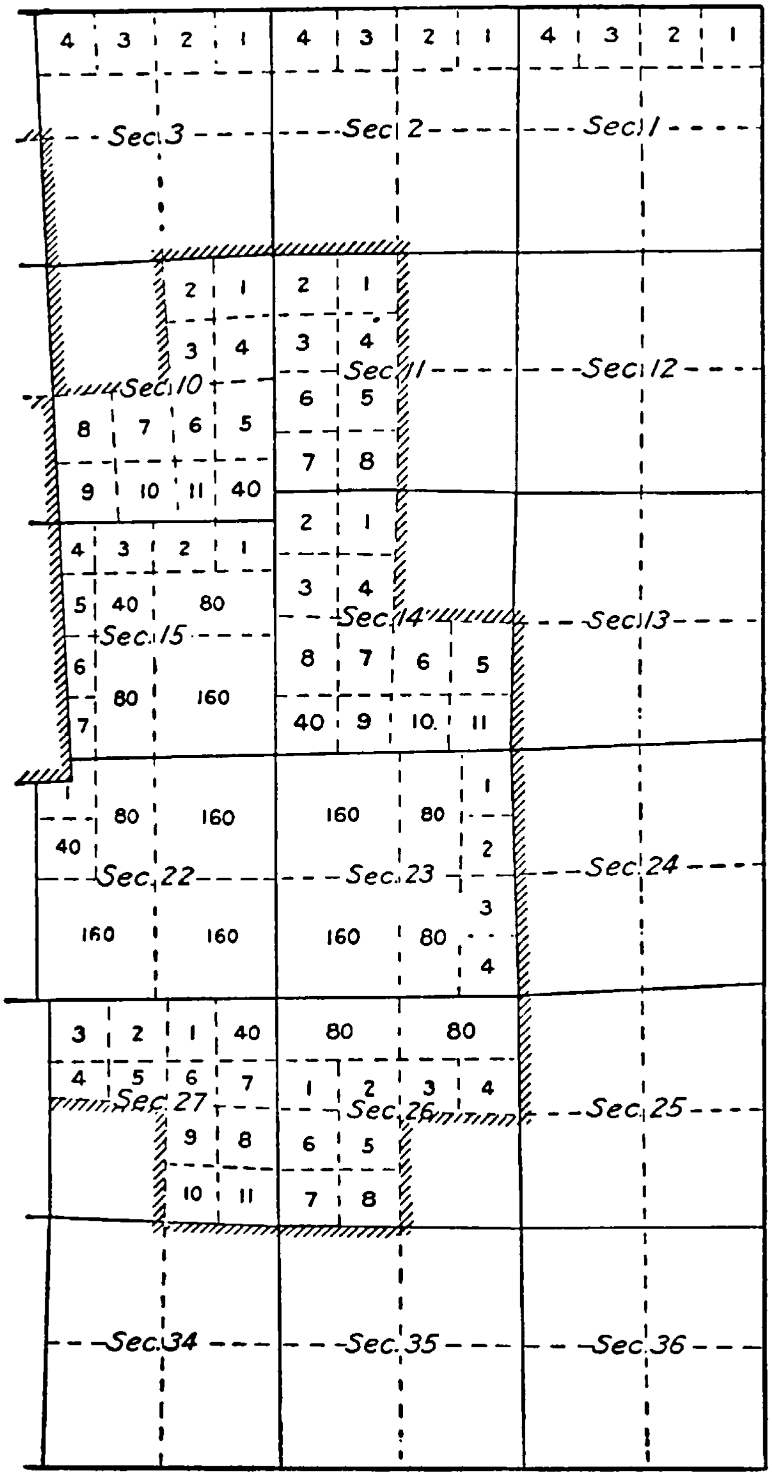
**225.** After the partially surveyed sections have been fully completed the engineer may proceed with the subdivision of the remaining portions of the township. Every condition represents a separate problem, and few specific rules would serve any purpose in guiding the engineer to a definite procedure. If no irregularities are to be found in the previously established lines the new survey may proceed normally, but if defective conditions are encountered the irregularities are not to be extended into unsurveyed sections any farther than necessary to incorporate the resulting fractional measurements into suitable fractional lots adjoining the former surveys. Preference should be given to extending all surveys from south to north and from east to west, but if a better control is available by reversing the procedure in one or both directions, thus resulting in a simpler and better survey in respect to minimizing the number of extra corners as well as fractional lots, such reversal of procedure is fully warranted. The principle relating to controlling coördinate measurements in two directions at right angles, as along the south and east boundaries of a township, may be applied to the subdivisional lines best suited to

Fig. 65 (West half)



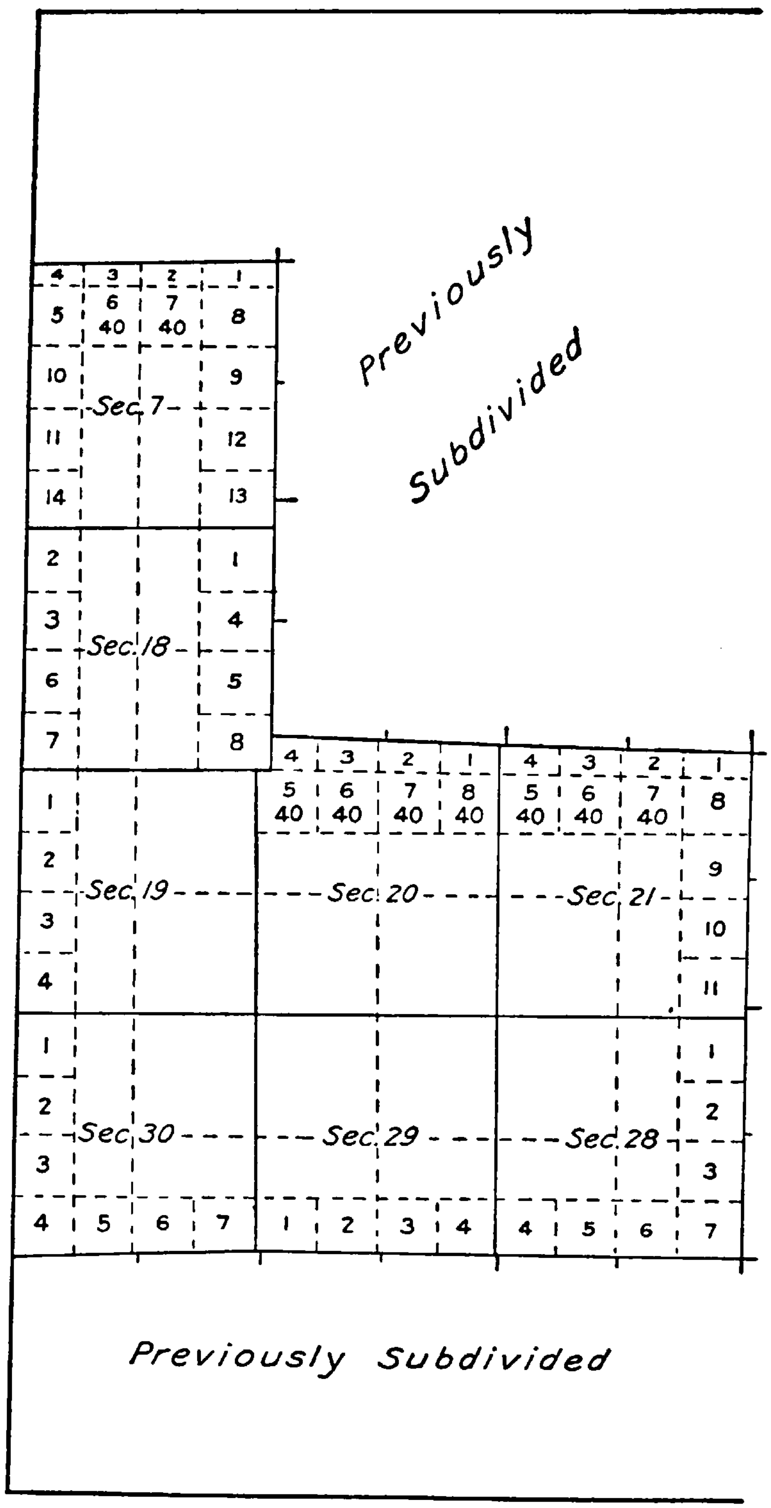

**Example showing the completion of partially surveyed sections, the subdivision of resulting from**

Fig. 65 (East half)



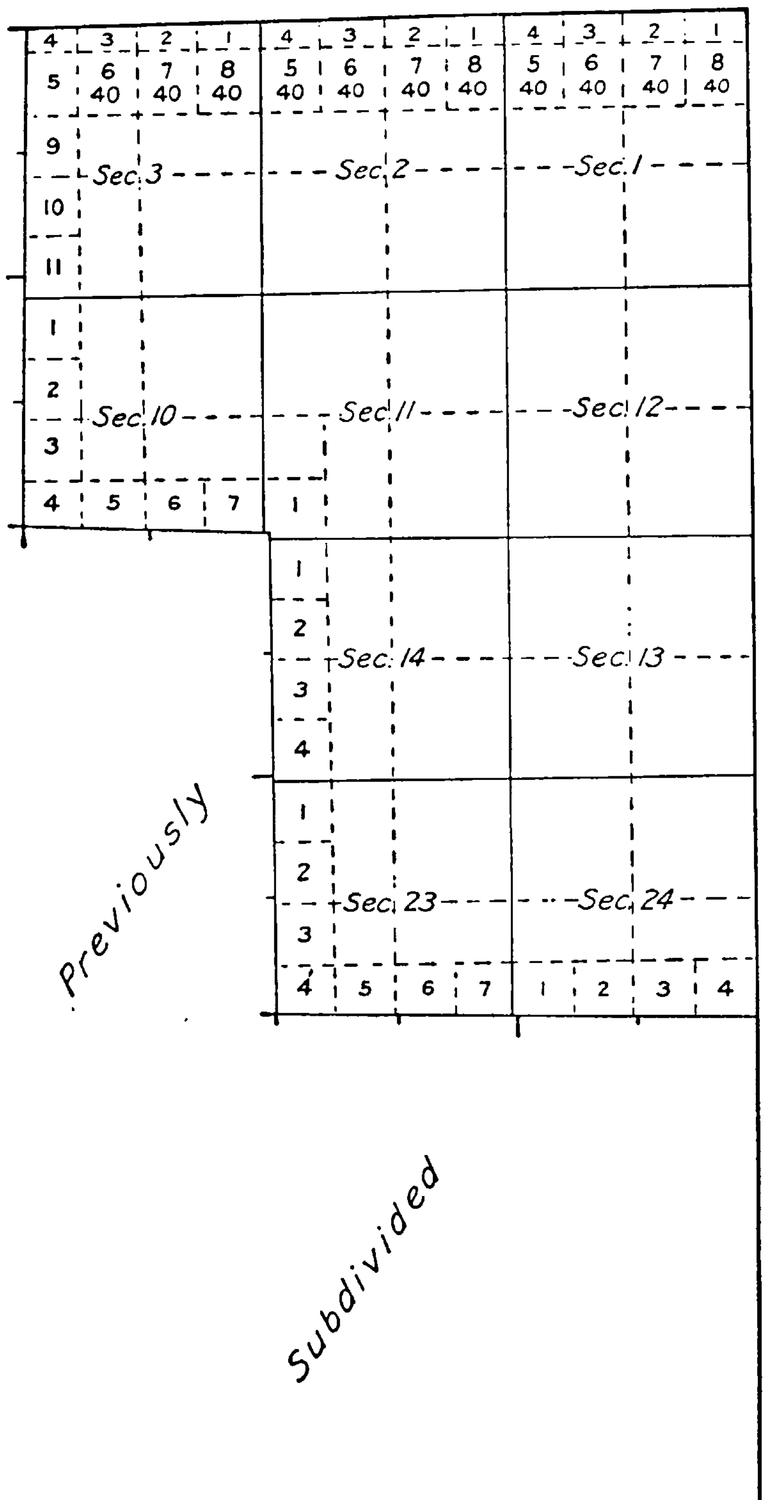

**fractional sections, and the completion of the subdivisional lines of a partial township fragmentary surveys.**

Fig. 66 (West half)




Example showing the completion of the subdivisional lines

Fig. 66 (East half)




of a partial township resulting from fragmentary surveys.

control the new surveys to be executed; and, if the selected bases are defective in alinement, in whole or in part, the new section lines may serve the function of a sectional guide meridian or a sectional correction line as required. The corners from which the new surveys are to be initiated and controlled in latitude and departure will be termed corners of four sections, or of two sections as appropriate, and where the terminal lines cannot be connected regularly with the previously established section corners by random and true line not exceeding 21′ from cardinal, a closing section corner will be established in full accord with the principle relating to the establishment of closing section corners on the north or west boundaries of a township where the latter lines are found to be defective in measurement. The fractional measurements of the closing section lines will be placed adjacent to the old surveys, and the distance from the closing section corner to the nearest original corner will be measured; the original lines forming the boundary of the lands to be surveyed will be retraced, as already provided, and the marks upon the original corners will be appropriately modified as necessary; new quarter-section corners marked to control the subdivision of the new sections will be established on the original lines at midpoints between the closing section corners, or at 40 chains from one direction, according to the manner in which a new section is to be subdivided.

There are generally two or more ways in which a fractional subdivision may be executed, but a careful study by the regional or public survey office of a sketch plat submitted by the cadastral engineer, representing existing conditions, will generally reveal the superiority of one method over another, and will avoid objectionable results as far as existing conditions relating to the original surveys will permit.

## MEANDERING

**226.** All navigable bodies of water and other important rivers and lakes (as hereinafter described) are to be segregated from the public lands at mean high-water elevation. The traverse of the margin of a permanent natural body of water is termed a meander line. In original surveys, meander lines are not run as boundary lines but for the purpose of defining the sinuosities of the bank or shore line, and for 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 case of a reservation boundary, does not entitle it to be called a meander line except where it closely follows the bank of a stream or lake. The legal riparian rights connected with meander lines do not apply in case of other irregular lines, as the latter are strict boundaries.

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. *Raide* v. *Dollar*, 203 P. 469 (1921). 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 and many of the State courts assert the principle that meander lines are not boundaries defining the area of ownership of tracts adjacent to waters. The general rule is that meander lines are not run 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, being the boundary. When by action of water the bed of the body of water changes, high-water mark changes and ownership of adjoining land progresses with it. *Lane* v. *United States*, 274 Fed. 290 (C. C. A. 5, 1921); *Harper* v. *Holston*, 205 P. 1062 (Wash. 1922).

Meander lines will not be established at the segregation line between upland and swamp or overflowed land, but at the ordinary high-water mark of the actual margin of the river or lake on which such swamp or overflowed lands border.

**227.** Practically all inland bodies of water pass through an annual cycle of changes from mean low water to flood stages, between the extremes of which will be found mean high water. In regions of broken topography, especially where bodies of water are bounded by sharply sloping lands, the horizontal distance between the margins of the various water elevations is comparatively slight, and the engineer will not experience much difficulty in determining the horizontal position of mean high-water level with approximate accuracy; but in level regions, or in any locality where the meanderable bodies of water are bordered by relatively flat lands, the horizontal distance between the successive levels is relatively great. The engineer will find the most reliable indication of mean high-water elevation in the evidence made by the water's action at its various stages, which will generally be found well marked in the soil, and in timbered localities a very certain indication of the locus of the various important water levels will be found in the belting of the native forest species.

Mean high-water elevation will be found at the margin of the area occupied by the water for the greater portion of each average year;

at this level a definite escarpment in the soil will generally be traceable, at the top of which is the true position for the engineer to run the meander line. A pronounced escarpment, the result of the action of storm and flood waters, will often be found above the principal water level, and separated from the latter by the storm or flood beach; another less evidence escarpment will often be found at the average low-water level, especially of lakes, the lower escarpment being separated from the principal escarpment by the normal beach or shore. While these questions properly belong to the realm of geology, they should not be overlooked in the survey of a meander line.

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

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

**229.** Inasmuch as it is not practicable in public-land surveys to meander in such a way as to follow and reproduce all the minute windings of the high-water line, the United States Supreme Court has given the principles governing the use and purpose of meandering shores in its decision in a noted case 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 water-course, and not the meander line as actually run on the land, is the boundary. *Railroad Co.* v. *Schurmeir*, 7 Wall. 273, 286–287 (1868).

**230.** The engineer will commence the meander line at one of the meander corners, follow the bank or shore line, and determine the true bearing and measure the exact length of each course, from the beginning to the next meander corner. All meander courses are to be taken or counted from the true meridian and will be determined with precision; "transit angles" showing only the amount of the deviation from the preceding course are not acceptable in field notes of meanders. For convenience the courses of meander lines should be adjusted to the exact quarter degree; meander lines are not strict boundaries and this method will give approximate agreement with the minute sinuosities of mean high-water elevation. Again, for convenience of platting and computation, the engineer is required to adopt turning points at distances of whole chains, or multiples of 10 links, with odd links only in the final course.

In cases where the engineer finds it impossible to carry his meander line along mean high-water mark, his notes should state the distance therefrom and the obstacles which justify the deviation. A table of latitudes and departures of the meander courses should be computed before leaving the vicinity, and if misclosure is found, indicating error in measurement or in reading courses, the lines should be rerun.

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

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

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## Rivers

**231.** 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 embraced in the class denominated "navigable," the right-angle width of which is 3 chains and upwards, will be meandered on both banks, at the ordinary mean high-water mark, by taking the general courses and distances of their sinuosities. Rivers not classed as navigable will not be meandered above the point where the average right-angle width is less than 3 chains, except when duly authorized.

Shallow streams, and intermittent streams without well defined channel or banks, will not be meandered, even when more than 3 chains wide. Tidewater streams will be meandered at ordinary mean high tide as far as navigable, even when less than 3 chains wide. Tidewater inlets and bayous will be recorded, and will be meandered if more than 3 chains in width, but when non-navigable will not be meandered when less than 3 chains wide.

## Lakes

**232.** The meanders of all lakes of the area of 25 acres and upwards, will be commenced at a meander corner and continued, as above directed for navigable streams; from said corner, the courses and distances of the entire margin of the same, and the intersections with all meander corners established thereon, will be noted.

In the case of lakes which are found to be located entirely within the boundaries of a section, a quarter-section line, if one crosses the lake, will be run from one of the quarter-section corners, on a theoretical course to connect with the opposite quarter-section corner, to the margin of the lake, and the distance will be measured; then at the point thus determined a "special meander corner" will be established. Where one or both of the opposite quarter-section corners cannot be established, and in all cases where the distances across a lake exceed 40 chains or the physical crossing is difficult, a special meander corner will be established on the meander line on the center line of the section at midpoint in departure or at midpoint in latitude, or proportionally in a fractional section. The temporary point set when running the meander line will be corrected to the true center line position for monumentation. If a meanderable lake is found to be located entirely within a quarter section, an "auxiliary meander corner" will be established at some suitable point on its margin, and a connecting line will be run from said monument to a regular corner on the section boundary. A connecting traverse line will be recorded, if one is run, but it will also be reduced to the equivalent direct connecting course and distance, all of which will be stated in the field notes, and the course and length of the direct connecting line will be shown on the plat of the survey.

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

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

## Islands

**233.** In the progress of the regular surveys every island above the mean high-water elevation of any meanderable body of water, excepting only those islands which may have formed in navigable bodies of water after the date of the admission of a State into the Union, will be definitely located by triangulation or direct measurement or other suitable process, and will be meandered and shown upon the official plat.

In the survey of the mainland fronting on any non-navigable body of water, any island opposite thereto, above mean high-water elevation, is subject to survey. Also, even though the United States may have parted with its title to the adjoining mainland, an island in any meandered body of water, navigable or non-navigable, known or proven to have been in existence at the date of the admission of a State into the Union, and at the date of the survey of the mainland, if omitted from said original survey, remains public land of the United States, and as such the island is subject to survey. This is because such islands were not then a part of the *bed* of the stream, 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 such islands is often more or less difficult, and 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 will be 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 indentification 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 will be extended as nearly in accordance with the plan of regular surveys as conditions will permit, and the usual township, section, quarter-section and meander corners will be established on the island. If an island falls in two sections only, the line between those particular sections should be established in its proper theoretical position based upon suitable sights and calculations. If an island falls entirely in one section, and is large enough to be subdivided (over 50 acres in area), a suitable sight or calculation will be made to locate on the margin of the island an intersection with the theoretical position of any suitable subdivision-of-section line, and at the point thus determined a "special meander corner" will be established. In the case of an island falling entirely in one section and found to be too small to be subdivided, an "auxiliary meander corner" will be established at any suitable point on its margin, which will be accurately connected with any regular corner on the mainland. Section 277. The direct course and length of the connecting line will be given in the field notes, together with all sights, measurements, triangulations and traverse lines upon which the calculation may be based. The course and length of the direct connecting line will be shown on the plat.

The meander line of an island will be surveyed in harmony with principles and rules heretofore stated; all township and section lines crossing the island will be shown on the plat; and, if the island is large enough to be subdivided, the subdivision will be accomplished by the protraction of suitable subdivision-of-section lines in their correct theoretical position.

Agricultural upland within the limits of swamp and overflowed lands should be so classified and shown upon the plat accordingly, but such land will not be meandered as an island.

## LIMITS OF CLOSURE

**234.** Under the general subjects of "township exteriors" and "subdivision of townships" certain definite limits were prescribed beyond which previously established surveys are classed as "defective," or in the case of new surveys corrective steps are required. Such limits constitute the standard of accuracy of the United States rectangular surveys, and, for convenience, have been variously referred to as the "rectangular limit," "limit for the control of new surveys," "limit relating to defective exteriors and section lines," "limits for subdivision," etc., each expression having been formed to suit the descriptive exigency of the text. A more general requirement known as the "limit of closure" will be applied as a test of the accuracy of the alinement and measurement of all classes of lines embraced in any closed figure incident to the public-land surveys, and corrective steps will be required wherever this test discloses an error beyond the allowable limit.

The "error of closure" of a survey may be defined, in general terms, as the ratio of the length of the line representing the equivalent of the errors in latitude and departure (as found by a table of latitudes and departures) to the length of the perimeter of the figure constituting the survey; but, with due regard for the controlling coordinate governing lines of a rectangular survey, pronounced accuracy in latitude will not be permitted to offset gross error in departure, or vice versa, and, in order to be consistent with this fundamental theory, a double test must be applied in place of the one expressed in general terms. The "limit of closure" fixed for the United States rectangular surveys may be expressed by the fraction $\frac{1}{452}$ provided that the limit of closure in neither latitude nor departure exceeds $\frac{1}{640}$, and where a survey qualifies under the latter limit the former is bound to be satisfied; thus an accumulative error of 12½ links per mile of perimeter, in either latitude or departure, will not be exceeded in an acceptable survey. The limit of closure as thus expressed may be applied to various specific conditions as heretofore stated.

The latitudes and departures of a normal section shall each close within 50 links; of a normal range or tier of sections, within 175 links; and of a normal township, within 300 links. The boundaries of each fractional section including irregular claim lines or meanders, or the meanders of an island or lake in the interior of a section, should close within a limit to be determined by the fraction $\frac{1}{640}$ when the error in either latitude or departure is considered separately; the same rule will be applied to all broken or irregular boundaries.

Engineers are required to compute all doubtful closings while in the field in the immediate vicinity of a particular line, or series of lines, in question, and to accomplish all necessary corrective work before concluding a survey.

Further attention is required on the subject of the accuracy of the current surveys when considered apart from the basic limit of 21′ departure from cardinal, or 50 links per mile allowable tolerance in measurement, when these are applied as a test of acceptable rectangularity, especially in initiating or closing, new surveys from, or upon, the approved older surveys that may lack modern requirements as to accuracy. The question relates to the matter of the dependability of the record direction and length of lines as currently returned, or the reliance that can be placed on those values. To what extent can those values be incorporated safely into other surveys that presume to set up definite standards of accuracy, or for mapping purposes of the various classes?

This is a test that bears directly on the improved technique which is now practiced in the making of the public land surveys. The latter has its own limit in the elements of cost and good judgment as to what may suitably be required in the region under survey. The question may be resolved further into what should be expected through the greater part of the work, for the type of country and justifiable costs, and that limit of tolerance which can be allowed where discrepancies become the disturbing factor in the closure.

When all elements are given due weight, good judgment calls for the average closures, and limits of tolerance, as expressed in the following tabulations:

| Character of country; basic economic value | Average closures in lat. & dep. per sq. mi., quartered as a tolerance in the direction and length of line per mile; accuracy to be attained in at least ⅔ of the survey | | Limit of tolerance in the closure, and in the direction and length of line per mile; not to be exceeded, nor to be approached in excess of ⅓ of the survey | | Closure limits when expressed by the usual fraction, and by linear ratio | |
|---|---|---|---|---|---|---|
| Class E: Extremely rough mountainous land, heavily timbered, dense undergrowth, exceptionally difficult to survey; value chiefly for grazing, timber, recreation, reclamation reservoirs, wildlife preserves, etc. | 25 lks. | 6.2 lks., 2′40″ | 50 lks. | 12.5 lks., 5′20″ | 1/905<br>1:1280 | 1/452<br>1:640 |
| Class D: Rough mountainous land, scattering timber, considerable undergrowth; value chiefly for grazing, timber, recreation, reclamation reservoirs, wildlife preserves, etc. | 16 lks. | 4.0 lks., 1′40″ | 25 lks. | 6.2 lks., 2′40″ | 1/1414<br>1:2000 | 1/905<br>1:1280 |
| Class C: Valuable mineral deposits, improved or cultivated lands, reclaimed agricultural lands, small tract areas; other areas where this accuracy can be attained at reasonable cost. | 8 lks. | 2.0 lks., 0′50″ | 16 lks. | 4.0 lks., 1′40″ | 1/2828<br>1:4000 | 1/1414<br>1:2000 |

*Requirements in Methods* [2]

Class E: Care in all measurement, orientation, and transit angles, as prescribed in chapter II.

Class D: Correction for tape expansion or contraction under extreme ranges of temperature, and better care in all measurements, orientation, and transit angles.

Class C: Approximate temperature correction; approximately uniform tension, but avoiding sag; stadia excluded; extra care in slope reductions; greater care in orientation; angular values 20″ or better and not accumulative.

## MARKING LINES BETWEEN CORNERS

**235.** The marking of a survey upon the ground in such a manner as to fix forever the position of the legal lines in relation to the earth's surface is the final step in the field work, and is accomplished in three ways, which, if well executed, will individually or collectively furnish the means of the identification of the survey at even remote future dates. Careful attention to these details is one of the most important phases of the engineer's field work. (*a*) The regular corners of the public-land surveys are marked by fixed monuments of specified character as described in chapter IV; (*b*) the relation of the officially surveyed lines to natural topographical features is recorded in much detail as hereinafter outlined, and again exemplified in the specimen field notes; and (*c*) the locus of the legal lines, wherever living timber is encountered, is plainly marked upon the forest trees, which is accomplished by the process of "blazing" and by "hack" marks.

A "blaze" is an artificial mark which is ordinarily made upon a tree trunk at about breast height, in which a flat scar is left upon the tree surface. The bark and a very small amount of the live wood tissue are removed, leaving a smooth surface which forever brands the tree. The size of the blaze depends somewhat upon the size of the tree, but is never made larger than the surface of an ax blade; a blaze 5 or 6 inches in height and from 2 to 4 inches in width is ample to mark any tree.

A "hack" is also an artificial mark which is ordinarily made upon a tree trunk at about breast height, in which a horizontal notch is cut into the surface of the tree. The notch is made "V-shaped," and is cut through the bark and well into the wood. Two hacks are cut in order to distinguish those made in the survey from accidental marks resulting from other causes; a vertical section of the completed official hack mark resembles a "double-V" ($\lessgtr$) extending across a tree from 2 to 6 inches in length, depending upon the diameter of the tree. The "hack" and "blaze" marks are equally permanent, but so different in character that one mark should never be mistaken for the other.

[2] Precision surveys in metropolitan areas are regarded as Class A cadastral surveys; townsite surveys (sec. 480) are termed Class B cadastral surveys.

The marking of trees along the surveyed lines is required by law as positively as the erection of monuments (R. S. sec. 2395; 43 U. S. C., sec. 751). All lines on which are to be established the legal corners will be marked after this method, viz: Those trees which may be intersected by the line will have two hacks or notches cut on each of the sides facing the line, without any other marks whatever. These are called sight trees or line trees. A sufficient number of other trees standing within 50 links of the line, on either side of it, will be blazed on two sides quartering toward the line, in order to render the line conspicuous, and readily to be traced in either direction, the blazes to be opposite each other coinciding in direction with the line where the trees stand very near it, and to approach nearer each other toward the line the farther the line passes from the blazed trees.

Due care will ever be taken to have the lines so well marked as to be readily followed, and to cut the blazes plainly enough to leave recognizable scars as long as the trees stand. This can be accomplished by blazing just through the bark into the live wood tissue. Where trees 2 inches or more in diameter occur along a line, the required blazes will not be omitted. Where trees have branches growing to the ground, the blazes will be omitted unless it is necessary to remove the branches to permit sighting.

Lines are also to be marked by cutting away enough of the undergrowth to facilitate correct sighting of instruments. Where lines cross deep wooded valleys, by sighting over the tops, the usual blazing of trees in the low ground when accessible will be performed. 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 will be marked only with reference to the established true line, and where lines are run by the "random and true" line method, the marking of line trees and the blazing will be accomplished by returning over the line after all corrections or adjustments to the final line are definitely known. A sufficient number of temporary stakes should be set along a random line to render it generally unnecessary to rerun the true line instrumentally merely for the purpose of blazing the line through timber, as this can usually be accomplished by properly estimating the distance from the temporary stakes, but intersections with line trees will be made with precision, and distances thereto accurately measured.

## SUMMARY OF OBJECTS TO BE NOTED, AND SKETCHES

**236.** The field notes and plat of a survey are designed to furnish not only a technical record of the procedure, but also of equal importance a report upon the character of the land, soil and timber traversed by the survey, and a detailed schedule of the topographical features along every line, with accurate connections showing the relation of the rectangular surveys to other surveys, to natural objects and to improvements. A triple purpose is thus served: (*a*) the technical procedure is made a matter of official record; (*b*) general information relating to a region is gathered; and, (*c*) the "calls" of the field notes and the representations of the plat in respect to objects along the surveyed lines furnish important evidence by which the locus of the survey becomes practically unchangeable as contemplated by law.

The specimen field notes and plats are intended to standardize the form of record, and many special matters relating to these subjects are brought together in chapters VIII and IX, but before concluding the special questions concerning rectangular surveys it is deemed expedient to outline the technical and topographical features which are to be carefully observed and recorded in the field during the progress of the public-land surveys:

1. The precise course and length of every line run, noting all necessary offsets therefrom, with the reason for making them, and method employed.

2. The kind and diameter of all bearing trees, with the course and distance of the same from their respective corners, and the markings; all bearing objects and marks thereon, if any; and the precise relative position of witness corners to the true corners.

3. The kind of material of which 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 all trees which it intersects, and their markings.

5. Intersections by line of land objects. The distance at which the line intersects the boundary lines of every reservation, townsite, or private claim, noting the exact bearing of such boundary lines, and the precise distance to the nearest boundary corner; the center line of every railroad, canal, ditch, electric transmission line, or other right-of-way across public lands, noting the width of the right-of-way and the precise bearing of the center line; the change from one character of land to another, with the approximate bearing of the line of demarcation, and the estimated height in feet of the ascents and descents

over the principal slopes typifying the topography of the country traversed, with the direction of said slopes; the distance to and the direction of the principal ridges, spurs, divides, rim rock, precipitous cliffs, etc.; the distance to where the line enters or leaves heavy or scattering timber, with the approximate bearing of the margin of all heavy timber, and the distance to where the line enters or leaves dense undergrowth.

6. Intersections by line of water objects. All unmeandered rivers, creeks and smaller water-courses which the line crosses; the distance measured on the true line to the center of the same in the case of the smaller streams, and to both banks in the case of the larger streams, the course downstream at points of intersection, and their widths on line, if only the center is noted. All intermittent water-courses, such as ravines, gulches, arroyos, draws, dry-drains, etc.

7. The land's surface; whether level, rolling, broken, hilly or mountainous.

8. The soil; whether rocky, stony, gravelly, sandy, loam, clay, etc.

9. Timber; the several kinds of timber and undergrowth, in the order in which they predominate.

10. Bottom lands to be described as upland or swamp and overflowed, as contradistinguished under the law, noting the extent and approximate position of the latter, and depth of overflow at seasonal periods. The segregation of lands fit for cultivation without artificial drainage, from the swamp and overflowed lands, where the latter are subject to selection by the States, is always accomplished by legal subdivision, and any smallest legal subdivision is classified as all upland or all swamp and overflowed land accordingly as more than half of the same may be of the character of the one or of the other class of lands; bottom lands will be classified with special consideration to these matters.

11. Springs of water, whether fresh, saline, or mineral, with the course of the stream flowing therefrom. The location of all streams, springs, or water-holes, which because of their environment may be deemed to be of value in connection with the utilization of public grazing lands, and which may be designated as public watering places, will be specially noted.

12. Lakes and ponds, describing their banks, tributaries and outlet, and whether the water is pure or stagnant, deep or shallow.

13. Improvements; towns and villages; post offices; Indian occupancy; houses or cabins, fields, or other improvements; mineral claims; mill-sites; United States location monuments, and all other official monuments not belonging to the system of rectangular surveys; will be located by bearing and distance or by intersecting bearings from given points.

14. Coal banks or beds, all ore bodies, with particular description of the same as to quality and extent; all mining surface improvements and underground workings; and salt licks. All reliable information that can be obtained respecting these objects, whether they be on the line or not, will appear in the general description.

15. Roads and trails, with their directions, whence and whither.

16. Rapids, cataracts, cascades, or falls of water, in their approximate position and estimated height of their fall in feet.

17. Stone quarries and ledges of rocks, with the kind of stone they afford.

18. Natural curiosities, petrifactions, 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, immediately preceding the general description (item 20), the record of the observations as required in section 40, including the observed local attraction within the area of the survey. The value at the township or section corner at the southeasterly point of the survey, corrected to the mean magnetic declination, will be shown on the plat.

20. *General description.*—The above information will be summarized by townships in a general description which will be made the concluding part of the field notes of every survey. The general description will be made to embrace many more comprehensive details in regard to the characteristics of the region than is feasible to cover as an intimate part of the technical record of the survey, as follows:—

*Land.*—A general outline of the drainage and topographical features of the township and approximate range of elevation above sea level.

*Soil.*—The prevailing and characteristic soil types. (See special reference to soil classification, sections 536 to 539, chapter VII, and appendix VII.)

*Timber.*—The predominant forest species, age, size, condition, etc.

*Evidence of mineral.*—All known bodies of mineral, and lands whose formation suggests mineral-bearing characteristics, especially with reference to lands of volcanic or igneous origin, will be listed by appropriate legal subdivision, with brief description of the mineral indications. On the other hand, if the engineer finds no apparent indication of mineral deposits, a report to that effect will be embodied in the general description.

*Watering places.*—The areas embracing all streams, springs, or water holes as may be of special value as public watering places, in connection with the utilization of public grazing lands, will be listed by appropriate legal subdivision, with brief description of the nature of such water supply.

*Settlement.*—The extent of the settlement at the time of the survey.

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*Industry.*—The industrial possibilities of the township, especially as to the adaptability of the region to agricultural pursuits, stock raising, lumbering, mining, or other profitable enterprise.

*Special.*—All exceptional steps in the technical process of the survey, and other special matters required in paragraphs Nos. 1 to 19, inclusive, of the above summary, not otherwise suitably recorded will be reported in the general description.

In addition to the field notes the engineers are required to prepare, as the work progresses, an outline diagram showing the course and length of all established lines with connections, and a topographical sketch embracing all features usually shown upon the completed official township plat. These maps will be made to scale, drawn in pencil only, if desired, and will be kept up with the progress of the field work. The interiors of the sections will be fully completed; the topographical features will be sketched with care while in the view of the engineer, and the position within the section of the various details which are to be shown on the completed plat will be located with an accuracy commensurate with their relative importance. The design of the specimen township plat will be followed closely in the preparation of the outline diagram and topographical sketch plat, except that it will generally be desirable to employ a separate sheet for each of the two purposes. These maps will then form the basis of the official plat, the ultimate purpose of which is a true and complete graphic representation of the public lands surveyed.

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 section 462, paragraph 8; and in sections 602 to 617, inclusive.

# Chapter IV

# CORNER MONUMENTS



## LEGAL SIGNIFICANCE OF THE MONUMENT

**237.** The purpose of the monumentation is to establish the permanent marking of the lines, and to fix the corner positions so that the location of the lands may always be definitely known. The survey embraces certain definite technical procedure, also the marking of certain fixed points, as will be described in this chapter, though the establishment of a survey may not be termed completed until the field notes and plat and every detail of the operation have been accepted, as contemplated by law, by the Director, Bureau of Land Management.

The law provides that the original corners established during the process of the survey shall forever remain fixed in position, even to disregarding technical errors in the execution of the survey, where discrepancies may have passed undetected prior to the acceptance of the survey. As an aid to the permanence, the Congress provides for the purchase of durable material for the corner monuments, also a penalty for the defacing of any marks relating to the survey (fly leaf *V*). If it were possible to carry out the full intent of the surveying laws in regard to these particulars, the most troublesome of the subsequent problems relating to the survey would be avoided.

The courts attach major importance to evidence relating to the original position of the monument, such evidence being given far greater weight than the record relating to bearings and lengths of lines. It is the purpose that the monuments shall serve every necessary requirement for the identification of the survey. The legal importance as thus briefly outlined, makes it mandatory upon the chief of the field party to exercise constant diligence in the workmanlike construction of lasting monuments, and alertness in skillfully relating the same with natural objects or improvements, to the end that the greatest possible permanence may be secured.

**238.** If the engineer is called upon to alter the condition of a previously established monument, the utmost regard should be shown for the evidence of the original location; the monument will 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 thereto.

**239.** Prescribed monuments are employed to mark the position of the quarter-section, section, township and meander corners, appropriate to the subdivision of the public lands; also at such sixteenth-section corners as the requirements of the written special instructions or the exigencies of the survey of fractional sections may demand; also at all angle points along an irregular boundary line, and at intermediate intervals of 40 and 80 chains along such limiting boundary. A more extended discussion of the subject of angle points and other monuments to be established upon irregular boundaries will be found in chapters VI and VII.

Additionally, monumentation will be established as needed down to the corners of 2½-acre, or ¼ ¼ ¼ ¼-section, as required in the subdivision of sections into units smaller than the regular quarter-quarter section, when stipulated in the special instructions, or when making the eliminations provided in sections 253, and 489 to 495, inclusive. Marks are as detailed in section 274.

General departures from the use of the regulation monument are permitted only when authorized in the special instructions, under conditions that may warrant such alternatives. Among them are the need for more durable monumentation in important areas; substitutions in those cases where the conditions at the time of survey make it impracticable to procure, within the available time limit, the quantity of the regulation monuments that would be required; or where the difficulties of transportation to the point of use render it more practicable to adopt one of the approved substitutes. Limited departures because of site conditions may be made as approved by the regional administrator.

**240.** The position of every corner monument will be evidenced by the best of such accessories as may be available, and where the corner point itself can not be marked in the usual manner an appropriate witness corner or reference monument will be established. Sections 249 to 254, inclusive. A witness meander corner will be established upon secure ground wherever the intersection of a surveyed line with the mean high-water elevation of a meanderable body of water falls at a point where the monument would be liable to destruction. Section 228.

**241.** The field notes relating to the establishment of a monument will be introduced at the logical place where the true position for the corner is indicated as having been attained.

The description of the monument will embrace: (*a*) The significance of its position; (*b*) length and diameter of an iron post; or the kind and length, width and breadth of a stone; or the species and the breast height diameter of a tree; (*c*) the depth set in the ground, with mention of additional support if any; (*d*) the markings upon the monument; and (*e*) the nature of the accessories, including character, size, position, and markings.

## CORNER MATERIAL

**242.** The Bureau of Land Management has adopted a standard iron post for monumenting the public-land surveys, which will be generally used unless exceptional circumstances warrant the use of other material. This practice is deemed so important that no substitutions are permitted excepting as provided in section 239, and, if authorized, a statement will be given in the field notes, in explanation as to why the standard iron posts were not employed.

The post is made from wrought iron pipe, zinc coated, 2 inches inside diameter, which is cut into lengths of 30 inches; one end of the pipe is split for about 4 or 5 inches, and the two halves are spread to form flanges or foot plates; a brass cap is securely fastened to the top. The pipe is filled with concrete.

Brass tablets are supplied for placing in rock outcrop, and for imbedding in concrete monuments. The tablet is 3¼ inches in diameter, and has a stem 3½ inches long; the top bears the same official inscription as that of the cap of the iron post.

## CONSTRUCTION OF MONUMENTS AND MARKING FOR IDENTIFICATION

**243.** The caps of the iron posts are to be suitably and plainly marked with steel dies at the time when used; the posts will be set in the ground about three-fourths of their length; and earth and stone, if the latter is at hand, will be tamped into the excavation to give the post a solid anchorage.

**244.** Durable native stone may be substituted for the model iron post, if the procedure has been duly authorized, but no stone will be used which measures less than 20 inches in length, or less than 6 inches in either of its minor dimensions, or less than 1,000 cubic inches in volume. A stone should always be selected with regard to its durability when exposed to the usual weathering influences. Stone will not be used as a corner monument where its position falls among large quantities of loose surface stone or slide rock.

**245.** A stone will be suitably and legibly marked with a steel chisel or punch with such letters, figures, grooves or notches, as may be required, and will be set firmly in the ground about three-fourths of its length.

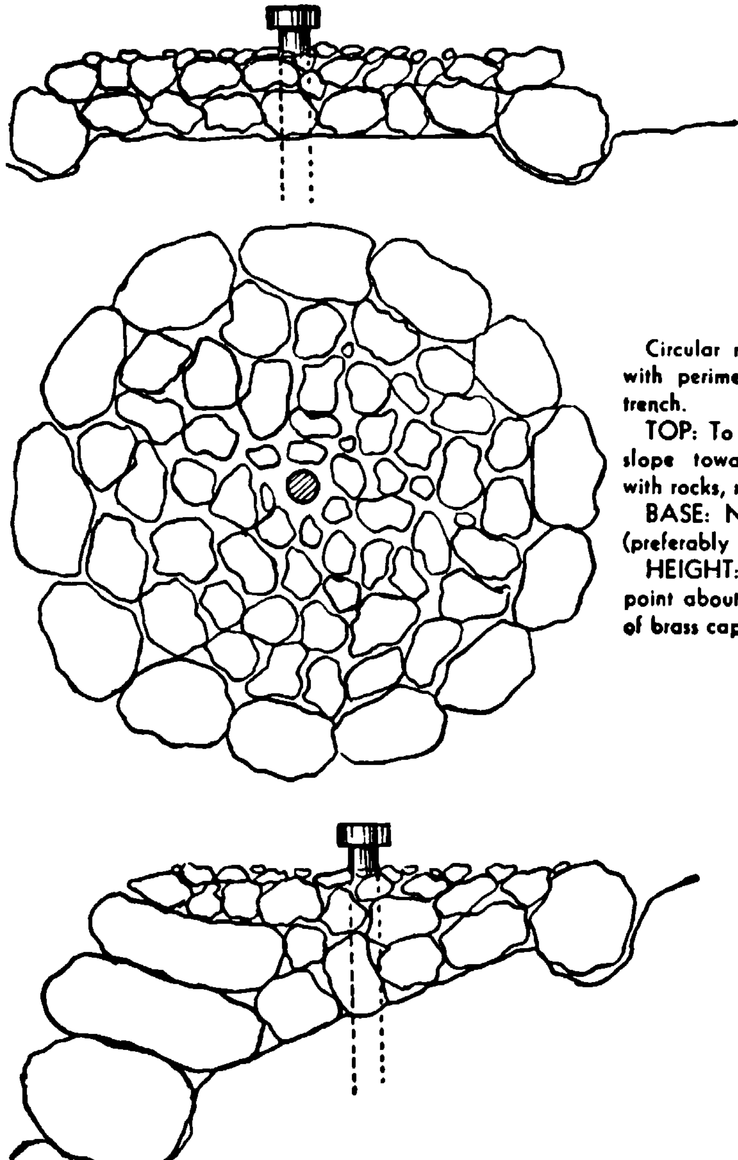
**246.** Both iron post and stone monuments will always be set the usual depth in the ground unless it is impossible to complete the excavation, in which case the monument will be planted as deep as conditions will permit, and the necessary support will be secured by a stone mound. Section 327.

In loose, wind-blown soil, much more stability will be given the monument 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. Stone or clay may not be available. However, the location may be of enough importance to justify the procurement of cement, to be used either for the making of concrete to surround the iron post, or merely to mix with the loose dry-sand, which when moistened, and after the mixture hardens, will at least prevent the blowing of the soil.

It is difficult to construct a stable monument in marshland; underpinning may be required in some cases, or some other special means for supporting the iron post. The alkaline soils and salts, salt-water marshes, wind-blown salts in the coastal areas, and the organic-acid ground-water of some swamp areas, all attack both ordinary iron and concrete, and will destroy them in a few years. Section 239.

**247.** Where the corner point falls upon surface rock, preventing excavation, a cross (X) will be cut at the exact corner point, and, if feasible, the monument will be erected in the same position, supported by a large stone mound of broad base, so well constructed that it will possess thorough stability.

The tablet may be 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. The cementing to be permanent must be done with clean first-class materials, carefully proportioned. The marks to be made



**STONE MOUND**

Circular mound of stones around post with perimeter of larger stones set in a trench.

TOP: To be nearly level or with slight slope toward outer edge. Constructed with rocks, rubble, and tamped soil.

BASE: Not less than 3 ft. diameter (preferably 4 to 6 ft. dia.).

HEIGHT: From the ground surface to a point about 2 or 3 inches below the base of brass cap.

Stone mound, protecting the monument.

upon the tablet, and the selection and marking of the accessories will be the same as for iron-post monuments.

**248.** Where the corner point falls exactly at the position occupied by a tree, the tree will be appropriately marked for the corner, even where it appears to be fully matured and shows indications that in a few years it may begin to deteriorate, care being taken to secure the full quota of accessories, including the use of reference monuments. Section 297.

Sound trees of a hardy species, and yet too small to receive the usual marks without undue injury, will be marked with an "X" only, at breast height, on the *south* side. On the smooth barked trees use a scribe cutting lightly into the bark; on the rough barked trees, two axe cuts reaching just into the live wood tissue.



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## WITNESS CORNERS, REFERENCE MONUMENTS, AND WITNESS POINTS

**249.** A *witness corner*, by conventional usage, is a monumented point usually on a line of the survey and near a corner. It is employed in situations where it is impracticable to occupy the site of a corner.

When the true point for a corner falls upon 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 can not be occupied, a witness corner will be established at some suitable point where the monument may be permanently constructed, but preferably on a line of the survey.

Usually only one witness corner will be established in each instance and it will be located upon any one of the surveyed 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 limiting distance, that can be occupied and marked, a witness corner may be located in any direction within a distance of 5 chains.

**250.** A *reference monument* is an accessory and is employed in situations where the site of a corner is such that a permanent monument can not 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 (×) stone or some suitable article will be buried in the ground at the true corner point. At least two reference monuments will be established at suitable places outside of the roadway, if bearing trees or a nearby bearing object are not available. Due allowance should be made for probable grading, cuts or fills, or for other road improvement; placing the reference monuments where they are not liable to be disturbed.

The surface of gravel, macadam, or bituminous-topped roads should not be dug into without the approval of the proper authority, but if permission is granted, a deposit at the true corner point may be made. In case of hard surface, a tablet, copper bolt, large nail, or cross (×) may be placed at the true point if that has been permitted. In any event such corner can be occupied, and may be marked temporarily by paint, or scratch. Two reference monuments will be established, following the practice for highway surveys to the extent that is feasible, and will ordinarily suffice in the public-land surveying practice, but four may be employed if that seems to be required. If practicable, when two monuments are employed they will be placed equidistant and in opposite directions; where four are employed they will be placed in opposite directions in the four quadrants.

**251.** A *witness point* is a monumented station on a line of the survey and is employed 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; and for marking the end stations of a long triangulation 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.

**252.** Monuments marking corners that fall in cultivated fields or meadows should be so constructed as to interefere with farming operations as little as possible and should conform to the wishes of the owner in so far 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 will be employed if available within a reasonable distance and careful bearings to one or more distant objects will be recorded if available.

**253.** All of the lines of a survey will be completed in the regular manner if the true point for a corner is accessible. Where the point cannot be attained or occupied, a line connecting with the true corner may be regarded as surveyed if it has been completed by the running and measurement of a suitable offset or traverse, resulting in a closed figure which approaches the true corner point within the limits prescribed for the setting of a witness corner.

In those surveys that are to be continued over rough mountainous terrain or impassable marsh, by triangulation, stadia measurement, or offset, passing over one or more regular corner positions that cannot be occupied, the beginning and end stations on the true line will be marked by a witness corner if within 10 chains of an omitted corner, or by a witness point if more than that distance.

On the other hand if the survey is to be discontinued because of rough mountainous terrain, waste or useless lands, or impassable marsh, the whole of the section will be regarded as surveyed if the section lines have been measured and all section and quarter-section corners are monumented in place or are witnessed within the prescribed limits. If there is no suitable place for a witness section corner within the prescribed limits, one or more legal subdivisions will be eliminated as provided in sections 489 to 497, incl.

**254.** The field notes will show every detail of the relation of a witness corner or reference monument to the true point for a corner; a witness point will be duly recorded. In the case of witness corners, the direct

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connecting course and distance will be shown upon the plat of the survey. If there are many witness corners, and in all cases of difficult plat lettering, where it may interfere with the plat subject, the data relating to the direction and distance may be indicated by marginal memorandum or tabulation. Reference monuments and witness points will not be shown or tabulated on the plat.

## MARKING CORNER MONUMENTS

**255.** All classes of corner monuments are to be marked in accordance with a system hereinafter described which has been devised to furnish a ready identification of the position of the monument which bears the marks. Capital letters and Arabic figures are employed to mark iron post 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 employed to convey the information. The notches and grooves relate, in the case of an exterior corner, to the normal number of miles from the monument to the adjoining township corners; in the case of a subdivisional corner, to the normal number of miles from the monument to the east and south township boundary lines, as hereinafter described more fully, thus furnishing the means of ascertaining the appropriate section numbers.

**256.** All markings should be accomplished neatly, distinctly, and durably; the marks are to be carefully arranged. An assortment of steel dies, stone chisels and punches, and timber scribes, in good condition for use, should always be at hand.

**257.** A witness corner monument will be constructed the same as a regular corner for which it stands. The marks on an iron post monument will be similar to those on a regular corner with the addition of the letters "W C" and an arrow pointing to the true corner. On a stone, "W C" (only), on the south face if the true line field notes are to read running north; on the east face if running west. On a tree, two hacks each on the north and south sides on a meridional line; on the east and west sides if it is a latitudinal line; both the same as a line tree, which serves exactly the same purpose. Sections 235; 236, paragraph 4; 299.

A reference monument normally will be marked the same as a bearing tree located in a similar position with the addition of an arrow pointing to the true corner, 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 will be marked only with the letters "R M" and an arrow pointing to the true corner position.

Witness Point: The marks on the iron post, "W P" (only), at the top, the date at the bottom, and S with the section number (only), on each of the halves appropriate for the line of the survey. On a stone, "W P" (only), on the face as in marking a witness corner. A tree that is intersected by the true line will be marked as a line tree, which of course has the same function as that intended for a witness point.

*All accessories*, section 318.

**258.** The following schedule is an index of the ordinary markings common to all classes of corners and accessories:—

| *Marks* | *To indicate—* | *Marks* | *To indicate—* |
|---|---|---|---|
| A M | Amended, sec. 163. | R | Range. |
| A M C | Auxiliary meander corner. | R M | Reference monument. |
| A P | Angle point. | S | Section. |
| B O | Bearing object. | S | South. |
| B T | Bearing tree. | S C | Standard corner. |
| C | Center. | SE | Southeast. |
| C C | Closing corner. | S M C | Special meander corner. |
| E | East. | SW | Southwest. |
| L M | Location monument. | T | Township. |
| M | Mile. | TR | Tract. |
| M C | Meander corner. | W | West. |
| N | North. | W C | Witness corner. |
| NE | Northeast. | W P | Witness point. |
| NW | Northwest. | ¼ | Quarter section. |
| P L | Public land (unsurveyed). | 1/16 | Sixteenth section. |

## MARKS ON IRON POST MONUMENTS

**259.** The markings upon the brass cap of an iron post should always be made to read from the south side of the monument, and all iron posts will be marked with the year number at the date when established.

**260.** *Standard township corners* are to be marked "S C" and the township on the north half, and the ranges and sections in the proper quadrants; as for example:

S C
T 25 N
R 17 E | R 18 E
S 36 | S 31
1916

**261.** *Closing township corners* are to be marked "C C" on the half from which the closing line approaches the monument, with the township (or range) on the same half, and the ranges (or townships) and sections in the proper quadrants; also (as far as known at the time) the township, range and section, or the initials or abbreviation of the State, reservation, grant or private claim, upon which the township exterior closes; as for example:

T25N R17E
S 36
S1 | S6
R17E | R18E
T [illegible] N
CC
1916

T24N
T24N | R17E
S31
~~S36~~ — CC
S6
R16E | T23N
1916

T20N
R120W
S32
UTAH — CC
S5
T19N
1916

262. *Corners common to four townships* are to be marked with the townships on the north and south halves, the ranges on the east and west halves, and the sections in the four quadrants; as for example:

T23N
R17E | R18E
S36 | S31
S1 | S6
T22N
1916

263. *Corners common to two townships only* are to be marked with the township (or range) common to both on the proper half, and the ranges (or townships) and sections in the proper quadrants; also (as far as known at the time) the township, range and section upon the opposite half; as for example:

T3N
R7W
S36 | T2N
R6W
S1 | S6
T2N
1916

T14S
R7W | R6W
S36 | S31
T15S R7W S1
1916

264. *Corners referring to one township only* are to be marked with the township, range and section in the particular quadrant which is concerned; also (as far as known at the time) the township, range and section upon the opposite part; as for example:

T20N R5W
T19N | S31
R6W
S1
1916

T23N
R19W
S36
T22N R19W
S1
1916

T35N
R44E
S31
T34N R43E
S1
1916

265. *Standard section corners* are to be marked "S C" and the township and range on the north half, and the sections in the proper quadrants; as for example:

SC
T25N | R17E
S35 | S36
1916

**266.** *Closing section corners* are to be marked "C C" and the township and range on the half from which the closing line approaches the monument, and the sections in the proper quadrants; also (as far as known at the time) the township, range and section, or the initials or abbreviation of the State, reservation, grant or private claim, upon which the section line closes, with the exception that in the case of an interior closing section corner, the township and range numbers will not be repeated; as for example:

T 25 N R 17 E<br>
S 35<br>
S 2 | S 1<br>
T 24 N | R 17 E<br>
CC<br>
1916

TR 48<br>
S 26 | S 25<br>
T 12 N | R 5 W<br>
CC<br>
1916

T 14 N<br>
S 10<br>
S 16 | CC<br>
S 15<br>
R 16 E<br>
1916

**267.** *Corners common to four sections* are to be marked: (*a*) On an exterior, with the township (or range) common to the adjoining townships, the ranges (or townships) upon the opposite sides of the exterior, and the sections; and (*b*) a subdivisional corner, with the township, range and sections; all appropriately set forth as follows:

T 25 N<br>
R 17 E | R 18 E<br>
S 12 | S 7<br>
S 13 | S 18<br>
1916

T 26 N R 17 E<br>
S 35 | S 36<br>
S 2 | S 1<br>
T 25 N<br>
1916

T 25 N R 17 E<br>
S 23 | S 24<br>
S 26 | S 25<br>
1916

**268.** *Section corners common to two sections only* are to be marked with the township and range on the half facing the sections to which the corner belongs, and the sections in the proper quadrants; also (as far as known at the time) the township, range and section upon the opposite half, except that in the case of an interior corner, the township and range numbers will not be repeated; as for example:

T 14 S | T 14 S<br>
S 12 |<br>
| R 18 E<br>
S 13 |<br>
R 17 E | S 7<br>
1916

T 27 N | R 17 W<br>
S 31 | S 32<br>
T 26 N R 17 W<br>
S 6<br>
1916

T 14 S | R 20 W<br>
S 10 | S 11<br>
S 14<br>
1916

**269.** *Section corners referring to one section only* are to be marked with the township, range and section in the particular quadrant which is concerned; also (if known at the time) the section upon the opposite part; as for example:

| S 10 / T 84 N / R 73 W / S 16 / 1916 | T 27 N / R 16 W / S 17 / S 20 / 1916 | S 28 / T 57 N / R 63 W / S 34 / 1916 |
|---|---|---|

**270.** *Standard quarter-section corners* are to be marked "S C ¼" and the section, all on the north half; as for example:

SC
¼ S 36
1916

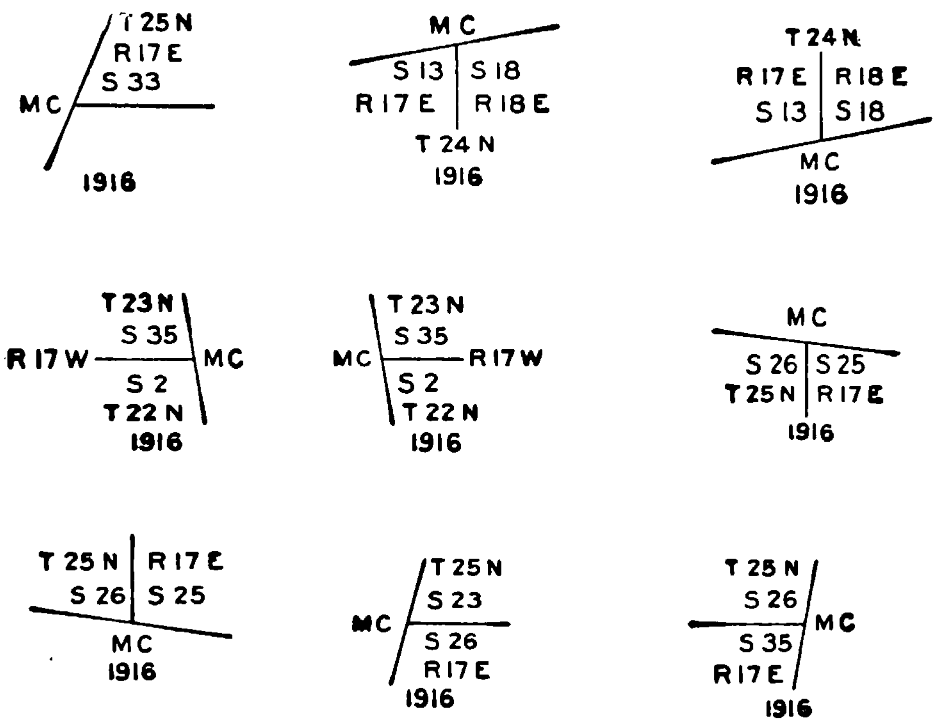
**271.** *Quarter-section corners of maximum control* are to be marked (*a*) on a meridional line, "¼" on the north, and the sections on the east and west halves; and, (*b*) on a latitudinal line, "¼" on the west, and the sections on the north and south halves; as for example:

| ¼ / S 13 \| S 18 / 1916 | ¼ S 21 / S 28 / 1916 |
|---|---|

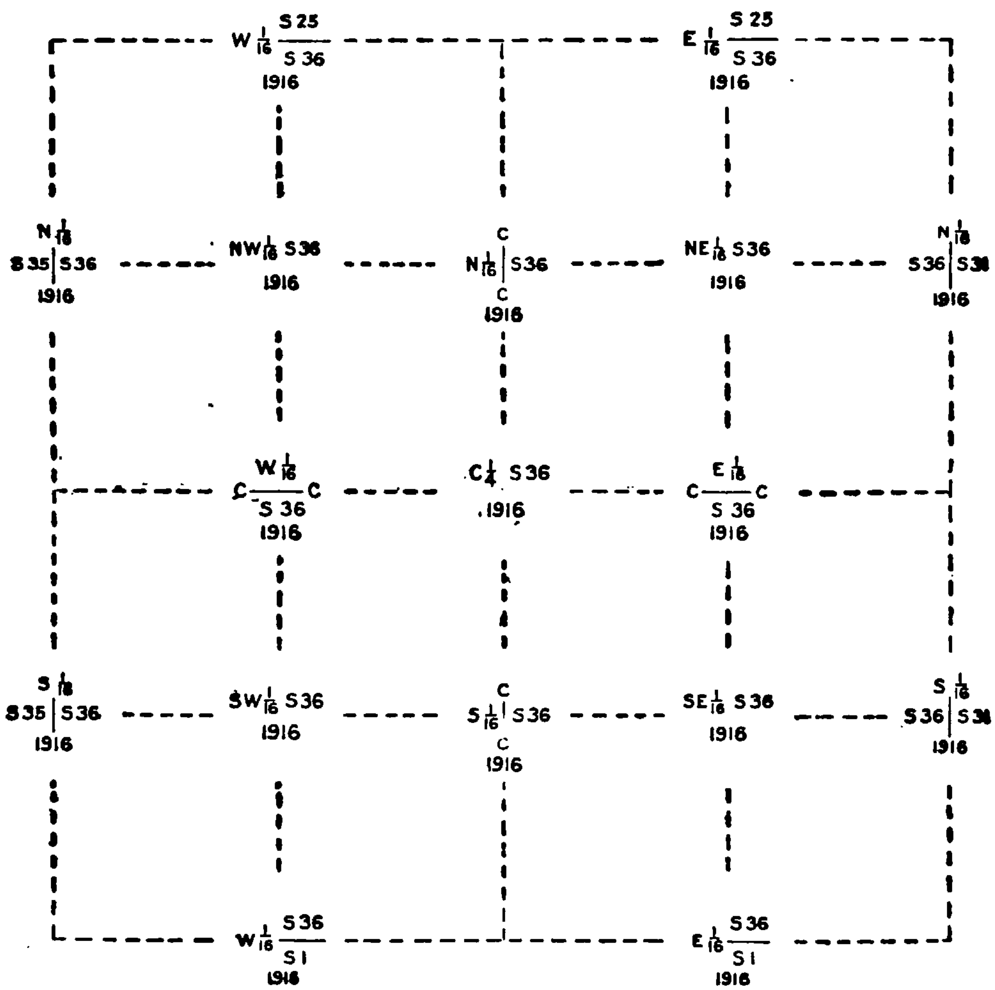
**272.** *Quarter-section corners of minimum control* are to be marked "¼" and the section, all on the half toward the particular section which is concerned; as for example:

| ¼ S 4 / 1916 | ¼ S 16 / 1916 | ¼ S 7 / 1916 |
|---|---|---|

**273.** *Meander corners* are to be marked "M C" on the half toward the meanderable body of water, and the additional marks (*a*) on a standard parallel or other line controlling surveys to one side only, with the township, range, and section toward the surveyed land; (*b*) on an exterior, with the township (or range) common to the adjoining townships, the ranges (or townships) upon the opposite sides of the exterior, and the sections; and (*c*), on a subdivisional line, with the township, range, and sections; all appropriately set forth as follows:



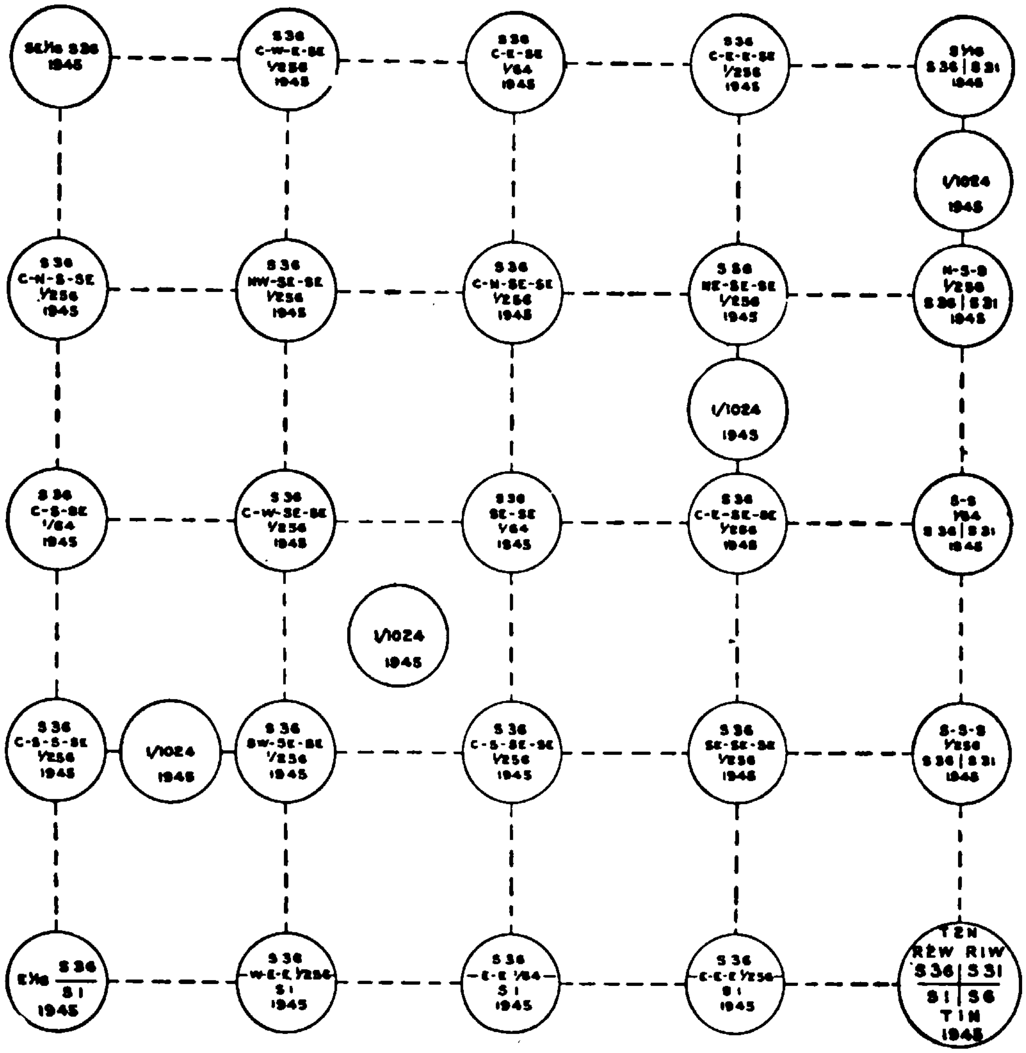
**274.** *The interior quarter-section and all sixteenth-section corners,* when required by the written special instructions, are to be marked in accordance with the scheme shown in the following diagram:




*Corners of minor subdivisions.* In those surveys where a quarter-quarter section is to be subdivided into quarter-quarter-quarter sections ($\frac{1}{64}$ or 10-acre units), or aliquot parts as small as $\frac{1}{256}$ (2.5 acres), the required monuments on the boundaries of the quarter-quarter section, and those that may be needed for the perimeter lines within the quarter-quarter section, will be marked on the plan indicated below.

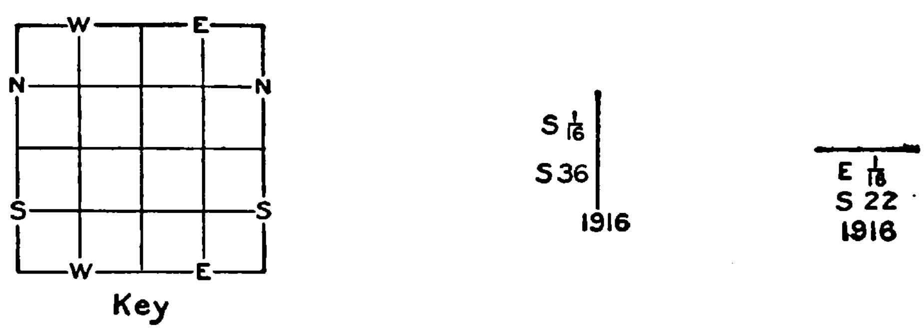
The diagram shows the marking for the monuments at corners of 2.5-acre units within one regular quarter-quarter section. If those units, or any one of them, are to be quartered, only the fraction $\frac{1}{1024}$ will be used for marking whatever monuments may be required of that order, including also the year number.

Markings on monuments at the corners of $\frac{1}{64}$ and $\frac{1}{256}$ of a section, when subdivided as aliquot parts, for example on the boundaries of and within the SE¼SE¼ sec. 36:



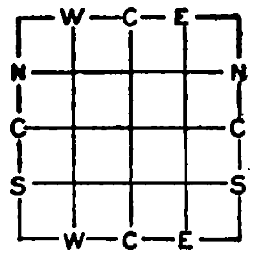

If 1/1024 corners are used they will be marked 1/1024 only.

**275.** *Sixteenth-section corners of minimum control* are to be marked, with a key letter (N, E, S, or W) to indicate the position of the monument, and "1/16" and the section, all on the half toward the particular section which is concerned; as for example:



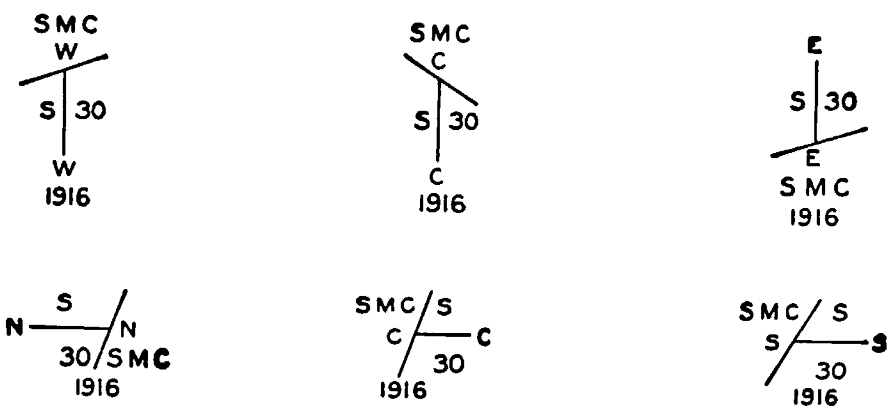
**276.** *Special meander corners* are to be marked in accordance with the following scheme:

Key letters (N, E, S, W, or C) will be used in pairs to indicate the position of the subdivision-of-section line.




Key

The marks "S M C" will be placed on the half toward the meanderable body of water, and the section on the opposite half, as for example:



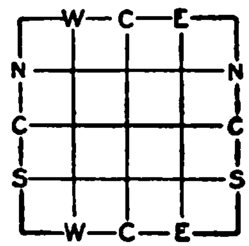

**277.** *Auxiliary meander corners* will be marked "A M C" and the township, range, and section; as for example:

A M C
T 64 N R 37 W
S 29
1916

When *two or more* auxiliary meander corners are found to be required for islands that are situated within the same section, their identification will be secured as explained in section 233, and *not* by serial number.

**278.** *Closing subdivision-of-section corners* are to be marked in accordance with the following scheme:

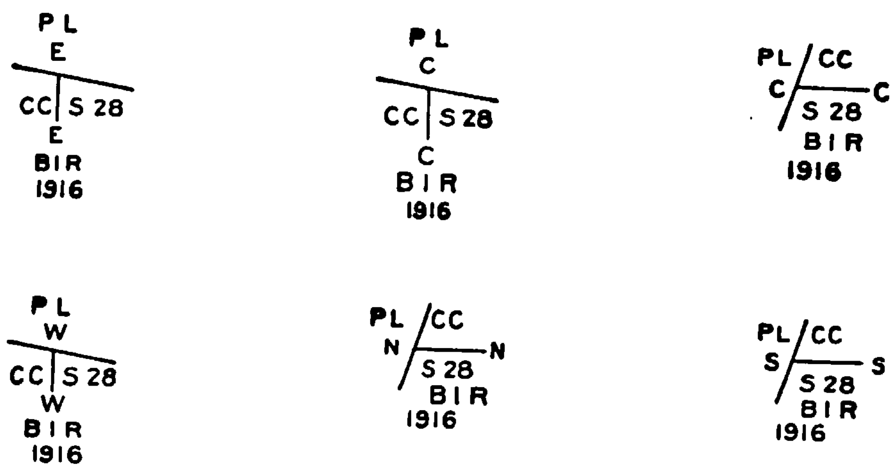
Key letters (N, E, S, W, or C) will be used in pairs to indicate the position of the subdivision-of-section line.



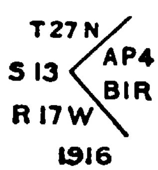

Key

The marks "C C" and the section will be placed on the half from which the closing line approaches the monument.

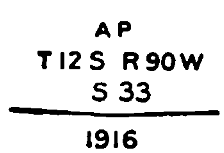
(The marks "B I R" indicate "Blackfeet Indian Reservation.")



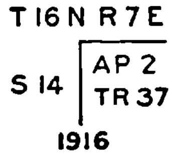

**279.** Markings for miscellaneous angle points along irregular boundaries:



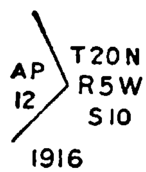

For "angle point No. 4" on the boundary of the "Blackfeet Indian Reservation," falling on surveyed land.




For "angle point" on the south boundary of section 33, superseding an old standard corner on a defective line, not subject to rectification.



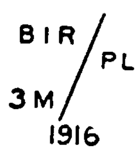

For "angle point No. 2" on the boundary of a private claim ("Tract No. 37") falling on surveyed land.



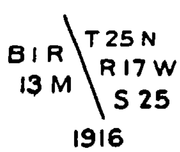

For "angle point No. 12" on a reestablished non-riparian meander line; the marks "A P" and the serial number will be placed on the half toward the land erroneously omitted from the original survey.

**280.** Markings for intermediate corners[1] 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

**281.** Where a stone monument is established the letters, figures, and grooves will be cut on the exposed faces or sides of the stone, but not on its top or end; the notches will be cut upon the exposed vertical edges. Grooves are employed where the faces of a stone are oriented to the cardinal; notches where the vertical edges are turned to the cardinal. All marks will be made from 1 to 1½ inches in size, and will be plainly and permanently chiseled into the stone.

**282.** *Standard township corners* (oriented with the faces to the cardinal) are to be marked "S C" on the north face, with the township on the same face, and the ranges on the adjoining faces; as for example:

S C 25 N on N.,<br>
18 E " E., and<br>
17 E " W. face.

[1] The marked stations along a boundary are not corners in the strict sense, but merely monumented points. The term has been established by long usage; it is continued for that reason.

**283.** *Closing township corners* (oriented with the faces to the cardinal) are to be marked "C C" and with six (or fewer) grooves on the face from which the closing line approaches the monument—the grooves to indicate the normal number of miles (or fractional parts) from the monument to the adjoining township corner—with the township (or range) on the same face, and the ranges (or townships) on the adjoining faces; also the initial or abbreviation of the State, reservation, grant or private claim, on the face toward such irregular tract as may be closed upon; as for example:

20 N on N.,
C C 120 W and 5 grooves (on line between sections 5 and 32) on E.,
19 N on S., and
UTAH " W. face.

**284.** *Corners common to four townships* (oriented with the edges to the cardinal) are to be marked with the townships on the northeast and southwest faces, and the ranges on the southeast and northwest faces; as for example:

23 N on NE.,
18 E " SE.,
22 N " SW., and
17 E " NW. face.

**285.** *Corners common to two townships only* (oriented with the faces to the cardinal) are to be marked with the township (or range) common to both on the face toward the townships, and the ranges (or townships) on the adjoining faces; as for example:

3 N on N.,
2 N " S., and
7 W " W. face.

**286.** *Corners referring to one township only* (oriented with the edges to the cardinal) are to be marked with the township and range on the face toward the particular township; as for example:

23 N 7 W on NW. face.

**287.** *Standard section corners* (oriented with the faces to the cardinal) are to be marked "S C" on the north face, and with from one to five grooves on the east and west faces, the grooves to indicate, respectively, the number of miles from the monument to the adjoining (regular) township corner; as for example:

S C on N.,
1 groove on E., and
5 grooves on W. face (standard corner of sections 35 and 36).

288. *Closing section corners* (oriented with the faces to the cardinal) are to be marked "C C" and with from one to six grooves on the face from which the closing line approaches the monument, and from one to five grooves on each of the adjoining faces—the grooves to indicate the number of miles (or fractional parts) from the monument to each of the three (regular) township boundary lines in the same directions, respectively—also the initials or abbreviation of the State, reservation, grant or private claim, on the face toward such irregular tract as may be closed upon; as for example:

2 grooves on E.,
C C and 6 " " S., and
4 " " W. face (on line between sections 2 and 3 closing on a standard parallel).

289. *Corners common to four sections* (oriented with the edges to the cardinal) are to be marked (*a*) on an exterior, with from one to five notches each on two opposite edges, north and south on a meridional line, and east and west on a latitudinal line, each to indicate, respectively, the number of miles from the monument to the adjoining (regular) township corner; and (*b*) a subdivisional corner, with from one to five notches on the east and south edges, each to indicate, respectively, the number of miles from the monument to the (regular) east and south township boundary lines. The subdivisional section corners of a fractional township will be marked with reference to the theoretical position of normal east and south boundaries, whether surveyed or not; as for example:

2 notches on N. and 4 notches on S. edge (for corner of sections 7, 12, 13 and 18 on a range line).
2 notches on E. and 4 notches on W. edge (for corner of sections 2, 3, 34 and 35 on a township line).
2 notches on E. and 4 notches on S. edge (for corner of sections 10, 11, 14 and 15, of a subdivisional survey).

290. *Section corners common to two sections only* (oriented with the

edges to the cardinal) are to be marked with the sections on the faces toward the particular sections to which the corner belongs; as for example:

S 13 on SW., and
S 12 " NW. face (for corner of sections 12 and 13 on the east boundary of a township).
S 11 on NE., and
S 10 " NW. face (for corner of sections 10 and 11 of a subdivisional survey running north from the monument).

**291.** *Section corners referring to one section only* (oriented with the edges to the cardinal) are to be marked with the section on the face toward the particular section which is concerned; as for example:

S 17 on NW. face (for southeast corner of section 17).

**292.** *Standard quarter-section corners* (oriented with the faces to the cardinal) are to be marked "S C ¼" on the north face.

**293.** *Quarter-section corners of maximum control* (oriented with the faces to the cardinal) are to be marked (*a*) on a meridional line, "¼" on the west face; and (*b*) on a latitudinal line, "¼" on the north face.

**294.** *Quarter-section corners of minimum control* (oriented with the faces to the cardinal) are to be marked "¼" and the section, all on the face toward the particular section which is concerned; as for example:

¼ S 4 on S. face (for quarter-section corner on the north boundary of section 4).

**295.** *Meander corners* (oriented with the faces to the cardinal) are to be marked "M C" on the face toward the meanderable body of water, and with from one to six grooves on each of the other faces, each to indicate the number of miles (or fractional parts) from the monument to the (regular) township boundary line in the same direction, respectively; as for example:

M C on N.,
6 grooves " E.,
4 " " S., and
6 " " W. face (for meander corner of fractional sections 13 and 18, on the south side of a meanderable body of water).

**296.** *Special and auxiliary meander corners* (oriented with the faces to the cardinal) are to be marked "S M C" or "A M C," as the case



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may be, on the face toward the meanderable body of water, and the section on the opposite face; as for example:

S M C on N., and
S 19 " S. face (for special meander corner on a meridional subdivision-of-section line in section 19, on the south side of a meanderable body of water).

S 20 on E., and
A M C " W. face (for auxiliary meander corner in section 20, on the east side of a meanderable body of water).

## MARKS ON TREE MONUMENTS

**297.** Where the true point for a corner is found to fall in the position occupied by a sound living tree, the tree will be made the monument. A tree will be removed if it is too small to be marked. Section 248.

**298.** The species of the tree and its diameter, breast height, will be noted, where a tree is to be made a monument; the appropriate marks will be made upon the trunk of the tree immediately above the root crown. A series of marks to be made upon a particular side of a tree will be scribed in a vertical line reading downward.

**299.** In the case of certain trees, including the aspen, beech and locust (smooth 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 removing just enough of the outer growth to expose a flat surface of the live wood tissue immediately underneath the bark; the marks thus made will remain as long as the tree is sound, but the blaze and marks will be covered by a gradual overgrowth, showing an outward scar for many years. In regions subject to heavy snowfall it is desirable to make a small additional blaze at a height of 6 or 8 feet above the ground, which will serve to attract attention to the tree during the winter season. The ends of 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.

The practice relating to the manner of marking trees, as above outlined, is designed to cause the least possible injury to the tree, by enabling a rapid overgrowth; also, to place the marks in a position where they will remain on the stump if the trunk should be removed.

Various practices have obtained in the past in different localities, some of which are objectionable by causing unnecessary injury to a tree, or on account of the marks being placed in a position where there is danger of their removal with the trunk in case the tree is cut down.

**300.** The above caution applies equally to the marking of bearing trees, and the engineer is advised, when making retracements, resurveys, etc., not to remove the overgrowth on a tree monument or bearing tree unless it is absolutely necessary to do so in order to identify 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) will furnish an exact count of the number of years (one annual ring for each growing season) from the date of original marking to the date when uncovered. After an old blaze has been uncovered, conditions are favorable for the decaying process to set in; the engineer should then adopt additional means to evidence the position of the corner.

**301.** *Standard township corners* are to be marked "S C" and the township on the north side, and the ranges and sections on the east and west sides; as for example:

S C T 25 N on N.,
R 18 E S 31 " E., and
R 17 E S 36 " W. side.

**302.** *Closing township corners* are to be marked "C C" and the township (or range) on the side from which the closing line approaches the monument, and the ranges (or townships) and sections on the adjoining sides; also the initials or abbrevation of the State, reservation, grant or private claim, on the side toward any irregular tract which may be closed upon; as for example:

R 18 E S 6 on E.,
C C T 24 N " S., and
R 17 E S 1 " W. side.

**303.** *Corners common to four townships* are to be marked with the township and section on the northeast and southwest sides, and the range and section on the southeast and northwest sides; as for example:

T 23 N S 31 on NE.,
R 18 E S 6 " SE.,
T 22 N S 1 " SW., and
R 17 E S 36 " NW. side.

**304.** *Corners common to two townships only* are to be marked with the township, range and section on the sides toward the particular townships; as for example:

T 2 N R 7 W S 1 on SW., and
T 3 N R 7 W S 36 " NW. side.

**305.** *Corners referring to one township only* are to be marked with the township, range, and section on the side toward the particular township which is concerned; as for example:

T 23 N R 7 W S 36 on NW. side.

**306.** *Standard section corners* are to be marked "S C" and the township and range on the north side, and the sections on the east and west sides; as for example:

S C T 25 N R 17 E on N.,
S 36 " E., and
S 35 " W. side.

**307.** *Closing section corners* are to be marked "C C" and the township and range on the side from which the closing line approaches the monument, and the sections on the adjoining sides; also the initials or abbreviation of the State, reservation, grant or private claim on the side toward any irregular tract which may be closed upon; as for example:

S 1 on E.,
C C T 24 N R 17 E " S., and
S 2 " W. side.

**308.** *Corners common to four sections* are to be marked (*a*) on an exterior, with the township (or townships), ranges (or range) and sections; and (*b*) a subdivisional corner, with the township, range and section; all appropriately set forth as follows:

(a) T 25 N S 7 on NE.,
R 18 E S 18 " SE.,
R 17 E S 13 " SW., and
S 12 " NW. side.

(a) T 26 N S 36 on NE.,
R 17 E S 1 " SE.,
T 25 N S 2 " SW., and
S 35 " NW. side.

(b) T 25 N S 24 on NE.,
R 17 E S 25 " SE.,
S 26 " SW., and
S 23 " NW. side.

**309.** *Section corners common to two sections only* are to be marked with the township and section, and the range and section, on the sides toward the particular sections to which the corner belongs; as for example:

T 14 S S 11 on NE., and
R 20 W S 10 " NW. side.

**310.** *Section corners referring to one section only* are to be marked with the township, range and section on the side toward the particular section which is concerned; as for example:

T 27 N R 16 W S 17 on NW. side.

**311.** *Standard quarter-section corners* are to be marked "S C ¼" and the section, all on the north side; as for example:

S C ¼ S 36 on N. side.

**312.** *Quarter-section corners of maximum control* are to be marked (*a*) on a meridional line, "¼" and the section on the west side, and the section on the east side; and (*b*) on a latitudinal line, "¼" and the section on the north side, and the section on the south side; as for example:

S 18 on E., and
¼ S 13 " W. side.

¼ S 21 on N., and
S 28 " S. side.

**313.** *Quarter-section corners of minimum control* are to be marked "¼" and the section, all on the side toward the particular section which is concerned; as for example:

¼ S 7 on E. side (for quarter-section corner on the west boundary of section 7).

**314.** *Meander corners* are to be marked "M C" on the side toward the meanderable body of water, and the additional marks (*a*) on a standard parallel or other line controlling surveys to one side only, with the township, range and section on the side toward the 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; as for example:

(a) M C on E., and
T 25 N R 17 E S 33 " NW. side (for meander corner on a standard parallel, on the west side of a meanderable body of water).

(b) T 24 N on N.,
R 18 E S 18 " E.,
M C " S., and
R 17 E S 13 " W. side (for meander corner on a range line, on the north side of a meanderable body of water).

(b) T 23 N S 35 on N.,
M C " E.,
T 22 N S 2 " S., and
R 17 W " W. side (for meander corner on a township line, on the west side of a meanderable body of water).

(c) S 23 on N.,
T 25 N R 17 E " E.,
S 26 " S., and
M C " W. side (for meander corner on a latitudinal section line, on the east side of a meanderable body of water).

(c) M C on N.,
S 9 " E.,
T 4 N R 7 W " S., and
S 8 " W. side (for meander corner on a meridional section line, on the south side of a meanderable body of water).

**315.** *Special and auxiliary meander corners* are to be marked "S M C" or "A M C", as the case may be, on the side toward the meanderable body of water, and the section on the opposite side; as for example:

S M C on E., and
S 14 " W. side (for special meander corner on a latitudinal subdivision-of-section line in section 14, on the west side of a meanderable body of water).

A M C on N., and
S 9 " S. side (for auxiliary meander corner in section 9, on the south side of a meanderable body of water).

## CORNER ACCESSORIES

**316.** The purpose of 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 in the event of the destruction or removal of the monument, its position may be identified as long as any part of the accessories remains in evidence. The accessories consist of three general classes, one or more of which are to be employed at each and every corner established in the public-land surveys (excepting for corners of minor subdivisions and where specifically not required by the Manual text, or omitted by the special instructions), preference being given in the order of their permanence conditional upon the character of the ground in the locality of the monument, as follows:

(*a*) Bearing trees, or other natural objects such as notable cliffs and boulders; permanent improvements; reference monuments; (*b*) mound of stone; (*c*) pits and memorials.

**317.** The engineer cannot perform any more important service in connection with his official duties than to employ whatever means may be necessary permanently and accurately to evidence the location of the corners established in his survey, and where the usual accessories, or combinations of the same, cannot be employed, such other means should be adopted as will best serve the purpose.

**318.** 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 letters "W C", and the section number was made to agree with the section in which the tree or object actually stood.

The new rule is as follows:

*Witness Corner:* Bearing objects, if available, treated as in secs. 319 and 323. Bearing trees, with direction and distance from the monument, marked with an "×" (only), at breast height, on the side facing the monument, and the letters "B T" (only) at the base. Mounds of stone treated as in sections 246, 326, and 327; arranged as in sections 330 to 347, incl., as though the monument were located at the true corner.

*Reference Monument:* All bearing objects and bearing trees, including marks, with reference 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.

## BEARING TREES AND BEARING OBJECTS

**319.** Bearing trees are to be selected for marking when available, ordinarily within a distance of 3 chains of the corner; a greater distance if important. One tree will be marked in each section in accordance with the plan as hereinafter set out, unless a tree in one or more positions may not be available. A full description of each bearing tree will be embodied in the field notes; this will include 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. Sections 320, 321, 322.

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 will be supplemental to the marking of bearing trees, or to fill out a quota where trees may not be available in some sections. The description of the cliff or boulder will be such as to 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. Section 323.

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. Section 324.

**320.** The marks upon a bearing tree will be made upon the side facing the monument, and will be scribed in the manner already outlined for marking tree corner monuments. The marks will embrace the information suggested in the schedule hereinafter given, with such letters and figures as may be appropriate for a particular corner, and will include the letters "B T"; a tree will always be marked to agree with the section in which it stands, and will be marked in a vertical line reading downward, ending in the letters "B T" at the lower end of the blaze approximately 6 inches above the root crown.

**321.** There is a great difference in the longevity of trees, and in their rate of decay; trees should therefore be selected, if possible, with a view to the length of their probable life, their soundness, favorable site conditions and size. Sound trees from 5 to 8 inches in diameter, of the most hardy species, favorably located, are to be preferred for

Marking a bearing tree as an accessory to a corner.

marking. Trees 5 inches in diameter will not be selected for marking if larger trees are available, and it is generally better to avoid marking fully matured trees, especially those showing signs of decay. Trees 4 inches in diameter, or less, if no better trees are available, will be marked with the letters "B T" only at the base, and an "×" at breast height, facing the monument. The species, size and exact position of the bearing trees are of vital importance, as this data will generally serve to identify a bearing tree without uncovering the marks, or even to identify two or more stumps after all evidence of the marks has disappeared.

**322.** Generally only one tree will be marked in each section at a particular corner, but in certain instances, hereinafter described, two trees are required in a section. In such cases it is better to select trees of different species; or of widely different size, direction or distance. If the trees are of the same species, in order that confusion may be avoided in the future identification of a remaining tree where the companion tree has disappeared, one tree will be marked with an "×" only.

**323.** A cross (×) and the letters "B O" will be chiseled into a bearing object, if it is a rock cliff or boulder; the record should be such as to enable another surveyor to determine just where the marks will be found. The rock bearing object is the most permanent of all accessories; it will be used wherever practicable, and within a distance of 5 chains.

**324.** A connection to any permanent artificial object or improvement may be included in this general class of corner accessories. The field notes should be explicit in describing such objects, and should indicate the exact point to which a connection is made, as "southwest corner of foundation of Smith's house," "center of Smith's well," "pipe of Smith's windmill," etc. No marks will be made upon private property.

## MEMORIALS

**325.** In every case 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 will be 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 (×) stone, a charred stake, a quart

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of charcoal, or pieces of metal will constitute a suitable memorial. A full description of such articles will be embodied in the field notes wherever they are employed as a memorial. When replacing an old monument with a new one, such as substituting an iron post for an old marked stone, the old marker will be preserved as a memorial.

## MOUND OF STONE

**326.** Where a native stone is available and the surface of the ground is favorable, a mound of stone will always be 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 will be built as stable as possible, will consist of not fewer than five stones, and will be not less than 2 feet base and 1½ feet high. Where the ground is suitable, the stone mound surrounding the iron post, or when used as an accessory, will be improved by first digging a circular trench, 4 to 6 inches deep, for an outer ring, then place the base of the larger stones in the trench. In stony ground the size of the mound will be sufficiently increased to make it conspicuous. The position of the accessory mound will be as shown in the schedule hereinafter stated; the nearest point on its base will be about 6 inches distant from the monument. The field notes will show the size and position of the mound.

**327.** Where it is necessary to support a monument in a stone mound, and if bearing trees or other objects are not available, a marked (X) stone or other memorial will be deposited alongside the monument.

A stone mound accessory, in addition to the mound surrounding a monument, will be built in all cases where this will aid materially in making the location conspicuous.

## PITS

**328.** Where the full quota of trees or other bearing objects are unavailable for marking, the position of the monument will, under certain favorable conditions, be evidenced by pits. No pits should be dug in a roadway, or where the ground is overflowed for any considerable period, or upon steep slopes, or where the earth will wash, or in a loose or light soil, or where there is no native sod, or where suitable stone for a mound is at hand.

A firm soil covered with a healthy native sod is most favorable for a permanent pit. Under such conditions the pits will gradually fill with a material slightly different from the original soil, and a new species of vegetation will generally take the place of the native grass; these characteristics, under favorable conditions, make it possible to identify the original location of the pits after the lapse of many years.

**329.** All pits will be dug 18 inches square and 12 inches deep, with the nearest side 3 feet distant from the corner monument, oriented with a square side (and not a corner) towards the monument, arranged as shown in the schedule hereinafter given; the earth removed will be scattered in such a way that it will not again fill the pits. A description of the pits will be embodied in the field notes, and will include, in every instance, a statement of their size and position; this is particularly important in view of the fact that the practice herein outlined differs materially (in the interest of simplicity) from that set forth in earlier editions of the Manual.

## ARRANGEMENT AND MARKING OF CORNER ACCESSORIES

**330.** *Standard township corner*
*Standard section corners.*

Two bearing trees, one in each section north of the standard parallel, each marked "S C" and the township, range and section; as

T 25 N R 18 E S 31 S C B T.

Mound of stone, north of corner.

Three pits, one each on line north, east and west.

**331.** *Closing township corners.*
*Closing section corners.*

Two bearing trees, one in each section to the right and left of the closing line, each marked "C C" and the township, range and section; as

T 24 N R 18 E S 6 C C B T.

Mound of stone, on the closing line.

Three pits, one on the closing line and one each to the right and left on the line closed upon.

**332.** *Corners common to four townships.*

Four bearing trees, one in each section, each marked with the township, range and section; as

T 22 N R 17 E S 1 B T.

**Mound** of stone, south of corner.

**Four pits**, one each on line north, east, south and west.

**333.** *Corners common to two townships only.*

Two bearing trees, one in each section cornering at the monument, each marked with the township, range and section; as

T 2 N R 7 W S 1 B T.

Mound of stone, on the line between the two townships cornering at the monument.

Three pits, one each on the three lines connecting at the monument.

**334.** *Corners referring to one township only.*

Two bearing trees, both in the township cornering at the monument, each marked with the township, range and section; as

T 23 N R 19 W S 36 B T.

Mound of stone, in the township cornering at the monument, at 45° from cardinal direction at the monument.

Two pits, one each on the two lines connecting at the monument.

**335.** *Corners common to four sections.*

Four bearing trees, one in each section, each marked with the township, range and section; as

T 26 N R 17 E S 35 B T.

Mound of stone, west of corner.

Four pits, one in each section northeast, southeast, southwest and northwest.

**336.** *Section corners common to two sections only.*

Two bearing trees, one in each section cornering at the monument, each marked with the township, range and section; as

T 14 S R 17 E S 12 B T.

Mound of stone, on the line between the two sections cornering at the monument.

Two pits, one in each section at 45° from cardinal direction at the monument.

**337.** *Section corners referring to one section only.*

Two bearing trees, both in the section cornering at the monument, each marked with the township, range and section; as

T 27 N R 16 W S 17 B T.

Mound of stone, in the section cornering at the monument, at 45° from cardinal direction at the monument.

Two pits, one 3 feet and one 6 feet distant, both in the section cornering at the monument, at 45° from cardinal direction at the monument.

**338.** *Standard quarter-section corners.*

Two bearing trees, both north of the standard parallel, each marked "¼" and "S C" and the section; as

¼ S 36 S C B T.

Mound of stone, north of corner.

Two pits, one each on line east and west.

**339.** *Quarter-section corners of maximum control.*

Two bearing trees, one in each section, each marked "¼" and the section; as

¼ S 16 B T.

Mound of stone: (*a*) On a meridional line, west of corner; and, (*b*) on a latitudinal line, north of corner.

Two pits, one in each direction on the line passing through the monument.

**340.** *Quarter-section corners of minimum control.*

Two bearing trees, both in the particular section which is concerned, each marked "¼" and the section; as

¼ S 7 B T.

Mound of stone, in the particular section which is concerned, in a cardinal direction from the monument.

Two pits, one in each direction on the line passing through the monument.

**341.** *Meander corners.*

Two bearing trees: (*a*) On a standard parallel or other line controlling surveys to one side only, both in the particular section which is concerned; and (*b*) on all other lines, one in each section to the right and left of the line; all marked "M C" and with the township, range and section; as

T 25 N R 14 E S 32 M C B T.

Mound of stone, on the surveyed line on the opposite side of the monument from the meanderable body of water.

Two pits, one 3 feet and one 6 feet distant, on the surveyed line on the opposite side of the monument from the meanderable body of water.

**342.** *The interior quarter-section and all sixteenth-section corners,* when required by the written special instructions.

Two bearing trees, marked (with letters and figures ending in "B T") as shown in the following diagram:

Mound of stone, in a cardinal direction from the monument, as shown (with symbol "") in the following diagram:

Two pits, in a cardinal direction from the monument, as shown (with symbol "□") in the following diagram (Figure 98):

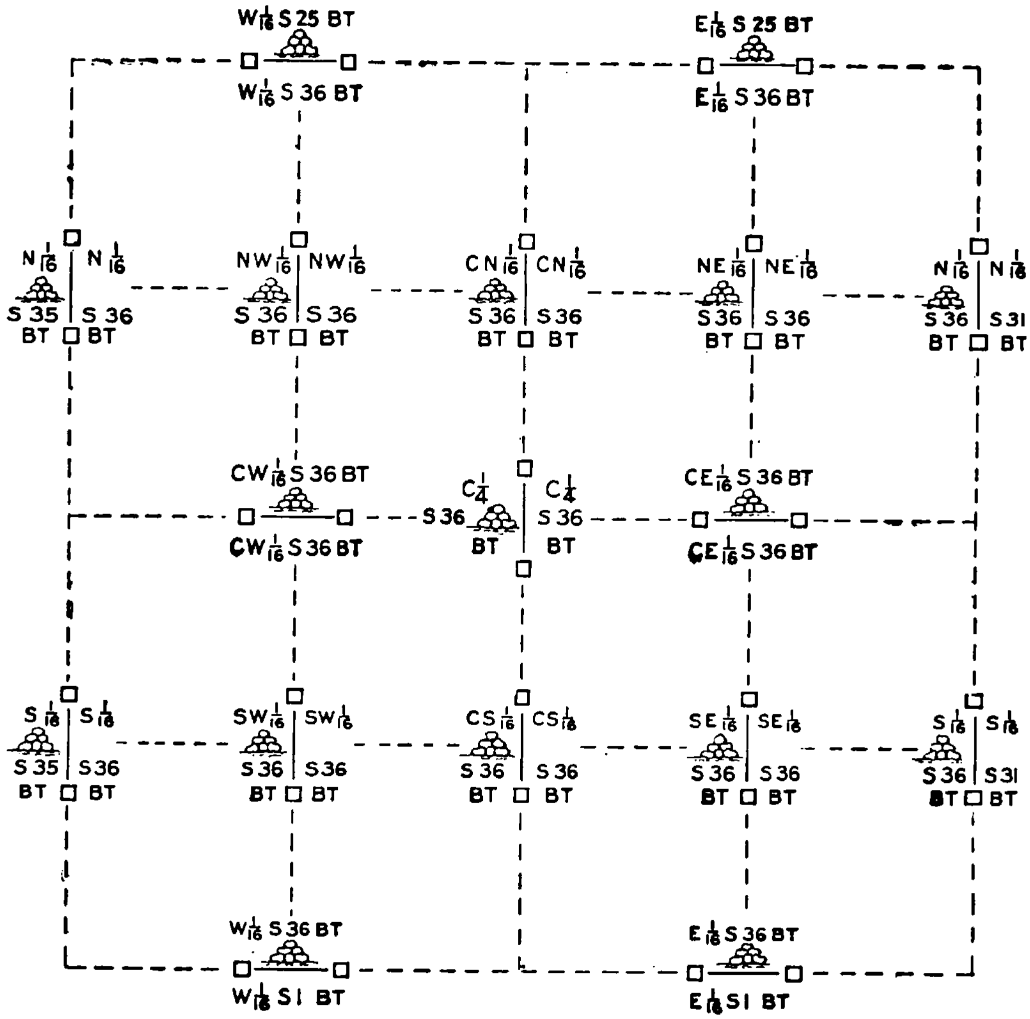
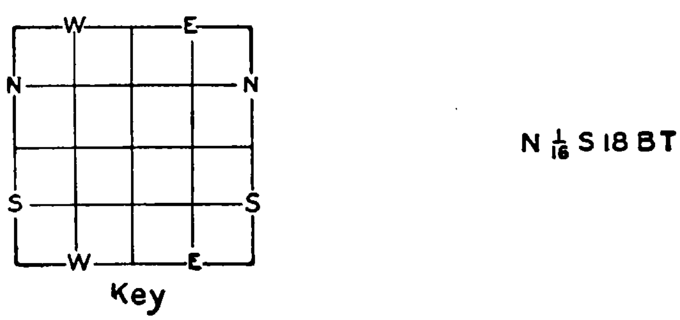



FIGURE 98.

**343.** *Sixteenth-section corners of minimum control.*

Two bearing trees, both in the particular section which is concerned, each marked with a key letter (N, E, S or W) to indicate the position of the monument, and "1/16" and the section; as



Mound of stone, in the particular section which is concerned, in a cardinal direction from the monument.

Two pits, one in each direction on the section line passing through the monument.

**344.** *Special and auxiliary meander corners.*

Two bearing trees, each marked "S M C" or "A M C," as the case may be, and the section; as

S 14 S M C B T, or
S 14 A M C B T.

Mound of stone, on the opposite side of the monument from the meanderable body of water.

Two pits, one 3 feet and one 6 feet distant, on the opposite side of the monument from the meanderable body of water.

**345.** *Closing subdivision-of-section corners.*

Two bearing trees, both in the particular section which is concerned, each marked "C C" and the section; as

S 9 C C B T.

Mound of stone, on the closing line.

Three pits, one on the closing line and one each to the right and left on the line closed upon.

**346.** *Miscellaneous angle points along irregular boundaries.*

(*a*) Two bearing trees, where the monuments are less than 1 mile apart, one on each side of the boundary; and (*b*) four bearing trees, where the monuments are 1 mile or more apart, two on each side of the boundary; each marked "A P" and a serial or section number, or both, also the initials or abbreviation of the State, reservation, grant, private claim or public land, as appropriate; as

A P 2 TR 37 B T, and
A P S 14 B T (for "angle point No. 2" on the boundary of a private claim "Tract No. 37" falling on surveyed land).

Mound of stone, on the medial line between the boundary lines intersecting at the monument, and in the direction toward the reservation, grant or private claim.[2]

Two pits, one in each direction on the lines intersecting at the monument.

[2] 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.

**347.** *Intermediate corners along irregular boundaries.*

(*a*) Two bearing trees, where the monuments are less than 1 mile apart, one on each side of the boundary; and (*b*) four bearing trees, where the monuments are 1 mile or more apart, two on each side of the boundary; each marked with the number of the mile or half-mile corner and the letter "M" to (indicate "mile corner"), and the initials or abbreviation of the State, reservation, grant, private claim or public land, as appropriate; as

47 M COLO BT, and
47 M OKLA BT (for "47th mile" corner on the boundary line between the States of "Colorado" and "Oklahoma").

Mound of stone, on a line at right angles to the boundary, and in direction toward the reservation, grant, or private claim.[2]

Two pits, one in each direction on the boundary.

[2] Footnote 2 on p. 279.

# Chapter V

# RESTORATION OF LOST CORNERS



**Primary Methods**



**Secondary Methods**





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# IDENTIFICATION OF EXISTENT CORNERS

**348.** It is the purpose of this chapter of the Manual to outline the guiding principles which are to be observed in the identification of existent corners, and thereafter to set forth the particular rules which are to be applied in the recovery of the position of lost corners originally established in the execution of the United States rectangular surveys.

All surveyors, whether employed by the United States or not, are cautioned to note the difference between the regulations pertaining to the establishment of the original surveys of the public lands and those relating to the subsequent identification of said official surveys and the replacement of missing monuments thereof.

In the extension of the rectangular surveys it devolves upon the cadastral engineers of the Bureau of Land Management to identify the initial lines of his group and to replace all lost corners thereof. On the other hand in the subdivision of sections and in the location of property lines generally, it falls to the county or other local surveyor to identify the official corners, and where a required corner is missing the local surveyor will be called upon to recover the point. Thus it will be seen that local surveyors as well as cadastral engineers of the Bureau of Land Management are constantly called upon to search for existing evidence of original monuments, and in this work the surveyors will be guided by the same general methods. Should the search for a monument result in failure, the appropriate restorative surveying process to be observed by either surveyor will be based upon the same rules as hereinafter outlined. The text that follows draws no distinction between the duties of the two classes of surveyors.

**349.** The terms "corner" and "monument" are used largely in the same sense, though a distinction should be noted to clarify the subject matter of this chapter. The term "corner" is employed to denote a point determined by the surveying process, whereas the "monument" is the physical structure erected for the purpose of marking the corner point upon the earth's surface.

The "corners" of the public land surveys are those that determine the boundaries of the various subdivisions which are represented on the official plat, i. e.—the township corner, the section corner, the quarter-section corner, 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; long usage has given acceptance to the term. A monumented "angle point" of a boundary marks a turning point, and in that sense it is a corner of the survey.

The "monuments" of the public land surveys range from 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 (×) at the exact point of the corner, and other special types of markers, some of which are more substantial; any of these are termed "monuments". The several classes of accessories, such as bearing trees, bearing objects, mounds of stone, and pits dug in the sod or soil, are aids in the finding and identification, and afford evidence for the perpetuation of the corner position.

The restoration of a lost or obliterated corner has to do with the replacing of a monument that has disappeared so far as this relates to physical evidence, or other means of identification short of a remeasurement of the lines that were surveyed in the establishment of this and the nearest existent corners of that survey in the two or four directions. If there should be acceptable collateral evidence by which the original position may be accurately located, the monument may be regarded as obliterated, but not lost; the point is then referred to as an "obliterated corner".

The replacement of a lost or obliterated corner is not a resurvey in itself, as the latter term implies a much wider application of the methods, at least one or more whole sections, but usually involving a whole township in the Bureau of Land Management practice. Section 387. In either case, however, the question is not where a new or exact running of the lines would locate the corner, but *where* or in what particular position was the corner established in the beginning, in the approved official survey. *The evidence*, to be acceptable, or to be given value, must be such as to have a bearing upon the *latter fact*.

**350.** The rules for the restoration of lost corners are not to be applied until after the development of all evidence, both original and collateral, that may be found acceptable, though the methods of proportionate measurement will aid materially in the recovery of the evidence, and will indicate what the resulting locations may be as based upon the known control.

*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 that is contained in the field notes, or where the point can be 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.*

**351.** The process of again bringing to light the physical evidence of an original monument is founded on the principle of intelligent search for the calls of the field notes of the original survey, guided by the controlling influence of known points. The problems incident to the search are vastly simplified whenever a retracement may be projected from known points, and the final search for a monument should cover the zone surrounding one, two, three or four temporary points as may be determined by connections with known corners in one, two, three or four directions, according to the number of points which will ultimately control the relocation in case the corner in question should be declared lost.

**352.** The character of the original monument is the most important factor in regard to its lasting qualities, and the search should be directed to an examination for such evidence as may reasonably be expected to remain. The evidence is bound to range from that which is least conclusive to that which is unquestionable, and the requisite support of corroborative evidence is necessary in direct proportion to the uncertainty of any feature regarding whose authenticity there may be danger of dispute.

A stone, wooden post, tree corner, deposit corner, and the modern iron post monument are all subject to more or less deteriorating changes through various influences, depending upon the character of the original monument, its local site conditions, and the lapse of time, and all such factors should be taken into consideration when comparing the particular evidence in question with the description contained in the original field notes.

**353.** If the evidence of the monument is not fully conclusive, the engineer's attention will be directed at once to the record accessories; this step is so generally necessary that it should be considered simultaneously with the search for the monument; in fact, in their broader significance the accessories are a part of the monument.

The underlying principles relating to the identification of the corner accessories, subject to the changes which may be expected in the period intervening after the date of the original survey, have already been fully outlined in chapter IV. It will suffice to state that the evidence of the accessories should agree with the record contained in the field notes of the original survey, subject only to such changes as reasonably may be expected.

**354.** In case of material disagreement between the particular evidence in question and the record calls, the process of elimination of those features regarding which there may be doubt, after making due allowance for natural changes, will serve a most useful purpose, as follows:

(*a*) The character and dimensions of the monument in evidence should not be widely different from the record;

(*b*) The markings in evidence should not be inconsistent with the record; and, (*c*) The nature of the accessories in evidence, including size, position and markings, should not be greatly at variance with the record.

A certain measure of allowance for ordinary discrepancies should enter into the consideration of the evidence of a monument and its accessories, and no definite rule can be laid down as to what shall be sufficient evidence in such cases. Much must be left to the skill, fidelity, and good judgment of the engineer in the performance of his work, ever bearing in mind the relation of one monument to another, and the relation of all to the recorded natural objects and items of topography.

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, which are usually begun at known corners, and run in accord with the plan of the original survey, will ascertain 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. A line will not be regarded as doubtful if the retracement affords the recovery of acceptable evidence.

**355.** *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, or 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.*

A corner will not be considered as lost if its position can be recovered satisfactorily by means of the testimony and acts of witnesses having positive knowledge of the precise location of the original monument. The expert testimony of surveyors who may have identified the original monument prior to its destruction and thereupon recorded new accessories or connections, etc., is by far the most reliable, though landowners are often able to furnish valuable testimony. The greatest care is necessary in order to establish the bona fide character of the record intervening after the destruction of an original monument. Full inquiry may often serve to bring to light various records relating to the original corners, and memoranda of private markings, etc., and the engineer should make use of all such sources of information. The matter of boundary disputes should be carefully looked into insofar as adverse claimants may base their contentions upon evidence of the original survey, and if such disputes have resulted in a boundary suit, the record testimony and the court's decision should be carefully examined relative to any information which may shed light upon the position of an original monument.

The testimony of individuals may relate to knowledge of the original monument or the accessories, prior to their destruction, or to any other marks fixing the locus of the original survey, and the value of such testimony may be weighted in proportion to its completeness and agreement with the calls of the field notes of the original survey, also upon the steps taken to preserve the location of the original marks. All such evidence should be put to the severest possible tests by confirmation relating to known original corners and other calls of the original field notes, particularly to line trees, blazed lines and items of topography.

It is impossible to outline a definite rule for the acceptance or non-acceptance of the testimony of individuals. Corroborative evidence becomes necessary in direct proportion to the uncertainty of the particular statements advanced by the individual who testifies. It will be well for the engineer to bear in mind that conflicting statements and contrary views of interested parties are fruitful of boundary disputes.

The points outlined below will be a guide to the engineer or surveyor for what he is called upon to show in the field notes, or in the report of a field examination, as the weight to be given to the testimony which is to be passed upon as an element in the restoration of a lost or obliterated corner. The witness, or the record evidence, should be duly qualified, in the sense that the knowledge or information should be first hand, not hearsay, nor incomplete, nor just a personal opinion as to the original fact. Any testimony or record statement should manifestly be such as can stand an appropriate test as to its bona fide character. The testimony, or the record, must be sufficiently accurate within a reasonable limit for what is required in normal surveying practice

Any marks that were made either before or subsequent to the official survey, or at the time of the survey by others than 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 shown by fully authenticated field notes, or qualified testimony.

One additional caution, addressed especially to the cadastral engineer employed by the Bureau of Land Management, is to bear in mind that his professional work is technical in character, not legal or judicial, i. e.—the engineer or 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. Section 391.

**355**

Where public lands are involved the final authority to approve or to disapprove the procedure for the restoration of a lost or obliterated corner rests with the Director, Bureau of Land Management. If privately-owned lands are affected the Director will give careful consideration to any dissatisfaction or protest made by an interested person concerning the work of an engineer employed by the Bureau. In this sense, however, it should be obvious that 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. Sections 13, 390.

Where a corner marks the boundary between, or in any manner controls the location of the subdivisional lines that form the boundary of privately-owned property, dissatisfaction on the part of or dispute between the owners may be brought before the local court of competent jurisdiction. The Director, Bureau of Land Management, unless the United States may be a party in the suit or other proceeding, will not be bound by the opinion of the court if public lands are involved, if it should be shown subsequently that evidence of the official survey was disregarded, or if there should be some other gross departure from the basic principles of good surveying practice.

The above conditions and procedures and many more are brought out much more appropriately in the leading court opinions where boundary cases are involved, which are available in the law libraries. There are several reference books [1] on the legal elements of surveying and boundaries, which cite many court opinions, and deal with these difficult subjects.

The treatment by the authorities of the questions of testimony and physical evidence, in all of the various phases, *as to acceptability*, amply demonstrate the importance of the principles herein mentioned, i. e.—due qualification, bona fide character, accuracy.

**356.** In those cases where witness corners were established in the original survey, the true point for the corner will be controlled by such witness corner, when the latter can be identified, by reference to the record in accordance with the general plan of the survey.

[1] A treatise on the Law of Surveying and Boundaries, by Frank Emerson Clark, of the Minnesota Bar. 2d edition, 1939; the Bobbs-Merrill Co., publishers, Indianapolis, Ind. Broadly applicable to the subject, dealing specifically with questions related directly to the United States rectangular system. Numerous citation of cases.

The Legal Elements of Boundaries and Adjacent Properties, by Ray Hamilton Skelton, C. E., assistant professor of civil engineering, University of Maryland. 1930; the Bobbs-Merrill Co., publishers, Indianapolis, Ind. Broadly applicable in dealing with the many legal questions that are involved in litigation over boundary location, the cases principally in the Colonial States of the Atlantic seaboard. Numerous citations on all of the many subjects.

Boundaries and Landmarks, a practical manual by A. C. Mulford, a civil engineer and land surveyor in the area of Long Island, New York. 1912; copyright, D. Van Nostrand Co., New York City. Advisory as to good practice, one surveyor to another.

The usual diligent search will be made for witness corners, but where the same can not be identified the position of the true point for the corner will usually be of major importance, rather than the point for the witness corner, and in such instances the engineer will proceed directly to the re-determination of the true corner position, adopting the particular methods which should govern the case in hand.

By their very nature witness corners have frequently been the cause of confusion, some of which may not be avoidable; in some cases a better practice may have avoided the resulting trouble. The confusion may usually be avoided by reference to the field notes of the survey. If the factual statements in the field notes are clear as to interpretation, it is merely then a question of direction and length of line from the monumented point to the true point for a corner. It is not quite so simple if there should be extensive obliteration, or if there were too numerous substitutions of witness corners at points that might have been monumented substantially through the exercise of greater care, skill, or diligence at the time of the first marking of the lines. The most unfortunate of the difficulties has come from "calling" for a witness corner in the field notes, such as the setting of a monument on a random line, or by some error of calculation for the correct distance on the true line, and not marking the monument "W C" plainly or at all.

Where an original witness corner has become lost and a new one is necessary for the proper monumentation of the lines, the practice called for in sections 249 to 254, inclusive, will be followed.

**357.** In the absence of an original monument, a line tree, or a definite connection to natural objects, or to improvements, which can be identified, may each fix a point of the original survey for both latitude and departure. The mean position of a blazed line, when identified as the original line, may sometimes help to fix a meridional line for departure, or a latitudinal line for latitude. Other calls of the original field notes in relation to various items of topography may assist materially in the recovery of the locus of the original survey. Such evidence may be developed in an infinite variety. It may be only such as to disprove other questionable features, or it may guide the engineer in a general way in arriving at the immediate vicinity of a line or corner, or in its best phases may be such as to fix the position of a line or corner beyond any doubt.

**358.** A certain measure of allowance should be made for ordinary discrepancies in the calls relating to items of topography. Such evidences should be considered more particularly in the aggregate, and when they are found to be corroborative an average may be secured to control the final adjustment, which will be governed largely by the evidences nearest the particular corner in question, giving the greatest weight to those features which agree most harmoniously with the record, and to such items as afford definite connection. A careful analysis will generally reveal the merits of authentic evidences as opposed to unreliable features bearing resemblance to the calls of the field notes, and in this matter the engineer will find an opportunity to exercise his skill to the fullest capacity.

**359.** It is a matter of utmost importance to determine where an identified call of the original field notes shall operate to control for both latitude and departure, or for either coordinate by itself, and finally as to the necessity for applying the rules for proportionate measurement where the distance between the identified points is considerable.

## RESTORATION OF LOST CORNERS

**360.** *A lost corner is a point of a survey whose position can not be determined, beyond reasonable doubt, either from 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.*

If there is some acceptable evidence of the original location that position will be employed in preference to the rule that would be applied to a lost corner.

**361.** The engineer is not prepared to consider the restoration of a lost corner until he has exhausted every other means of identifying its original position, and at this stage of his work he should have determined upon an approximate position of the original monument based upon his findings resulting from retracements leading from known corners to the lost corner, from one, two, three, or four directions in accordance with the plan of the original survey. The principle of proportionate measurement, which most nearly harmonizes surveying practice with the legal and equitable considerations involved in controversies concerning lost land boundaries, enters into the problem at this stage, and this plan of relocating a lost corner will always be employed unless outweighed to the contrary by physical evidence of the original survey. In cases where the relocated corner can not be made to harmonize with all the calls of the original field notes, due to unexplained discrepancy which is made apparent by the retracement, the engineer is required to determine which calls will be given major control, and those which must be subordinated.

**362.** The preliminary retracements furnish the only possible means of arriving at the discrepancies of the courses and distances of the original survey as compared with those derived in the process of re-running the lines, and the whole problem of proportionate measurement is one involving the adjustment of said discrepancies. The restoration of the lost corners can not proceed until the retracement of the original survey has been completed. The retracement will be based upon the courses and distances returned in the field notes of the original survey, or the equivalent by calculation, initiated and closed upon known original corners. Temporary stakes for future use in the relocation of all lost corners may be set when making the retracements.

**363.** In cases where the probable position cannot be made to harmonize with some of the calls of the field notes due to errors in descri ›tion or to discrepancies in measurement, made apparent by the retracement, it must be ascertained which of the calls for distances along the line are entitled to the greater weight. Aside from the technique of recovering the traces of the marks, the main problem is one that treats with the discrepancies in measurement.

*Existing original corners can not be disturbed; consequently, discrepancies between the new and those of the record measurements will not in any manner affect the measurements beyond the identified corners, but the differences will be distributed proportionately 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, so that the surveyor must recall the difficulties of keeping a chain at standard length, and the inaccuracies of measuring steep slopes by this method.

*All discrepancies in measurement should be carefully verified, if possible, with the object of placing each difference where it properly belongs. This is exceedingly important at times, because, if disregarded, the effect will be to give weight to a position where it is obviously not justified.*

*Accordingly, wherever it is possible to do so, the manifest errors in measurement will be removed from the general average difference, and will be 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 proportional measurement.*

**364.** The ordinary field problem consists in distributing the excess or deficiency between two existent corners in such a manner that the amount given to each interval shall bear the same proportion to the whole difference as the record length of the interval bears to the whole record distance. After having applied the proportionate difference to the record length of each interval the sum of the several parts will equal the new measurement of the whole distance.

*A proportionate measurement is one that gives concordant relation between all parts of the line, i. e.—the new values given to the several parts, as determined by the remeasurement, shall bear the same relation to the record lengths as the new measurement of the whole line bears to that record.*

**365.** *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 meridional or north and south proportion, or a latitudinal or east and west proportion. Examples, a quarter-section corner on the line between two section corners; all corners on standard parallels; and all intermediate positions on any township boundary line.

*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. The method may be referred to as a "four-way" proportion. Examples, a corner common to four townships, or one common to four sections within a township.

The double proportionate measurement is the best example of the principle that existent or known corners to the north and to the south should control any intermediate latitudinal position, and that corners east and west should control the position in longitude. Lengths of proportioned lines are comparable only when reduced to their cardinal equivalents.

**366.** It will almost invariably happen that discrepancies will be developed between the new measurements and the original measurements recorded in the field notes. When these differences occur the engineer will generally be required to adopt a proportionate measurement based upon a process conforming to the method followed in the original survey.

The principle of the precedence of one line over another of less original importance is recognized, relative to single or double proportionate measurement, in order to harmonize the restorative process with the method followed in the original survey, thus limiting the control.

*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

### (a) Double Proportionate Measurement

**367.** *The method of double proportionate measurement is generally applicable to the restoration of lost corners of four townships and of lost interior corners of four sections.*

One identified original corner is balanced by the control of a corresponding original corner upon the opposite side of a particular missing corner which is to be restored, each identified original corner being given a controlling weight inversely proportional to its distance from the lost corner.

**368.** *In order to restore a lost corner of four townships, 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.*

In the accompanying small scale diagram, the points $A$, $B$, $C$, and $D$ represent four original corners; on the large scale diagram the point $E$ represents the proportional measurement between $A$ and $B$; and, similarly, $F$ represents the proportional measurement between $C$ and $D$. The point $X$ satisfies the first control for latitude and the second control for departure.

**369.** 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, i. e.—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 of the distances by reference to the field notes.

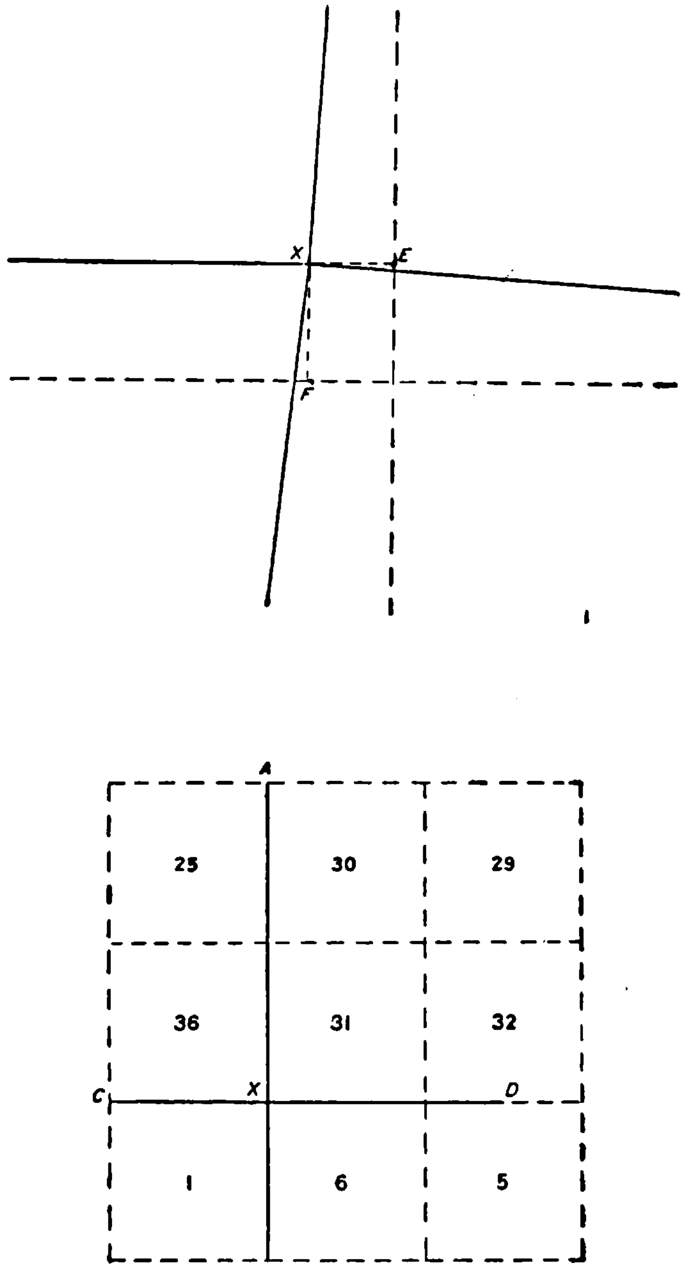


Fig. 67.

**The plan of double proportionate measurement.**
**The corner at point *X is lost*.**
**Points *A*, *B*, *C*, and *D* represent *known* corners.**
**First, locate point *E* for latitude by proportionate measurement north and south; then point *F* for departure by proportionate measurement east and west.**
**The point *X* will be located at the intersection of the lines—east or west through point *E*, and north or south through point *F*.**

*The plan of double proportionate measurement will be applied to the restoration of lost corners of four townships where all the lines therefrom* *have been run. Lost interior corners of four sections, where all the lines therefrom have been run, will also be reestablished by double proportionate measurement*, after *first relocating the required lost section corners on the township exteriors.*

**370.** *A lost interior corner of four sections will be restored by double proportionate measurement.*

When a number of interior corners of four sections, and the intermediate quarter-section corners, are missing on all sides of the one sought to be reestablished, the entire distance must, of course, be measured between the nearest identified corners both north and south, and east and west, in accordance with the rule laid down, after first relocating the required lost section corners on the township exteriors.

**371.** *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 the same diagram, if the latitudinal line in the direction of the point $D$ has not been established, the position of the 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 desired point of intersection.*

The application of these two rules should always be made after a test of the rule laid down in section 383, and be modified in accordance with the latter principle if it is then obvious that a more harmonious relation to the representations of the approved plat or plats would be thus accomplished. This is to say that what is intended by "record distance" or distances is the measure as it was determined and established in the original survey. Experienced judgment is required as to how these rules are to be applied. If the indications are that the original survey had been carelessly executed, it means that little if any definite standard of measurement (or direction of lines) 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 "yardstick" 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, for instance, that a record of 80.00 chains in distance means just that by exact standards, true horizontal measurement.

## (b) Single Proportionate Measurement

**372.** *The method of single proportionate measurement is generally applicable to the restoration of lost corners on standard parallels and other lines established with reference to definite alinement in one direction only. Intermediate corners on township exteriors and other controlling boundary lines are to be included in this class.*

In order to restore a lost corner by single proportionate measurement, a retracement will be made connecting the nearest identified regular corners on the line in question; a temporary stake (or stakes) will be set on the trial line at the original record distance (or distances); the total distance will be measured, also the falling at the objective corner.

On meridional township lines an adjustment will be made at each temporary stake for the proportional distance along the line, and then it will be set over to the east or to the west for falling, counting its proportional part from the point of beginning.

On east-and-west township lines and on standard parallels the proper adjustments should be made at each temporary stake for the proportional distance along the line, for the falling, and to secure the latitudinal curve,[2] i. e.—the temporary stake will be either advanced or set back for the proportional part of the difference between the record distance and the new measurement, then set over for the curvature of the line, and last corrected for the proportional part of the true falling.

The adjusted position is thus placed on the true line that connects the nearest identified corners, and at the same proportional interval from either as existed in the original survey. Any number of intermediate lost corners may be located on the same plan, by setting a temporary stake for each when making the retracement.

**373.** In many of the surveys the field notes and plats indicate two sets of corners along township boundaries, and frequently along section lines where parts of the township were subdivided at different dates. In these cases there are usually corners of two sections at regular intervals, and closing section corners that are placed upon the same line, but which were established later at the points of intersection in accordance with a developed offset. The quarter-section corners on such lines are usually controlling for one side only in the older practice.

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[2] Secs. 125 to 128, inclusive: the true latitudinal curve. Secs. 150 to 158, inclusive: the running of township exteriors. The term latitudinal curve as here employed denotes an easterly and westerly line properly ad justed to the same mean bearing from each monument to the next one in regular order, as distinguished from the long chord or great circle that would connect the initial and terminal points.

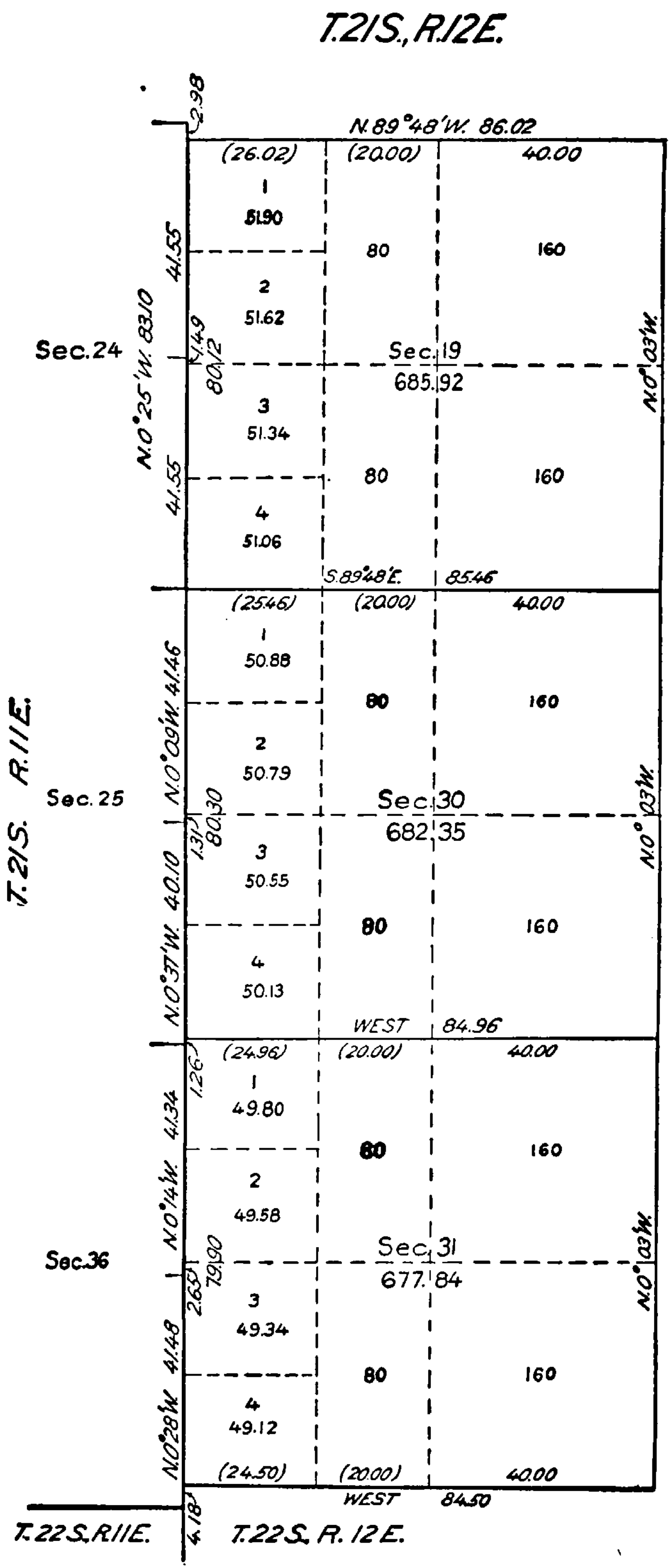


FIGURE 80.—Two sets of corners on an irregular township boundary.

In the more recent surveys, where the record calls for two sets of corners, those that are regarded as the corners of the two sections first established, and the quarter-section corners relating to the same sections, will be employed for the retracement, and will govern both the alinement and the proportional measurement along that line. The closing section corners, set at the intersections, will be employed in the usual way, i. e.—to govern the direction of the closing lines.

**374.** The term "original standard corners" will be understood to mean standard township, section, and quarter-section corners, meander corners terminating the survey of a standard parallel, and closing corners in those cases where they were originally established by measurement along the standard line as points from which to start a survey. No other meander or closing corners along a standard parallel will control the restoration of lost standard corners. Where *standard sixteenth-section corners* have been established in the running of a standard parallel, the existent corners will be employed in the regular manner as a control for the restoration of any lost corner or corners on the same plan as in the use of other existent standard corners.

*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.*

Corners on base lines are to be 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 will be treated as original standard corners; those that were set afterwards at the intersection of a meridional line will be regarded as closing corners.

**375.** *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, after the township corners have been identified or relocated.*

An exception to this rule will be noted in the case of any exterior the record of which shows deflections in alinement between the township corners.

Some township boundaries were not established as straight lines, termed an "irregular" exterior; e. g., where 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.



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In order to restore one or more lost corners or angle points on such irregular exteriors, a retracement between the nearest known corners will be made on the record courses and distances, to ascertain the direction and length of the closing distance; a temporary stake will be set for each missing corner or angle point; the closing distance will reduced to its equivalent *latitude and departure.*

On a meridional line the *latitude* of the closing distance will be distributed along the measurement of each course in proportion to its own difference in latitude, and then each temporary stake will be set over to the east or to the west for the *departure* of the closing distance in proportion to the total distance from the starting point.

Angle points and intermediate corners will be treated alike.

On a latitudinal line the temporary stakes should be placed to suit the usual adjustments for the curvature. The *departure* of the closing distance will be distributed along the measurement of each course in proportion to its own difference in departure, and then each temporary stake will be set over to the north or to the south for the *latitude* of the closing distance in proportion to the total distance from the starting point.

A second exception to the above rule is occasionally important, to be found in those cases where 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 materially long in one direction and correspondingly short in the opposite direction. This condition, when supported by corroborative collateral evidence as might generally be expected, would warrant an exception to the straight-line or two-way adjustment under the rules for the acceptance of evidence, e. i.—the evidence outweighs the record. The rules for a four-way or double proportionate measurement would then apply here, provided there is conclusive proof.

**376.** *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 relocated.*

"Half-Mile Posts", Alabama and Florida; explanation of the term, and treatment of the evidence of location. Manual Appendix V.

**377.** *Lost meander corners, originally established on a line projected across the meanderable body of water and marked upon both sides will be relocated by single proportionate measurement, after the section or quarter-section corners upon the opposite sides of the missing meander corner have been duly identified or relocated.*

**375**

Under favorable conditions a lost meander corner may be restored by treating the shore line as an identified natural feature, and, in the event of extensive obliteration of the original marks of the section and quarter-section corners within the locality (which would greatly limit the available control) this adjustment for position may be preferable to one obtained by proportionate measurement carried from a considerable distance. In extreme cases the restoration of a meander corner by adjustment of the record meander courses to the bank or shore line may actually be indispensable to the reconstruction of the section boundaries. Granting extensive obliteration, in a situation where there has been obvious stability to the bank or shore line, or absence of appreciable changes by erosion or accretion, and where the record meander courses and distances may be adjusted or conformed to the salents and angles of the physical bank or shore line, that method should be given a trial, and 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, or possibly may control the position only in latitude, or only in departure. Section 359. The factors must be considered with regard to the specific problem in hand.

## (c) Closing Corners

**378.** *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, itself properly identified or relocated; 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 that line on the opposite side of the missing closing corner; the temporary stake will then be adjusted as in single proportionate measurement. Sections 363, 372.

A 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.

An entirely different problem must be faced in those situations where, on extensive retracement and study, it becomes evident that the record tie from the closing corner to the monument called for in the field notes is either wholly fictitious, grossly in error, or carries some irreconcilable discrepancy. This is an extremely unfortunate situation when it occurs, but it must be dealt with. The safest procedure is for the engineer to report the facts to the regional or public survey office. The monument itself may be identified by the field note description, though grossly out of place with respect to the record connecting line. If that is the fact, the section boundary would normally be controlled by the position of the identified monument, resulting in a distorted section. If there be no evidence whatever of the closing corner, and ample proof that the closing was not made as called for in the field notes, none of the closing corners so involved should be restored without first verifying the nearest closings in the two directions which may be shown as authentic. The problem will then be studied in the light of that information with a view to the restoration which may be made most nearly in harmony with the official plat. No general rule can be advanced. The treatment should have official approval prior to the remonumentation of the lines.

**379.** The foregoing text completes the treatment of the general rules for the restoration of lost or obliterated corners as widely applicable to the rectangular surveys under the general and normal conditions, and where the principal problem has to do with the disappearance of monuments resulting from natural causes, and from the disturbances due to the clearing, cultivation, and other uses of the land. The special cases that are hereinafter cited with respect to broken boundary lines and limited control where the identical rules of proportionate measurement can not be applied do not have wide application and do not have similar importance excepting under those conditions, and as explained in the succeeding text.

While the preceding instructions will be applicable in a large majority of cases, it should be evident that if there seems to be some difficulty or inconsistent result, the search of the record data should be extended to ascertain if any call of the field notes, plat representation, or special instructions that were to be observed in the execution of the original survey, might have been overlooked, which when understood and noted would clarify the problem. This research and study assumes very 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; manifestly 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, i. e.—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.

There is another important factor that requires careful consideration, i. e.—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, or acquiescence, or adverse possession, property boundaries may be defined by roads, fences, or survey marks, disregarding exact conformation with the original section lines, and will 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 a great many cases there are subsurface marks in roadways, such as deposits of a marked stone or other durable material, that are exceptionally important evidence of the exact position of a corner when duly recovered, if the proof can be verified.

A property corner, when placed with due regard to the location of the original survey, should exercise a regular control upon the retracement, but not otherwise excepting in those cases where the agreement is so close as to constitute what is obviously the best available evidence.

## SECONDARY METHODS

### (*d*) Broken Boundaries

**380.** *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. Sections. 223, 511.

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, setting temporary angle points; the residual or closing error is ascertained by the direction and length of the line from the end of the last course to the objective meander corner. The residual is then distributed on the same plan as in balancing a survey for the computation of the areas of the lottings as represented on the plat. Section 593.

The general rule is that the adjustment to be applied to the $\left\{\begin{matrix}\text{latitude}\\ \text{departure}\end{matrix}\right\}$ of any course is to the resolved $\left\{\begin{matrix}\text{latitude}\\ \text{departure}\end{matrix}\right\}$ of the closing error, as the length of that course is to the total length of all the courses. Each adjustment is applied in a direction to reduce the closure, i. e.—if the *northings* are to be *increased*, then the *southings* will be *decreased*; etc.; 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, i. e.—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 (fig. 68.)

There is a similar problem in plotting the lottings within a section of a dependent resurvey when through distortion or other discrepancy large difference are found between the location of a record meander line and that of the true bank or shore, where the purpose is merely

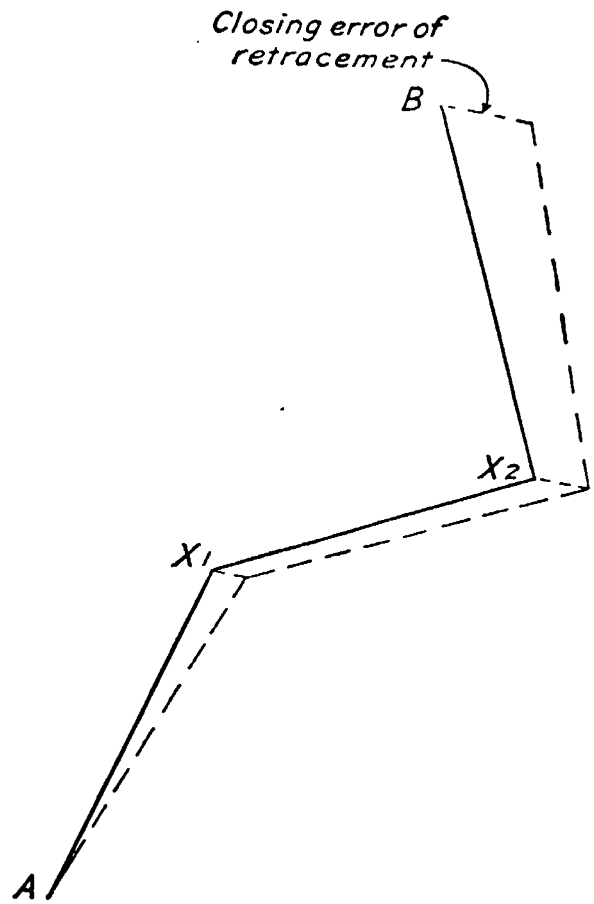



Fig. 68.

to represent these features in true relative position, as in those cases where the ordinary doctrine concerning the meander line appears to be applicable. Sections 226, 236, 659, 661, 665.

**381.** *Grant Boundaries.* In many of the States there are irregular grant and reservation boundaries that were established prior to the public-land subdivisional surveys, where the township and section lines are to regarded as the *closing lines.* The grant boundary field notes may call for natural objects, but these are frequently supplemented by metes-and-bounds descriptions. The natural calls are ordinarily given precedence, then the angle points of the metes-and-bounds survey, so far as these are existent and have been recovered.

Whatever uncertainties there are regarding the location of one or more angle points cannot be eliminated until after satisfying the natural calls, or before giving a proper orientation to the record courses, and a proportional adjustment in the lengths of lines, as may be necessary in order to conform to the ground control.

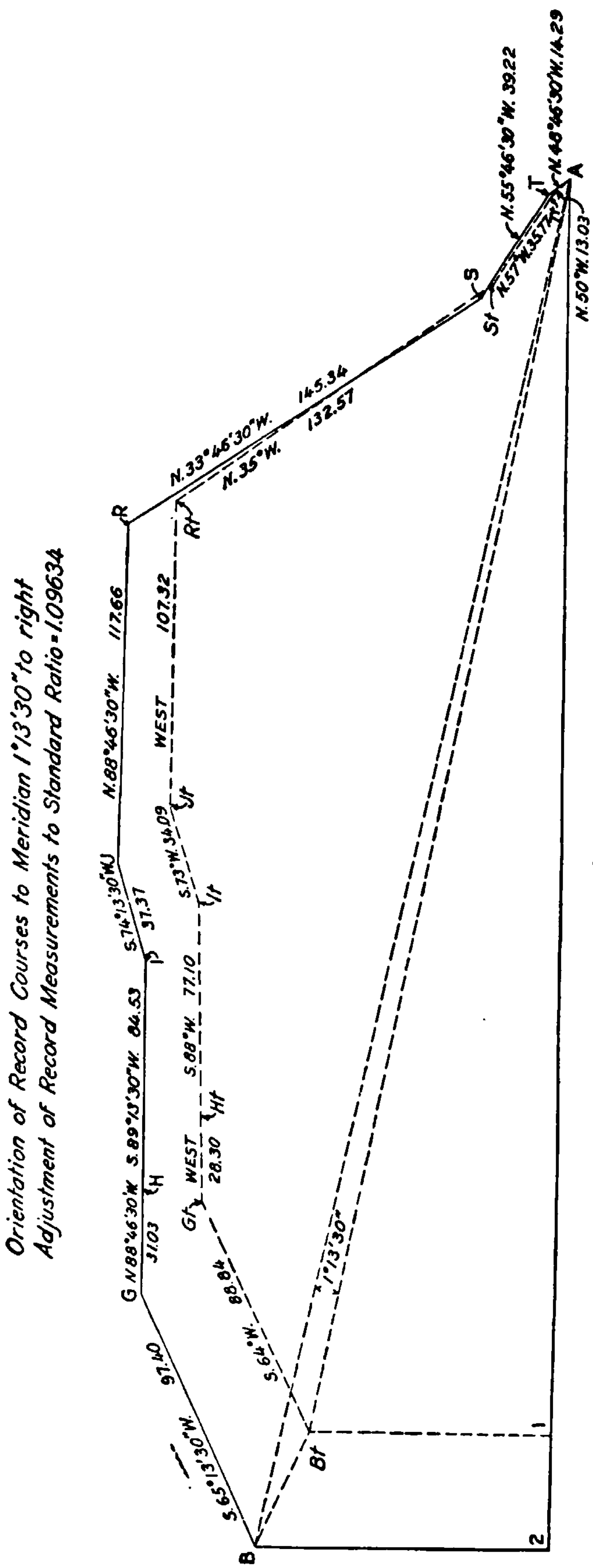
The retracement of an irregular grant boundary should be based on the record courses and distances, then, if it appears that one or more angle points are missing and that these are to be replaced, the trial lines should be corrected *uniformly* to the right, or to the left, and the lengths of the several courses should be adjusted on a *constant* ratio, longer or shorter as may be needed; both the angular and the linear corrections will be made as may be required to take up the falling of the trial lines.

The process of making the adjustments may be compared to that of transferring one drawing to another drawing of slightly different scale, where the pantograph or photograph method may be used for the reduction or enlargement of one drawing, and when the lines of that modified scale are plotted on the second drawing, as follows: direct lines of two (more or less distant) *common points* of control are selected; one drawing is pantographed or photographed to the scale of the other, on the ratio of the lengths of the control lines; the latter are then employed for the orientation. When the drawings are thus assembled all points, angles, straight or curved lines, etc., are placed in proper relative position.

The most direct method in the field, after satisfying the natural calls, is to connect the identified or acceptable points on the following plan:

(*a*) Reduce the record courses and distances to the total differences in latitude and departure, and compute the direction and length of the connecting line;

(*b*) Determine the exact ground differences in latitude and departure, by the most applicable field method, and compute the direction and length of the connecting true line;




Grant boundaries.

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(*c*) The angular difference in the direction of the record connecting line (*a*), and that of the connecting true line (*b*), will give the adjustment or correction to be made to the right, or to the left, in order to orient the record courses to the actual ground control; and,

(*d*) The ratio of the true length of line (*b*), to the calculated record connecting distance (*a*), will be the coefficient to apply to the record lengths of lines to conform with the ground control.

The corrections from magnetic bearings to true meridian courses may be made also, on the ground, on this identical plan (disregarding local attraction).

After the adjustments have been applied to the record courses, all in the same angular amount, and to the record distances, each one proportionally for length, and the locations for the angle points thus determined on the ground, the search for evidence of the record markers may be made with greater assurance, as the differences which may have been attributable to orientation and to the ratio of measurement will now be compensated. The method places the adjusted locations for the angle points where these will be in the most probable original position, thus aiding in the search for marks, and affording a better check of the collateral evidence. These are the points that are to be restored if the angle points are then regarded as lost.

The above method is applicable to those situations where the grant boundary survey preceded the public-land subdivision, and where the township and section lines are to be regarded as the *closing lines*. In more special situations where there are three or more lines that intersect at a common point within a group of irregular metes-and-bounds surveys, where the monument is lost, and if a balanced weight is to be given to all known control, the method that is set out in section 384 will be applicable.

## (e) Original Control

**382.** *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.* Sections 371, 383.

Examples will be found where lines have been discontinued at the intersection with large meanderable bodies of water, or at the border of what was classed as impassable ground.

### (f) Index Correction for Average Error in Alinement and Measurement

**383.** *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 surplus or deficiency in measurement, or a definite angle from cardinal that characterizes the original survey, it will be proper to make allowance for the average differences. An adjustment will be taken care of automatically in all cases where there exists a suitable basis for proportional measurement, but where such control in one direction is lacking, an average difference, if conclusive, will be made use of by applying the same to the record courses and distances.* Section 371.

### (g) Miscellaneous Control

**384.** It will be apparent to the experienced engineer that actual field conditions do not always furnish the basis for the application of the rules heretofore set forth, and while developing a plan of reconstruction to apply in an unusual case the engineer will at once note that the first consideration relates to a more or less arbitrary limitation of the control to be adopted. No definite rule can be laid down, except that there should be the closest possible adherence to the basic examples already given in the text and to the method of the original survey that is to be restored. The methods heretofore outlined readily harmonize surveying practice with legal decisions concerning the restoration of lost corners.

A strictly consistent mathematical recovery of a lost corner, not based upon any known legal decision, may be obtained by allowing every known corner within a reasonable radius to enter into the control, each original corner being given a weight inversely proportional to its distance from the missing corner. The principle will lead to the same result in some cases as by the methods previously outlined, it will yield a slightly different result under some circumstances. For the latter reason a miscellaneous control based upon such mathematical principle will not be adopted except as specifically approved by the regional administrator after due consideration of the facts in regard to the applicability of the method in the absence of a suitable basis for a regular control.

The problem in the field will be developed by a series of retracements each beginning at an accepted corner, thence following out the record courses and distances, each retracement terminating at a temporary stake in the vicinity of the objective lost corner. Each stake will be given a weight inversely proportional to the distance from the accepted corner to which it is related. The several temporary stakes will then be combined; the first two to be resolved into a point on the line between them, dividing the whole distance into two parts that will make the interval from either stake inversely proportional to the weights previously assigned, and the latter point will be given their combined weights. The last point will then be correlated with the third temporary stake on a similar plan. Three or more original corners will thus exercise their influence upon the final resultant position for the corner which is to be restored. The result will be the same no matter what the order of connecting the temporary stakes may be, but the omission of any element of the control or the introduction of an additional original corner will alter the final position. The field of influence should accordingly be selected with a view to obtaining a resultant balanced position which can not be materially changed by the introduction of other known points of control in that vicinity.

## SPECIAL CASES

**385.** 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, however, among experienced cadastral engineers, that if the original survey was made faithfully, and was supported by a reasonably good field-note record, the true location of the original lines and corners can be restored. That is the problem for which the basic principles have been outlined, and for which the rules have been laid down. The text must be discontinued at that point, as the rules can not be elaborated so as to be applicable for the reconstruction of a grossly erroneous survey, or for a survey the record field-notes of which are found to be fictitious. The question of jurisdiction then becomes paramount. If public lands are involved, the methods applicable to resurveys, as outlined in the next chapter, are designed to rectify the conditions where thus found to be at variance with the representations of the official field notes and plat.

**386.** The records of the regional or public survey offices are a reservoir of cumulative experience in dealing with the many types of special cases which come outside of the normal problem, each in its own area; the records in Washington include the special cases from all public-land States and Alaska. 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 engineer in the study of situations that are new to his own experience. When finding unusual situations, therefore, and difficulty in the application of the normal rules for the restoration of lost corners, the engineer is required to report the facts to the proper administrative office. Instructions will issue for the making of additional retracements where that appears to be necessary, particularly where that would be beyond the scope of the original instructions. In this connection, it is important to bear in mind that the problem in hand is one of restoration, to be kept distinct from an authority to engage in the running and marking of new lines as in an original survey.

# Chapter VI

# RESURVEYS



## JURISDICTION

**387.** Certain important considerations are involved in the execution of Government resurveys of an entirely different character from those relating strictly to the making of original surveys; these considerations present matters not referred to in chapter V. There is a twofold object of a resurvey: First, the adequate protection of existing rights acquired under the original survey in the matter of their location on the earth's surface, and, second, the proper marking of the boundaries of the remaining public lands.

The term "resurvey" is applied to the reestablishment or reconstruction of the land boundaries and subdivisions by the rerunning and remarking of the lines that were represented in the field-note record and on the plat of a previous official survey. This will include, as in the beginning, a field-note record of the retracement data, observations, measurements, and monuments descriptive of the work performed, and a plat that represents such resurvey, all subject to the approval of the directing authority.

The above definition of a resurvey is always intended, or implied, unless the term is explicitly modified as in an independent resurvey (sec. 428) or in some other appropriate manner. The adjective "dependent" applied to the term "resurvey" is employed for emphasis, and specifically to suggest the recovery and restoration of the prior official survey.

The term "retracement" is applied to a survey that is made for the purpose of verifying the direction and length of lines, and to identify the monuments and other marks of an established prior survey. The retracement, as such specifically does not modify the former line or lines, excepting where renewing the marks or monuments. The field-note record does afford, however, new evidence of the character and condition of the previous survey, including a careful redetermination of the direction and length of all lines retraced, and whether the retracement is corroborative of the former record field notes and plat, or not so in any particular.

In the October term, 1888, in the case of *Cragin* v. *Powell* (128 U. S., 691, 698), 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.

**388.** As already noted in chapter I, the Congress has authorized, under certain conditions, the remarking of the public-land surveys. The acts relating to resurveys contemplate a restoration of the monuments in those townships, (*a*) where because of obliteration the boundaries can be identified only through extensive retracements in units of whole townships or more, by surveyors experienced in this specialized work, and (*b*) where field investigation has shown that the conditions on the ground are in such disagreement with the representations of the official field notes and plat that the subdivisional lines cannot be identified with certainty as to location, in consequence of which that plat must necessarily be annulled as the basis for the disposal of the remaining public land.

The trend towards the conservation and better use of the public domain, has focussed attention on the need for a retracement and remarking of the lines of the older surveys, in most cases for a re-monumentation, including the plain marking of the lines through the forests, so as to insure the identification and maintenance of the boundaries between the federally-owned and the private lands. The questions always are those of need, jurisdiction, and cost.

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 initiate the action by showing the justification, addressing the Director through the usual official channels. The settlers and owners of the land may take the preliminary steps through a report of the facts submitted to the regional administrator, setting forth the conditions with respect to the monuments and other marks, discrepancies if known or alleged, and the limits of their ownership.[1] Sections 9, 10.

A State court of competent jurisdiction (in cases involving property boundaries) may make application to the Bureau of Land Management to cause a general resurvey of a township.

**389.** The engineer is advised to bear in mind the fact that in localities where resurveys are necessary the occasion for boundary disputes is ever present; he should accordingly exercise the greatest care in his technical work in the field and in the record thereof, so that the result of the resurvey shall relieve existing difficulties as far as possible without introducing new complications. As in the case of original surveys, the records of all resurveys must form an enduring basis upon which depends the security of the title to all lands acquired thereunder. The field notes should be so prepared that under the test of the closest possible scrutiny at all times, present and future, the record can be regarded as conclusive in the matter of the location of such rights.

**390.** The Bureau of Land Management has exclusive jurisdiction over all matters pertaining to surveys and resurveys affecting the public lands. As between private owners of lands the title to which has passed out of the United States, final determination in the matter of fixing the position of disputed land boundaries rests with the local court of competent jurisdiction. The rules of procedure laid down in the Manual of 1947 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 in so far as they represent the true location of a particular tract intended to be conveyed by a patent. The official resurveys are undertaken only when duly authorized, and the field work assigned to a cadastral engineer, 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.

[1] See current circular governing applications for resurveys.

## LIMIT OF AUTHORITY OF ENGINEER

**391.** There are certain questions of a purely judicial nature involved in resurveys of every description where the decision is to be reserved to the 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 judical question beyond the function of the engineer to determine whether or not specified lands have been duly earned under a certain entry. In the resurvey process the engineer will determine whether or not lands embraced within a claim as occupied have been correctly related in position to the original survey. Where the demonstration of this question may be one involving more or less uncertainty, as is often the case, the engineer will examine and weigh the evidence relating strictly to the surveying problem involved. He will interpret the evidence in respect to its effect upon the manner in which the resurvey shall be executed looking to the protection of the valid rights acquired under the original survey. The engineer has no authority to enter into an agreement looking to the exchange of one subdivision for another, or to bind the Bureau of Land Management in this particular.

## BONA FIDE RIGHTS OF CLAIMANTS

**392.** In order to carry out the provisions of the laws relating to resurveys, the engineer should understand fully the meaning of the words "bona fide rights" and under what circumstances it will be held that such rights have been impaired by a resurvey. In this connection attention is directed to the clause contained in the Act of March 3, 1909 (35 Stat., 845), as amended June 25, 1910 (36 Stat., 884; 43 U. S. C. sec. 772), which reads as follows:

> That no such resurvey or retracement shall be so executed as to impair the bona fide rights or claims of any claimant, entryman, or owner of lands affected by such resurvey or retracement.

The rights of claimants are to be given similar protection under the provisions of the Act of September 21, 1918 (40 Stat., 965; 43 U. S. C. sec. 773).

**393.** It will be understood that bona fide rights are those acquired in good faith under the law. Rights of this character can be affected by a resurvey only in the matter of *position or location* on the earth's surface, and the engineer will be concerned only with the question as to whether lands covered by such rights have been actually *located* in good faith. Other questions of good faith, such as priority of occupation, possession, continuous residence, value of improvements, and cultivation, when considered apart from the question of the position of the original survey, do not in any manner affect the problem of resurvey.

It is evident that the resurvey must afford adequate protection to bona fide vested rights in both improved and unimproved lands. In the final determination of the true position of all lands, whether improved or unimproved, in the absence of original corners, the necessity for more or less flexibility of method must be recognized, as the value of both of these classes of lands *may* be vitally affected by an arbitrary process of resurvey which is rigid in its application. Unimproved lands, however, where no apparent attempt has been made on the part of the owner to identify the same under their original descriptions (and where the inherent value of the lands in question is the same), are not *necessarily* affected in the same manner, and such unimproved lands may be adjusted to a position found by the engineer to be conformable to adjoining or near-by tracts, where all may be held to qualify under the rule of acceptable location.

**394.** The position of a tract of land in a surveyed township, 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. It is an obvious principle that 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 were poorly executed, it will still control the boundaries of land patented under it.

The question arises whether the technical rules for the restoration of lost corners are to be rigidly applied in all cases regardless of their effect on the position of improvements, or whether the position of the improvements is to be accepted without question regardless of the relation or irrelation of such improvements to the existing evidence of the original survey and to the description contained in the entry. Manifestly these opposite extremes are equally unacceptable. Somewhere between them, therefore, will be found the basis for a determination of the question as to when lands so improved are to be regarded as having been *located* in good faith or otherwise. It is clear that no definite specific set of rules can be laid down in advance for the determination of this question. This is a problem the solution of which must be found on the ground by the engineer; it is upon his judgment primarily that the responsibility for a determination of the question of good faith as to *location* must rest.

**395.** It may be held generally that an entryman has located his lands in good faith (referred to herein as an acceptable location of a



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claim or of a local point), when it is evident that his interpretation of the record of the original survey as related to the nearest existing corners at the time the lands were located (as defined by his fencing, culture, or other improvements) is indicative of such a degree of care and diligence upon his part, or that of his surveyor, in the ascertainment of his boundaries, as might be expected in the exercise of ordinary intelligence under existing conditions. From this it follows that lack of good faith is not necessarily chargeable against an entryman if he has not located himself according to a rigid application of the rules laid down for the restoration of lost corners, where complicated conditions involve a double set of corners, both of which may be regarded as authentic; or where there are no existing corners in one or more directions for an excessive distance; or where the existing marks are improperly related to an extraordinary degree; or where all evidences of the original survey which had been adopted by the entryman as a basis for his location have been lost before the resurvey is undertaken. Furthermore, the extent of recognition given by neighboring claimants to a local point used for the control of the location of claims very often carries with it the necessity for a consideration of its influence in the matter of the acceptability of such locations under the rule of good faith.

**396.** In cases involving extensive obliteration at the date of entry, the entryman or his successors in interest may be charged with the knowledge that the boundaries of the claim will probably be subject to more or less adjustment in the event of a resurvey, and that in the process of fixing the boundaries of groups of claims a general control applied to all must be favored as far as possible in the interest of equal fairness to all and of simplicity of resurvey. A claim which maifestly shows that no attempt has been made to relate the same in some manner to the original survey cannot generally be regarded as having been located in good faith.

**397.** Cases will arise where it may be evident that lands have been *occupied* in good faith, but whose boundaries as occupied are clearly in disagreement with the demonstrated position of the legal subdivisions called for in the description. Obviously the rule of good faith as to location cannot apply, and relief must be sought through the process of amended entry under R. S. sec. 2372, as amended February 24, 1909 (35 Stat. 645; 43 U. S. C. sec. 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 an *erroneous location,* in precisely the same manner as would obtain if the question of resurvey were not involved. Sec. 426.

398. The recognition of the principle that the restoration of a corner may be influenced by the position of one or more existing claims warrants, within suitable limits, the acceptance of an unofficial determination, in the manner hereinafter defined, which would not necessarily agree with that resulting from a rigid application of arbitrary rules laid down for the restoration of lost corners.

## GENERAL FIELD METHODS

**399.** When the retracements show that the principal resurvey problem is one of obliteration, with comparative absence of large discrepancies, i. e.—that the early survey had been made faithfully, then that official survey can be reconstructed or restored as it was in the beginning; the methods applied are termed a "dependent resurvey."

Conversely, if the retracements show the existence of intolerable discrepancies, i. e.—that the early survey had not been faithfully executed, usually including the fact that some of the lines had not been established, having no actual existence, and therefore incapable of reconstruction or restoration to conform with a fictitious record, entirely different methods can and must be applied to the public-land area, termed an "independent resurvey." In the latter circumstance, the boundaries of the patented lands are given special treatment for their protection, as nearly in harmony as possible with what could be afforded by local court decree.

**400.** The *dependent* resurvey is designed to accomplish a restoration of what purports to be the original conditions according to the record, based, first, upon identified existing corners of the original survey and other recognized and acceptable points of control, and, second, upon the restoration of missing corners by proportionate measurement in harmony with the record of the original survey. This type of resurvey is applicable to those cases showing fairly concordant relation between conditions on the ground and the record of the original survey. Titles, areas, and descriptions should remain absolutely unchanged in the typical dependent resurvey.

**401.** The *independent* resurvey provides methods adapted to considerable areas of public land where the original survey cannot be identified with any degree of certainty in accordance with the representations of the approved plat and field notes, and where the prevailing conditions are such that strictly restorative processes, when applied as an inflexible rule between existing monuments or adopted corner positions, are either inadequate or lead to unsatisfactory results. This type of resurvey provides for the segregation of individual tracts when necessary, or their conformation to the subdivisions of the resurvey if that can be done suitably. Generally, tract surveys can be avoided by restoring the section boundaries in which the claim is situated, using the same control that would have been employed to govern the tract survey, which in certain cases may be three-point, two-point, or even one-point control. In effect this may employ both types of resurvey in the same township, with the dependent resurvey covering those sections which include alienated lands. Tract segregations will be necessary only in those unusual cases where irrelated control prevents the reconstruction of sections that would adequately protect the alienated lands.

These processes are found to be more flexible in their application than those of the strictly dependent type, but at the same time they are intended duly to protect all private rights which have been acquired upon the basis of the original approved survey and plat. The independent type of resurvey supersedes the record of the original survey with respect to the identification and description of the remaining public lands. This will be made apparent by the representations of the approved resurvey plat.

The engineer or surveyor is not clothed with authority to decide boundary disputes, but may be regarded as one qualified by training and experience to testify in such cases. That statutory authority is vested in the court, by virtue of its legal capacity to weigh the evidence, the facts being shown by the testimony of the witnesses, including the surveyors, and by exhibit of the official records. The court is then qualified to weigh the evidence, to exercise discretion as to the preponderance of the evidence, its acceptability, and by court decree to enforce its opinion. The court will determine the facts as to the sufficiency of the control, or extent of the monuments and other marks of the official survey that can be relied upon, and how that control is to be applied. This will be binding in fixing the boundaries of privately-owned property, and would seldom be contested as to acceptability in fixing the boundaries between the public lands and the patented lands excepting as a convincing showing may be made that the monuments of the official survey had been disregarded, overlooked, or otherwise ignored in the testimony in the case, the court itself possessing no authority to set aside the official survey.

Where this flexibility in the application of surveying rules is invoked more or less as in restoring the section-line boundaries with less than normal control, and in making tract segregations, as in an independent resurvey, it must be clearly recognized that the statutory authority to review the effect upon the location of the boundaries of the privately-owned lands continues with the court in full force and effect as intended by law.

Descriptions will not be duplicated on the resurvey plat. Any subdivision whose description would ordinarily result in a repetition of the description of any land already alienated under the original survey, will be given an appropriate new designation. Sections 436, 455.

**402.** The basic principle, with respect to the protection of bona fide rights, involved in one type of resurvey is identical with that of the other type, whether dependent or independent; they are both to be regarded as an official demonstration, on the part of the Bureau of Land Management, in the light of the *best evidence available*, by means of the legal subdivisions of a dependent resurvey or by the tract segregations of an independent resurvey, of the *original* position of entered or patented legal subdivisions or lots included in the *original* description when related to the *original* survey. There is no legal authority for the substitution of the methods incident to an independent resurvey in disregard of identified evidence of the original survey.

**403.** A large proportion of the areas that require resurvey are of a character that a retracement and remarking of the lines may be undertaken and carried through without undue complication, and generally this condition has been fairly well established in the initial application and justification. If complications are encountered which cannot be successfully treated within the usual rules for a dependent resurvey, or which make the special instructions inadequate or inapplicable, a report is required from the field with the factual conditions set out for appropriate action. The questions are those of the extent of the obliteration, the relative harmony of the identified and recognized points of control, the evident faithfulness of the original survey, or otherwise, and the extent of the disposals by the Government.

**404.** The special instructions for an independent resurvey cannot be prepared without a factual report of whatever intolerable conditions there may be which may make it necessary to abandon the prior record-survey as a basis for the disposal of the remaining public lands. Such report should be an assembling of the data in respect to the local survey conditions; the facts with regard to the evidence of the record-survey; the degree to which identified points are concordant, or grossly irregular; the basis of the several claim locations; the existence of one or more unofficial local surveys that have been made on behalf of the claimants, and so recognized and adopted by them in fixing their boundaries; the extent of conflicts by overlapping surveys, or resulting from two sets of corner monuments; and any hiatus that may be anticipated.

**405.** When the development of complications gives indication that independent resurvey procedure may be necessary, this fact will require an authorization as to the scope of the examination in all cases excepting where the unsatisfactory conditions are purely local. The special instructions will then be drawn to indicate the particular considerations which should receive attention in the field. The work of the field examination, including the necessary retracements, search for evidence of monuments or other marks, topographic calls of the record field-notes, and other investigation, will then be entirely preliminary, and without the construction of new monuments of any kind. During this period interested parties should be informed that the field examination is strictly for the purpose of an ascertainment of the facts as to the character and condition of the prior record-survey, and that the resurvey, if one is to be undertaken later, will be planned primarily for the protection of all existing valid rights, and possibly with a view to the running of new lines for the identification and disposal of the remaining public lands, the detail of which cannot be assured in advance of formal action on the report.

**406.** The report of the field examination will be reviewed in the regional or public survey office. Appropriate special instructions will be drawn to show the detail of the proposed resurvey. Recommendation will be made as to whatever action may appear to be necessary as to the status of the public lands which may be affected. Among the very important considerations is the fixing of the outboundaries of the township or townships within the planned resurvey. These limiting boundaries, excepting only where the scope of an independent resurvey is unusually large, are to be lines which can be restored under the ordinary rules so as to protect the existing rights in the adjoining lands that are not to be resurveyed, or within which a resurvey has not been authorized at the time.

**407.** Occasionally, even where the report of the preliminary field examination appears to have been sufficiently full and explicit, unforeseen difficulties may be developed during the progress of the resurvey, by reason of the greater detail of the work, and additional opportunity for study. New factors may render the special instructions quite inapplicable, or be such that would evidently produce inconsistent or unsatisfactory results if carried through. Such dangers are ever present, adding greatly to the problem of resurvey, and to the responsibility of the chief of field party. In such cases, when encountered, it is of utmost importance that further monumentation be suspended for the time. Attention will be given to the needed additional retracements, or other examination, reporting promptly to the regional or public survey office as to this phase or change in the work in hand.

**408.** During the progress of the resurvey the engineer should advise all interested parties, as occasion and opportunity may offer, that the resurvey is not to be regarded as official or binding upon the United States until duly accepted by the Director, Bureau of Land Management, as provided by law, and that no contemplated alteration in the position of improvements or claim boundaries should be made in advance of the official acceptance of the resurvey.

## THE DEPENDENT RESURVEY

### General Control

**409.** A dependent resurvey is an official re-marking of the original lines upon a plan whereby existing evidence of the original survey is given primary control over the position of the lines to be reestablished. A certain amount of flexibility (as hereinafter described) is allowable in the dependent resurvey when necessary for the protection of bona fide rights of claimants, particularly in those cases where no objection is found to adopting a point acceptably located under the rule of good faith already laid down, when only slightly at variance with the theoretical position.

**410.** In both theory and practice the dependent resurvey is begun by making a retracement of the township exteriors and subdivisional lines of the established prior survey within the unit of the assigned work. This is done, first, for the identification of all marks and monuments that are called for in the record field-notes; second, for the study and use of the available supplemental survey records, and testimony of witnesses, to ascertain if this evidence is sufficiently well-qualified for the replacement of corners that may be treated as *obliterated, but not lost;* third, for the careful consideration of all additional collateral evidence as hereinafter described. The first two steps give the basic control for the resurvey, against which may be weighed the less certain collateral evidence, by comparison with the proportionate positions derived from the basic control.

The field processes are necessarily more or less varied to meet the local conditions. If the usual four-point control (for a section corner) appears to be wholly inapplicable, or decidely unsatisfactory, then a three-point control may be considered in weighing the collateral evidence. In extreme cases the collateral evidence may be weighed against the two-point control, particularly when supported by field-note calls to well-identified natural features. All such preliminary retracement, search, and study is of course directed to the identification of the boundaries of the alienated lands, and to what extent the resurvey may be carried through under the rules for proportional measurement, the latter to be so qualified that the result can be regarded as satisfactory if that plan is followed.

Ordinarily the one-point control is inconsistent with the general plan of a dependent resurvey. The courts have frequently 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," overlooking the fact that the record is equally applicable when reversing the direction of the control from other good corners, monuments, or marks, if such can be recovered by careful retracement. The use of the one-point control may be applicable where the prior survey was discontinued, by record, or through the failure actually to run and establish the line called for. If by record, the field notes may be followed explicitly. If discontinued by evident unfaithfulness in execution, its use would be limited to the making of a tract segregation where the claimant had given confidence to the so-called field notes.

**411.** The process of the dependent resurvey differs in scope from that applied for the usual restoration of one or more lost corners, as the rules governing a resurvey bring into consideration in a more comprehensive manner the position of recognized land boundaries, in the absence of evidence of the original corners. The engineer has noted the detailed instructions set forth in chapter V looking to the identification of existing evidence of the original survey and the application of the rules of proportionate measurement for the determination of the theoretical position of lost corners. These rules will be applied in the dependent resurvey generally with respect to the township as a unit, wherein the means of identification of each and every existent corner will be exhausted and the theoretical position determined for each lost corner. The former are to be considered as fixed points (except in most unusual cases) and may be monumented at any time; the latter will be subjected to the possible influence of points which may afterwards be determined to be acceptably located under the same rule of good faith, and will be marked only as temporary points until this question has been disposed of.

**412.** A complete retracement of the original survey will be made, based upon known corners, it being assumed that the exterior boundaries of the township to be resurveyed have been identified or restored under the rules already laid down in chapter V, and under those relating to the acceptability of a local point or claim location. It is not usually possible to follow the method and order of procedure shown in the record of the original survey (owing to missing corners), but the complete system of lines will be run out by preliminary retracement, usually beginning with the meridional lines between known corners, followed by the latitudinal lines between known corners, noting the intersections with the meridional lines. The engineer must be supplied with a complete copy of the record of the original survey. Temporary reference stakes are usually set on the meridional lines at the record measurement for each corner.

**413.** The preliminary retracements will lead at once to the identification of the known and plainer evidence of the original survey. A trial calculation will follow as to the latitudinal and longitudinal adjustments at each missing corner, to suit the proportions which may be derived when based upon these known corners. A second and more exhaustive search will then follow within the zone of the probable location of each missing corner for the more obscure evidence of the original survey. At this stage of his field work the engineer should exhaust every possible means of identifying the existent corners of the original survey. In many respects, the engineer will be compelled to adopt methods such as the actual field conditions seem to warrant, exercising skill and judgment.

If additional evidences of the original survey are found, a second trial calculation will then be made as to the latitudinal and longitudinal adjustments of the temporary reference stakes previously set at each missing corner, to suit the proportional measurements derived from all of the known original corners—exactly as outlined in chapter V. These calculated adjustments will determine the theoretical location of each lost corner with reference to the known existing evidence of the original survey.

In the absence of other considerations, the theoretical points thus determined by proportionate measurement, based upon existing original corners, are fixed to a mathematical certainty, and when these points have been determined, the evidence of the original survey and the record thereof have served their primary purpose. Then, and not until that time, is the engineer prepared to consider the weight of such collateral evidence as may be available.

**414.** The question now to be determined is whether the position of the lands claimed, occupied or improved is to be adopted under the rule of good faith as to location, and whether, if so adopted, the claims thus acceptably located can all be properly protected by the dependent plan of resurvey. If the position of any claim fails to qualify under the rule of good faith it may be disregarded as to the effect produced thereon by the plan of dependent resurvey. On the other hand, if these claims are held to be acceptably located under the same rule, they may be adopted as the determining factor in the position of the missing corner or corners; and if the claims are in such concordant relation to each other and to the identified evidences of the original survey as to receive full protection by the dependent plan of resurvey, the

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engineer may proceed with full assurance of the adequacy of the plan. Otherwise, the question of other processes analogous to those of an independent resurvey or to the amendment of description (as hereinafter explained) must be considered.

If two or more claims are acceptably located, but are discordantly related to each other to a considerable degree (by virtue of irregularities in the original survey), it will be clear that the general plan of dependent resurvey may not afford protection to such claims. In this case, as before stated, some other process must be adopted to protect the acceptably located claims.

**415.** These acceptably located points for the missing corners will receive all the authority and significance of an identified original corner, and when the influence thereof on the dependent plan of resurvey has been combined with that of the existing original corners previously identified, the adjustments of the temporary points in latitude and departure may be made accordingly.

**416.** In cases of distortion, if the distorted lines are to be adopted in the plan of dependent resurvey, it should be remembered that the lengths of lines, when subject to double proportion, are comparable only when reduced to cardinal equivalents or to equivalents along the direct lines between the nearest existing corners.

**417.** Many situations will arise where it will be manifest that it is better to accept a position based upon local interpretation rather than to disturb satisfactory existing conditions. The engineer will endeavor to avoid disturbing the position of locally recognized lines when such action may adversely affect improvements. At the same time extreme caution will be exercised in the matter of adopting local points of control, which when accepted must be given, as above stated, a significance similar to that of an original corner. The acceptance of duly qualified and locally recognized points of control should aid materially in obtaining simplicity of resurvey and avoid the need for special metes-and-bounds surveys (as hereinafter described), which would differ only slightly in position from the regular lines of the resurvey. In this manner a flexibility will be introduced in the plan of the dependent resurvey, at least to the point of protecting satisfactory local adjustments. Section 379.

**418.** The engineer should fully understand that the field of influence to be exercised by any acceptable location must be restricted to that already covered in a larger way by the existing evidences of the original survey, and that the adjustive process is of more or less local application. In this connection, it should be noted that the record of the original survey can not be abandoned in favor of an *indiscriminate* adoption of property corners unrelated to the original survey.

**419.** Thus when the bona fide rights are found to have been definitely established with reference to the location of lands the position of which can not otherwise be fully demonstrated by existing evidence of the original survey, the theoretical point determined by the primary control will be set aside in favor of a near-by *duly qualified* corresponding point, the position of which has been agreed upon by the adjoining property owners. Such a point may then be recognized as the best available evidence of the true position for the corner. Chief among this class of evidence forming the basis of the recognized position of land boundaries are recorded monuments established by local surveyors, duly agreed upon by the interested property owners; the position of boundary fences determined in the same manner; and the lines of public roads and drainage or irrigation ditches, when intended to be located with reference to the subdivisional lines. The local record in these cases, when available, may furnish evidence of the original survey. If a point qualifies as above, the presumption is strong that its position bears satisfactory relation to the original survey and that its correctness can not be successfully disputed. Points which actually qualify may be accepted as the best available evidence of the true position of the original survey. Section 379.

**420.** The field-note record of the resurvey should clearly set forth the reasons for the acceptance of a local point, where unofficial determinations of the above character do not represent actual marks of the original survey. Such recognized and acceptable local marks will be preserved, and described; where they are monuments of a durable nature, they will be fully described in the field notes and a full complement of the required accessories recorded, but without disturbing or remarking the existing monument. New monuments will be established if required for permanence, in addition to, but without destroying the evidence of, the local marks.

## Reestablishment of True Lines

**421.** The final calculations for the corners that are to be treated as lost will be based upon the known position of the corners of the general control as thus adopted, upon the plan of proportionate measurement, as provided in chapter V. The result of this process balances in regular proportion the differences between the measurements shown in the record of the original survey and those derived in the retracement. Thus the true lines of the dependent resurvey are determined through the influence exercised by the identified existent corners of the original survey, other identified calls of the record, and such collateral evidence of the position of recognized land boundaries as may properly be adopted for such influence.

**422.** The field procedure incident to the running and measurement of the true lines of the dependent resurvey will conform to the requirements of chapter II, while the marking of lines between corners and the notation of objects to be recorded will conform to the provisions of chapter III, and the monumentation of the survey will comply with chapter IV. The technical record of the resurvey will be broadened appropriately to show the relationship between the original survey and the reestablished lines.

The limit of closure that is prescribed in section 234 will be observed, stressing the need for greater accuracy, especially in the measurements, which largely govern the restoration of lost corners.

**423.** The field note description of an identified or accepted corner will be introduced into the technical record of the resurvey at the place in the true line notes where the position for the corner is indicated as having been attained. The record will embrace:

(*a*) A complete description of the remaining evidence of the original monument;

(*b*) A complete description of the new monument;

(*c*) A complete description of the original accessories as identified;

(*d*) A complete description of the new accessories;

(*e*) A concise statement relating to the recovery of a corner based upon identified line trees, blazed lines, items of topography, or other calls of the field notes of the original survey, in the absence of evidence of the monument or its accessories; and,

(*f*) A statement of fact relating to the relocation of an obliterated monument; or a statement of the determining features leading to the acceptance of a recognized local corner.

**424.** General titles (in addition to the regular page heading) will be inserted in the field notes of dependent resurveys to indicate the character of the resurvey, the technical record of which follows. Such titles will be inserted in the body of the field notes, as appropriate, and will show the name of the original surveyor and the year in which the original survey was executed; as, for example:

**Reestablishment of the surveys executed by John B. Smith, U. S. Surveyor, in 1842,**

and additional memoranda will be added as appropriate, explanatory of the method of control adopted in the restoration of one or more lost corners.

**425.** In addition to the usual data, the plat should carry a marginal memorandum that duly qualifies the character of the dependent resurvey, also a reference to the previous plat (or plats) to which it is related.

For example, in the case of a whole township completely resurveyed, the following general statement will be applicable:

This plat represents a retracement and reestablishment of the original township boundary and subdivisional lines designed to restore all corners in their ture original locations according to the best available evidence; and, excepting as new or modified vacant subdivisions are shown 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 where the township had not been completely resurveyed, the memorandum will be modified. A diagram may be added to clarify the detail where desired to visualize the related lines of the resurvey to those previously established.

The reference to modified lottings or areas will be omitted when there are no exceptions.

A necessary additional citation will take the following form:

Survey executed by ---------------- beginning ----------------, and completed ----------------, pursuant to special instructions for Group No. ------, dated------------------.

The desired historical references to the field notes and plats of the earlier surveys, and to lines more recently resurveyed that form a portion or portions of the plat outline, will be elaborated upon as needed to clarify every feature of the resurvey, to be incorporated in the introductory part of the field notes.

## Additional Methods for the Protection of Bona Fide Rights

**426.** In the execution of a dependent resurvey there may possibly arise rare cases where locally established corners controlling valuable improvements are so discordantly related to the existing authentic evidences of the original survey that such local corners can not qualify for adoption as acceptable collateral evidence (secs. 414 and 417), there being no legal authority for a disregard of the identified evidence of the original survey. Sections 395, 397, and 402. The usual appropriate treatment of this situation, where possible of application, consists in an amendment of the entry (sec. 397) from the entered to the occupied legal subdivisions in terms of the original survey. These cases are decidedly exceptional in any township where regular control has been developed by careful retracement and thorough search. No general remedy has been devised other than that of amendment of entry, and where such method appears to be impracticable the engineer will submit a detailed report of the conditions found, with recommendation for precedure suited to the particular situation to be dealt with and designed for protection to the claimant's improvements, but on a plan that will not disturb those who have acquired legal rights in the matter of consistent location.

A metes-and-bounds survey of an erroneous location cannot have the legal effect of an amendment of the entry. No legal title can be established by the occupancy of lands outside of the subdivisions named in the entry, except where the adjoining lands are privately owned, as adverse possession does not run against the United States, and sooner or later the claimant would find himself without a complete legal title to the lands upon which he had spent his labors. An amendment of entry, when the occupancy and improvement do not conform to the lines and subdivisions of the original survey, is the only safe course.

## Summary

**427.** A summary statement of the theory and practice of the dependent resurvey with respect to one township as a unit will demonstrate that attention should be given to certain minimum requirements as shown by the outline that follows.

The instrumental methods and the measurements are exactly as required in the execution of original surveys, but there is stressed the need for more than usual care in the determination of the length of lines, which is so largely controlling in the restoration of lost corners.

The rules for the identification of existent corners, the acceptance of collateral evidence with respect to obliterated corners, and for the restoration of lost corners are specifically as outlined in chapter V.

The monumentation in all respects is as required on original surveys, supplemented by a field-note record of all necessary descriptions, including the prior monumentation as identified by the physical evidence, the collateral record, and the monuments as reconstructed.

In order to accomplish a dependent resurvey, the township boundary lines are first retraced in their entirety, and completely restored in their original position, exactly as established in the beginning. This circumscribes the work to be done, and is usually carried out on that plan unless some condition is developed that requires supporting evidence that may be derived from the subdivisional surveys within the adjoining townships, before concluding the restoration of the township exteriors.

There follows a complete retracement of the interior lines. In practice, as applied to the very early surveys whose dates run back as much as 150 years in some cases, where resurvey is required, the engineer will be concerned usually with two primary considerations, which it is his responsibility to harmonize as far as that can be done along legal methods, though he is not clothed with legal jurisdiction to dispose of disputes, but rather to ascertain the facts in each situation. First, the restoration of what the record purports to be the original conditions; and, second, the protection of the bona fide rights of all claimants in the matter of their locations.

The first requirement must be fulfilled with reference to the evidence of the original survey; in this the discovery and identification of original monuments, marks, and corner positions is paramount, bearing in mind that frequently there may be only a few remaining original marks and that each additional supporting evidence adds manifest conclusiveness to the resurvey. This stage of the evidence is regarded as the basic control.

Second, there is not much that can be added in this summary, without undue repetition, in respect to the property rights of the landowners, entrymen, or other claimants, excepting to emphasize that the engineer is in exactly the same position as the local surveyor, and is bound by the same rules. The county surveyor may enlist the assistance of the county attorney, or the local court as needed; the cadastral engineer reports to the regional or public survey office when in doubt as to the procedure. The advice or instructions that follow in either case must necessarily depend upon the facts as reported by the surveyor. If the latter fails in his work, by oversight, carelessness, or inexperience, the regional or public survey office, the local attorney, or the court may be thereby misled, and the treatment of the situation may be entirely inapplicable. This responsibility on the part of the chief of field party calls for utmost thoroughness in every detail.

An outline of the subject of retracements, entirely advisory in character, for the information of county and other local surveyors, with a brief reference to property rights under State law, is contained in the Manual supplement—Restoration of Lost or Obliterated Corners and Subdivision of Sections, 1939.[3] The cadastral engineer is bound by the same rules when engaged in official surveys. There is sometimes an apparent overlap in jurisdiction, but in most cases the distinction in the duties is clear.

An example of the nature of certain satisfactory qualifying evidence (hypothetical, for illustration), and the needed computations converting from the retracement data to the true line courses and distances: Manual Appendix VI.

A second short example (specimen field notes) of the introductory statements that are appropriate in the field notes, together with extracts from the true line field notes to show the acceptable forms of description applicable to a dependent resurvey: Manual Appendix VIII.

[3] Superintendent of Documents, Government Printing Office, Washington, D. C.

## THE INDEPENDENT RESURVEY

**428**. An independent resurvey is an official running and marking of new township and section boundary lines without regard for the location of the record lines and corner monuments, or other marks of the prior survey which the independent resurvey is designed to supersede. The independent resurvey may be effective only with respect to the public lands and for that reason there necessarily must be an identification and suitable segregation of all entered or patented subdivisions of the sections of the original survey which are not identical with the corresponding legal subdivisions of the independent resurvey. Sections 563, 564, 565, 645, 646.

The independent resurvey is accomplished by three distinct steps:

(*a*) The reestablishment of the outboundaries of the lands subject to resurvey, following the method of a dependent resurvey.

(*b*) The segregation of lands embraced in any valid claim where the initial steps have been taken looking to the disposal of the title of the United States based upon the former approved plat. The tract segregations do not modify the private titles, but are designed to give official recognition and respect to all such rights when required for the identification of the remaining public lands.

(*c*) New exterior, subdivisional and meander lines as necessary, established upon a new regular plan, which, for every purpose of identification and description of the public lands involved, becomes the prevailing survey.

### Reestablishment of Outboundaries

**429**. The limiting boundaries of the lands subject to independent resurvey must agree with the previously established and identified exterior or subdivisional lines of the approved original surveys. In order to qualify as a suitable limiting boundary as aforementioned, a line of the accepted established surveys will be selected which can be conclusively identified (by existing original or properly restored corners) in one position to the exclusion of all others and which by its known position adequately protects all rights (located in good faith as hereinbefore defined) based upon any township plat showing subdivisions of the public lands adjacent to said boundary. Such outboundaries of the lands to be resurveyed by the independent process must necessarily be retraced and reestablished in their true original position. The lands upon one side of such outboundary are to be resubdivided upon a new plan, while upon the opposite side of such line the original subdivisions are to be strictly maintained and none of the original conditions are to be disturbed.

**430.** The outboundaries are generally selected along the locus of the previously established township exteriors where the existing evidence gives positive proof of the location of the original survey, and where conditions on the ground are harmoniously related to the record of said original survey. In special cases certain section lines may fully qualify as suitable lines to mark the limit of the independent resurvey; such section lines will then be duly retraced and reestablished in their true original position. Particular attention will be given to this very important subject at the time when the field examination is made with a view to maintaining the original survey as far as consistent. Sections 401, 436, 438.

**431.** In those cases where a proper limiting boundary can not be secured without involving the necessity for the inclusion in the group of a greater number of townships than administratively practicable to execute in one assignment, the necessity may arise for the extension of tract segregations (as hereinafter outlined) into a township ungrouped for resurvey. In such cases, under specific authority of the Bureau of Land Management, any tract found to extend across such group outboundary will be segregated in full, whether or not the tract was originally described as in the township to be resurveyed, and the necessary official steps will thereupon be taken in the matter of suspension of the lands in the adjoining township from further disposal and of additional investigations with a view to a resurvey of all or a portion of the said adjoining township. See second rule, section 445

**432.** The special instructions will show specifically what lines have been selected to limit the dependent resurvey, the latter to restore the boundaries of those sections where there are alienated lands. Where making this change in method, the dependent resurvey will be restricted to those sections where the retracements indicate that some suitable control can be applied for the restoration of those section boundaries. The retracement and reestablishment of the outboundaries of those sections concludes what may be termed the *dependent resurvey;* this will precede the running of the remaining lines, termed the *independent resurvey,* the latter being devoid of adequate control that can be derived from the prior survey.

A special problem is presented in those situations where the Director finds that it is advisable to cancel or annul a former accepted survey because of the showing of *gross irregularities*, such as badly distorted section boundaries whose lengths and directions are unreasonably at variance with the record, usually coupled with the fact that some of the lines never had actual existence in fact. The cancellation action can be taken only by the Director, and requires ample justification to show that even though the monuments may be identified in portions of the area, the lines when restored under the rules for proportionate



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measurement do not constitute an acceptable basis for the identification of the remaining public land. This applies to the public land, and has no bearing on the identification of the alienated subdivisions described in terms of the prior survey.

The abandonment of a former survey that is marked on the ground requires that the location of the existing monuments be determined by direction and length of line connecting to the nearest new monument, then treated as in section 163. See also section 459.

A factual statement will be required in the field-note record of the independent resurvey to show what proof has been established that the corresponding lines of the prior record-survey have no actual existence in fact, especially that no corner monuments have been overlooked, disregarded, or otherwise ignored. This is always at the risk of failure to find some of the record monuments. Where that does happen there is created the confusion that results from the existence on the ground of two sets of monuments which by record are there to mark similar described subdivisions. The field notes of the resurvey, of course, clear the conditions, but the situation is not so readily evident to the settler, nor to the local surveyor who may not be supplied with the field notes.

**433.** Where the lines of the independent resurvey are not to be initiated or closed upon the restored original corners of the outboundaries, said restored corners will be marked only with reference to the township, range and section to which they will thenceforth relate, and new regular corners of minimum control will be established as necessary to govern the lines of the independent resurvey, all as provided in section 164. During the preliminary stages of the resurvey there will often be more or less doubt as to whether an old corner will retain its former control or will have to be altered, and until this uncertainty has been removed the marking of a corner and its accessories should be deferred. The monumentation will follow the final determination of the future significance of each point. Where an old point is to be perpetuated merely to control the former alinement, but not the corner of a subdivision, its future significance will be that of an "angle point" only and the monument and its accessories will be marked accordingly.

## Metes-and-Bounds Survey of Private Claims

**434.** After the reestablishment of the outboundaries of the lands subject to independent resurvey has been accomplished in accordance with the requirements of the special instructions, the engineer's attention will be directed to the segregation or marking out of all duly entered, selected, reserved (in certain cases), granted, or patented lands whose description may be based upon the former approved plat, and which can not be conformed to the lines of the resurvey.

**435.** A status diagram will be furnished to the engineer showing all patented lands, valid entries, school sections, and other land grants, and all other disposals, reservations, or selections of lands whose position and description are based upon the original survey and plat, and whose boundaries can not legally be disturbed. In every case the various tracts shown upon the status diagram will be protected either by individual "metes-and-bounds" survey or by the assignment of appropriate subdivisions of the resurvey in case the latter lines (new section lines, or center lines of sections or quarter sections) are found to coincide or approximately agree with the boundaries of said tracts.

**436.** It is not to be understood that the metes-and-bounds survey of private claims must be completed before beginning the projection of the new lines of the independent resurvey. It has merely been deemed logical to consider the subject of the tract segregations in advance of the question of the establishment of new lines. The fact is that engineers will find it expedient to carry both branches of the survey along together in the locality of the camp or other field headquarters.

However, before making a tract segregation, and before the running of new section lines, it is necessary to make certain the discrepancies are such that no adequate or satisfactory basis can be shown for the restoration of the former section-line boundaries as a whole. The plan of the independent resurvey must be such that no lines, monuments, or plat representation will duplicate the description of any previous section where disposals have been made. Sections 401, 455. The record field notes and plat representing the prior survey of the remaining sections, now regarded as fictitious, fraudulent, or grossly erroneous beyond any tolerable limit, becomes abandoned at this point insofar as future disposals may be concerned.

**437.** The jurisdiction of the Bureau of Land Management, the limit of the authority of the engineer, and the bona fide rights of claimants, where entered or patented lands are involved, remain absolutely the same whether the resurvey is to be made upon the dependent or independent plan. Thus where the independent type of resurvey has been adopted as more feasible, identified corners of the original survey in the immediate vicinity of lands to be segregated will be employed for the control of the location of such lands. The question of the good faith of the entryman will in every case be fully considered, as previously outlined in this chapter, and where the evidence of the original survey is so obliterated that a charge of a lack of good faith can not be brought against an entryman whose claim boundaries may differ from a theoretical location determined by more rigid surveying rules, the available collateral evidence is to be regarded as the best indication of the original position of the claim, and the same will be employed as far as consistent for the control of the section boundaries within which such claim is located. Section 395.

**438.** 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 can not 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 will be marked by angle-point monumentation, and a tie made to a corner of the resurvey. Section 452.

**439.** Where the engineer can not point out, by suitable identification of the original surveys, the definite location of an entry based upon the former approved plat, the claimant or owner of such lands will be consulted as to the position of his boundary lines. The boundaries of the private claim, so determined, will be fixed, as between the private and public lands, subject to the official acceptance of the resurvey. Where dispute is encountered in regard to the adjustment of the line between adjoining patented tracts, each acceptably located under the rules already laid down, which can not be reconciled or suitably disposed of by surveying process, the tracts will be surveyed in conflict, as hereinafter provided, and so shown on the resurvey plat; the questions arising out of such conflict will be given administrative review with the field notes of the resurvey.

**440.** The owner of an unidentified claim will be called upon to indicate the boundary lines thereof if possible, and in this connection, should occasion arise, the engineer will explain the manner of adjusting differences between adjoining claims and what will constitute an acceptable location of a claim. The latter condition demands a form agreeing with the original entry, approximately regular boundaries, an area not widely inconsistent with that shown upon the original plat, and a location as nearly correct as may be expected from the existing evidence of the original survey, without overlapping into an adjoining township not subject to resurvey, except as provided in section 431. In every case where the outboundaries of the lands subject to "independent resurvey," have been reestablished by the "dependent" or "restorative" plan, the subdivisions of a tract situated and originally described as along or upon the opposite sides of such outboundary must agree with the line reestablished and harmonize in relative position.

**441.** In the execution of an independent resurvey, therefore, the identity of each tract to be segregated therein or indicated by conformation to the lines of the resurvey, whether patented or unpatented, must be maintained, and the engineer will not be allowed to change materially the configuration of a tract as shown by its original description in order to indemnify the owner thereof against deficiencies in area, to eliminate conflicts between entries, or for any other purpose. If improvements have been located in good faith, the tract survey should be so executed, or the conformation to the lines of the resurvey so indicated, as to cover as nearly as possible these improvements and at the same time maintain substantially the form of the entry as originally described. No departure from this rule will be allowed.

**442.** The question of amendment of entries for the purpose of permitting adjustments in terms of the resurvey involving lands not included within the original tract is a matter for adjudication by the Bureau of Land Management after the resurvey has been accepted and the plats thereof filed in the district land office.

**443.** In case of absentee owners an attempt should be made to establish consultation, in order that the claimant may point out the lands subject to a *metes-and-bounds survey*. If the owner cannot be found and there is no visible indication, such as a boundary fence, of the location of the limits of a claim, the engineer will exercise the alternative of locating the claim from the nearest original point of control or from a point of a neighboring claim, or of assigning to the entered or patented lands the appropriate subdivisions of the resurvey, all subject to the principles hereinbefore set forth. The controlling factors in such locations will be based upon the individual and neighborhood improvements (such as buildings, wells, springs of water, cultivated lands, public roads, fences, corners of recognized private surveys, etc.) which may indicate the evident intention of the entryman or patentee as to the position of his land.

**444.** Each nonconformable valid claim in a township will be given a serial tract number, commencing with No. 37 in the smallest numbered and entered section of the original plat, progressing through the township in the order in which lots and sections are numbered. A tract number will be used but once in a township, and if any tract lies partly in two or more townships subject to resurvey the number applied to the tract in the first township resurveyed will not be used for other tracts in the adjoining township.

**445.** The following rules will be observed in the execution of the *metes-and-bounds survey* of all specially designated tracts:

1. Each claim, acceptably located, but at variance with the lines of the resurvey, will be surveyed and monumented at each angle point.

2. Where a portion of a claim is originally described as in a township not subject to resurvey, such portion of the claim will not be surveyed by metes and bounds, provided the limiting boundary is found to qualify as set forth in section 429. The portion of the claim originally described as in the township to be resurveyed should ordinarily be defined in a position (either by segregation or conformation to the lines of the resurvey) which is properly related to the identified or restored corners on the limiting boundary. Sec. 431.

3. Where the boundaries of a claim are unacceptably located as pointed out by the claimant, the engineer will proceed with a proper survey of the tract in accordance with rules already stated which will result in a suitable relation to the original survey, and the corners of the tract as thus located will be monumented. If the claimant protests against such location, the engineer will request that the protest be made in writing (to be submitted with the returns of the resurvey), and will thereupon make an accurate connection with the corners of the claim as unacceptably located, to be made the subject of a complete report by the engineer, reviewing the facts with reference to the question of location. As a further protection [3] to an entryman thus unacceptably located see section 426.

4. Where, through a compliance by the engineer with the general rules above laid down, the metes-and-bounds segregation of a claim (or the conformation thereof to the lines of the resurvey) within the field of an independent resurvey (or the related subdivisions within the field of a dependent resurvey) fails to cover any or all of the lands, occupied, improved, or claimed by the entryman, patentee, or present owner, and the latter indicates a desire to amend his entry, that fact will be stated in the field notes, and a separate full report will be submitted describing the subdivisions actually occupied and sought to be acquired under the amended entry, but which are not covered by the tract as surveyed, all looking to the protection of the title to the lands actually earned.[3]

5. Where it so happens that the regular quarter-quarter sections embraced within a claim fall in approximately the same position as the regular quarter-quarter sections of the resurvey, and the entryman or patentee indicates a desire to conform his claim to the resurvey, and no apparent objection is found by the engineer, the facts will

[3] See current regulations relating to amendment of entries.

be stated in the field notes, and the claim will be so indicated upon the resurvey plat. Under this circumstance the metes-and-bounds survey of the tract will be omitted. However, where any tract whose original description includes *any fractional lot*, or where any part of a tract falls upon *any fractional lot* of the resurvey, the tracts will be segregated as a whole by metes-and-bounds survey, even though some or all of the lines of the tract may coincide with certain subdivisional lines of the resurvey.

No claim will 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, will be surveyed and monumented, and conflict shown upon the resurvey plat. Each intersection of conflicting boundaries will be determined upon the ground and recorded in the field notes, and the latter will show the number of acres in conflict with each other tract. Secs. 657, 664.

7. The angle points of a tract will be designated by serial numbers beginning with No. 1 at the northeast corner, and proceeding around the claim, running westerly from the initial corner. An angle point may be common to one, two, three, or four tracts, and will be monumented and marked as provided in chapter IV; as for example:

| AP 4<br>TR 38 | AP 3<br>TR 37 |
|---|---|
| AP 1<br>TR 45 | AP 2<br>TR 46 |

1919

T 26 N R 17 E
S 14

| AP 1<br>TR 38 | AP 2<br>TR 37 |
|---|---|

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T 26 N R 17 E

| AP 1<br>TR 37 | S 14 |
|---|---|

1919

8. No accessories will be required with the monuments at the angle points of the metes-and-bounds survey.

**446.** The regional office will furnish the engineer with an abstract of the valid entries, selections, reservations, patents, and grants, based upon the original plat of any township (or portion thereof) subject to resurvey. The resurvey cannot be regarded as complete until each and every claim described in said abstract of entries (and shown on the status diagram) as in the township to be resurveyed has received full protection in the matter of location. Aside from those disposals described as in the township to be resurveyed, there may also be furnished to the engineer, as a matter of information when needed, the status of all claims in the adjacent sections of the adjoining townships ungrouped for resurvey. The abstract will be included with the other data to accompany the written special instructions providing for a resurvey.

## Field Notes and Plat

**447.** The field notes of the metes-and-bounds survey of each valid claim will be preceded by a copy of the abstract of entry. A brief statement will then follow in each instance (or with suitable reference), concerning the principal factors controlling the location of the particular tract, and whether or not the claimant was consulted, or communicated with, in the matter of the identification of the boundaries of his claim. The statement should be clear as to whether the location of a claim, shown either as a tract segregation or as conforming to the lines of the resurvey, was controlled by collateral evidence, or by one or more identified corners of the original survey, nearby or remotely located, or by its relation to adjoining tracts. In case all of the tract segregations within a township can be covered by one general statement, the same should appear at the beginning of the field notes of the metes-and-bounds surveys. The field notes should be made to account for each and every tract shown upon the status diagram.

**448.** All claims should be accounted for on the plat of an independent resurvey and all will be shown either as segregated tracts or as conforming to the lines of the resurvey, as the case may be, with outline indicated by heavy black lines. An exception to this rule will be made in those rare cases where all the claims within a township have been conformed to the lines of the resurvey *under their original description*, in which event a statement may be made on the margin of the plat that—

All claims originally described as in this township are intended to conform to the lines of the resurvey under their original description.

**449.** The additional memorandum that is placed on the plat of the independent resurvey must necessarily be designed to clarify its very special and unusual character, especially to the effect that a former record plat that bears the same township and range numbers, presumably representing the same, or 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, and that in protection to whatever rights may have been acquired based upon the cancelled plat the locations have been identified as nearly as can be 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, will take the forms that are outlined in section 460.

**450.** The above statement will be 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.

**451.** The projection and measurement of the lines of thé metes-and-bounds survey and the technical record in respect to the same will conform to the usual practice in regular surveys. The mapping of important items of topography and valuable permanent improvements will be given attention with regard to this feature of the resurvey plat, yet it will be apparent that the amount of data to be shown in connection with the metes-and-bounds surveys makes it impossible, at the usual scale, to show objects of little relative importance. This class of data obtained during the progress of the work will *not* be required in the field notes of metes-and-bounds surveys.

**452.** At least one angle point of each tract survey will be connected with one of the regular corners of the resurvey, and where lines of claims are intersected by lines of the resurvey a connection will be made from the point of intersection to the nearest claim corner and recorded in the field notes of the regular section line. The latter will be considered a satisfactory connection to all adjoining claims located within the interior of either section. Where an extensive system of tract segregations has been surveyed, the interior tracts of the block will not require connections. The establishment of closing corners on the regular line when entering or leaving public land will conform to the general practice in this respect as provided in section 191.

## The Projection of New Lines

**453.** The problem of the subdivision of the remaining public lands, where new section lines are to be established, may be studied best, and the plan simplified, by reference to a lay-out which represents the restoration of the former section-line boundaries where that has been found practicable, plus the necessary tract segregations. If the report of the field examination was sufficiently explicit as to the factual data, it should include a plan for incorporation in the special instructions. If the conditions have not been ascertained, the resurvey must be resolved into two phases, first that incident to the identification of the alienated lands, and second the question of the subdivision of the remaining public lands. The latter plan must be deferred until the first phase of the resurvey has been accomplished.

**454.** A problem involving the resubdivision of vacant public lands, as in an independent resurvey, should be approached in the same way as practically all problems in fragmentary subdivision, though the independent resurvey may at times involve the resubdivision of a group of many townships wherein all conditions, except perhaps with relation to the tract segregation surveys, may be comparatively regular. First attention will be given to completing the new township exteriors which are to be independently resurveyed after having reestablished the outboundaries of the group on the dependent plan. The new exteriors will be carried forward and completed in harmony with the rules set forth in chapter III for the establishment of original surveys. The new section lines will be run out and marked as in regular or fragmentary subdivision as the situation may be and new meander lines will be run as required. The new exterior and subdivisional lines will usually be extended across small blocks of tract segregation surveys, noting connections as previously stated, and in such cases the new lines and corners will be fully monumented regardless of the fact that some points will fall within the tract segregation surveys. The latter points are required in their usual function to determine the subdivision of the public lands.

**455.** 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 that same section number, such part or parts of the new section will be given appropriate lot numbers. The new lot numbers will 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, those sections not being restorations of the sections that bear the same numbers of the prior survey (and same township and range), the lottings will be given numbers beginning with the next higher number above those that had been previously employed. Sections 401, 456.

The plan of running the new section boundaries, and of creating the needed new lottings, must be considered and perfected prior to the marking of the corner monuments.

Some new sections may develop as an elongation in order to absorb the discrepancy in the positions of the section-line boundaries as between the old and the new survey. This will be taken care of in the lottings of the new sections. This departure from normal is made necessary by the discrepancies of the prior survey, where the location of the alienated lands cannot be changed. Sections 498, 499.

A departure from the usual rule for lotting is necessary in order to provide suitable descriptions within unpatented entries and selections where such tract segregations may be subject to relinquishment or cancellation, also in other cases, to facilitate a subdivision of isolated tracts of public lands surveyed by metes and bounds. Two methods have been found available, each one better suited to particular situations. Neither method involves any change in the instructions for the field procedure heretofore laid down. The discussion of the merits of the two methods and the examples of their use are better adapted to the text of chapter IX, where the subject will be found in connection with other details to be shown upon the resurvey plats. Sections 651, 652, 655, 656.

**456.** Where a section of the resurvey is invaded by tract segregations, the lotting of the public lands will be carried out in accordance with the usual plan of lotting within fractional sections as outlined in chapter III. The numbering of the fractional lots will begin with the number next higher than the highest number employed in the section of the original survey which bears the same township, range and section number. This plan is intended to avoid any possible confusion which might arise from a duplication in the use of the same lot numbers.

**457.** The plan of the independent resurvey will be carefully studied for the proper placing of all needed quarter-section corners, both maximum control and minimum control, so as to provide for the position of the center lines of all sections, restored and new. Where two positions are found to come within less than half the closing limit for a section as prescribed in section 234, the point first derived as the appropriate position of the quarter-section corner of the restored section boundaries will be given maximum control. This rule is invoked in the interest of simplicity of survey and monumentation.

**458.** The general requirements of chapters II, III and IV will be fully observed in every respect throughout the execution of the independent resurvey and in the technical record thereof. General titles (in addition to the regular page heading) will be inserted in the field notes to indicate clearly the character of the independent resurvey, the technical record of which follows; such titles will be inserted in the body of the field notes, as appropriate, and will show the full significance of all lines; as for example:

(a) "Metes-and-bounds survey of private claims as originally located in accordance with the survey executed by John B. Smith, U. S. Surveyor, in 1842;" and

(b) "Independent resurvey, superseding the survey executed by John B. Smith. U. S. Surveyor, in 1842."

**459.** All monuments of the original survey, not otherwise reported upon, when traces thereof have been found, will be connected by course and distance with a corner of the resurvey, and such connection and a description of the traces of the original corner as identified will be recorded in the field notes of the resurvey. A useless monument will be destroyed after the point is found to be no longer needed for the survey of a claim of any kind whose location may in any way depend upon such monument. Section 163.

**460.** 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 449.

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 will 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 secs. ----, ----, ----, etc., (or certain sections) 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, and excepting for those tracts identified hereon, where these represent entered or patented parts of sections shown on the plat (or plats) approved ------------ (date or dates).

Where the phrase "certain sections" is shown parenthetically in the second paragraph above it is intended that if that form is employed a diagram will be added to identify those sections that have been restored, and those that have been independently resurveyed. Also, where two or more former plats are involved the year date should be indicated on the diagram. Referring to the same paragraph, the parenthetical exception as to new or modified lotting or areas will be omitted when there are no such exceptions.

The memoranda referred to in sections 448, 449, and 450, will be supplied as appropriate.

A necessary additional citation will take the following form:

Survey executed by ----------------, beginning ----------------, and completed ----------------, pursuant to special instructions for Group No. ----, dated ------------------.

It is important that the engineer make a careful study, during the period of the field work, of sections 645 to 667, on the construction of resurvey plats, to make certain that every possible condition has been given all required consideration while in the field, and that all necessary data has been secured.

The desired 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., will be carefully prepared to clarify every feature of the resurvey, to be incorporated in the introductory part of the field notes.

# Chapter VII

# SPECIAL SURVEYS AND INSTRUCTIONS



## SPECIAL INSTRUCTIONS

**461.** The detailed specifications for every survey assignment and the basic information necessary for accomplishing the field work, are set out in a written statement designated: "Special Instructions." The special instructions are an important unit of the record relating to the survey and are prepared by the officer in administrative charge of the work. Emphasis will be given to any provision in the Manual which may be more or less unusual in application, but the purpose is more especially to outline the extent of the work intended and the method and order of procedure. The special instructions will ordinarily be written in the third person, and, coupled with the Manual, will contain the necessary specifications and information for executing the survey.

**462.** The following arrangement of the subject matter will be adhered to so far as may be appropriate:

1. Title: Special Instructions; Group No. ------, ------------ (State); nature of survey, and location by township, range, and meridian.

2. Preliminary statement (bearing no address): In the execution of the surveys included under Group No. ------, ------------ (State) the chief of field party is authorized and directed to make the described examination, retracements, reestablishment of points of control, surveys, and resurveys hereinafter set out, and will be guided by the Manual of Surveying Instructions, the provisions of the following

special instructions, and such supplemental instructions as may be issued pursuant to the report of complications developed during the progress of the work or by reason of additional authorization.

3. Office authority to proceed with the described field work is contained in letter "E," -------- (number), dated ------------, based upon the application of ------------------. Reference will be made to any appropriate citation of departmental or Bureau instructions or authorization, or to any special act of Congress relating to the survey.

4. Appropriation: The costs of the field and office work incurred in the execution of the surveys herein directed, within approved official regulation, are payable from the appropriation: (give the exact title of the applicable appropriation, fund, or deposit, together with citation of the act of Congress under which any such deposit has been received).

5. Limit and character of work: Under this heading there will be described by township, range, and meridian the lines which are to be surveyed, together with designation by section numbers where parts of townships are intended. If the work involves other than original surveys, the statement will be extended to indicate the character of the fragmentary survey, or the type of resurvey, or the nature of the field examination, according to what has been authorized and what is expected of the engineer. It will be desirable generally, except in the case of strictly original surveys, to supply whatever supporting statements there may be needed, taken from the authorization or elsewhere in the record, for an understanding of the technical or legal questions relating to the work. Where private rights may be involved, which is often the case, the facts as known should be clearly brought out, and a statement made of such rules of practice as may require consideration in the field.

6. History of earlier surveys: Every new survey and all retracements and resurveys are predicated upon what has been previously accepted, and to the end that the engineer may proceed with the new work understandingly, a review of the established surveys will be carried into the special instructions. Full explanations will be given in the event of known or presumed complications.

7. Method and order of procedure: If the work to be done is primarily the extension of the original surveys, the statement of it will follow Manual principles and will be taken up in the following order:

(*a*) Standard parallels and guide meridians;

(*b*) Township exteriors; and,

(*c*) Subdivisions, including a reference to the running of meander lines if this class of work is expected, and to the subdivision of sections if required in whole or in part.

The instructions for each township should be completed separately, and so far as practicable the work should be set out in the order in which it is to be followed in the field. If there is any reason to anticipate complications, a statement of the treatment of the problem will serve both to inform the engineer as to what may be expected and to indicate the approved method that would be applied on the assumed hypothesis. Where helpful to call attention to the Manual rules, the references may be made by chapter and section numbers, but the engineer is charged with the responsibility of an understanding of all regular practice and familiarity with the Manual as a reference guide in unusual cases, and the burden of this is not to be transferred to the special instructions.

If the work involves other than original surveys, the responsibility for a statement of the situation and for the formulation of detailed specifications for the execution of whatever examinations, fragmentary surveys, resurveys, topographic surveys, or special monumentation may be required will pass to the author of the special instructions. There follows in this chapter a discussion of a number of the more usual types of special surveys, including subjects not appearing heretofore.

8. Diagrams: In the case of original surveys a blue-print diagram to accompany the special instructions will generally be desirable. Ordinarily the diagram will be constructed on a scale of at least 80 chains to an inch, and should indicate the record surveys within 2 miles of the limiting boundaries of the group. The directions and lengths of the established lines should be shown, together with the principal topographical features. The new work will be shown distinctively, and the method of procedure should be indicated where that will be helpful. All areas returned as surveyed will be clearly represented, together with the status of any outlying areas which the previous plats may show protracted as though surveyed.

All known claims or improvements or monuments of other official surveys as indicated in paragraphs 5 and 13, section 236, chapter III, will be noted in the special instructions. (See sec. 435, ch. VI, for the requirement that a status diagram be furnished with the instructions for independent resurveys.)

As a precaution to insure that the necessary accuracy be secured with reference to the topographic or map detail of the plat, or the location of important springs, water holes, streams, and lakes; principal ridges or divides between watersheds; developed or proposed range improvement; etc.; the special instructions will be supplemented by a status report, usually in the form of a diagram, showing all disposals and withdrawals in the area to be surveyed or resurveyed. There will also be supplied with the special instructions a list of the topo-

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graphic maps, aerial photographs and other available data which may be employed for the representation of important map features. Streams upon which withdrawals for power sites or other purpose have been made, or which appear to have potential value for such use, and all other streams and ridges or principal divides which constitute the boundaries of reserves, should be carefully located. If additional mapping appears to require special attention in the field, that fact will be indicated in the instructions. Sections 236, 615, 616.

9. Field notes, plats, and reports: The special instructions should point out what will be expected in connection with the preparation of the returns, with a view both to the specific understanding of what will be required and to the noting of the subjects which are to be given attention in the field. If anything is required in the way of a preliminary report or diagram to be sent in during the progress of the work, or if special lotting or other unusual matters are to be given consideration at the time of the preparation of the final returns, attention will be given to the same in the special instructions. There will also be noted the necessity for returning, for official use, the original copy of the special instructions, and all other papers which belong with the office record, and the data that may be added in the field, including the field computation sheets.

10. Modification of the instructions: The special instructions will ordinarily be signed by the ranking supervising officer in direct administrative charge of the work to be done, and will close with the advice that should conditions arise appearing to demand additional instructions, or require an interpretation of the instructions as issued, or which apparently make the special instructions inapplicable as prepared, the chief of field party will be expected promptly to submit a report of the situation, with such recommendations for office consideration as may be responsive to the authorization.

## SUBDIVISION OF SECTIONS

**463.** If there is need for the subdivision of sections the subject will be brought out in the special instructions, and if any unusual methods are required the same will be noted. The most frequent examples are those of Indian allotment surveys, subdivisions within reclamation projects, the determination of boundaries between public and privately owned lands of the national forests, subdividing sections for the purpose of administering the act of June 1, 1938 (52 Stat. 609; 43 U. S. C. sec. 682a), commonly known as the "Five-Acre-Tract Act," and in various types of fragmentary surveys. Subdivisions of sections are occasionally required to avoid a possibility of incorrect local survey, and sometimes in lieu of a remonumentation of disputed section or quarter-section corner positions affecting patented lands. Wherever so intended the subdivision-of-section lines will be run out in accordance with the adopted sectional lottings, and the monuments established.

**464.** The customary lottings are not to be found on many plats of the very old surveys, and the information about the recognized or adopted parts of the sections can be secured only by reference to the record of the disposals. The latter will more frequently show a disposal by aliquot parts, except within fractional sections, but often without the usual complement of quarter-section corners regularly established as under the practices set out in the several Manual editions. An inquiry into the assigned areas will sometimes be the only means of arriving at the intended disposals. In some very old surveys the usual quarter-section corners were not established on all true lines of survey, but the record will show instead that "half-mile" points were marked on the random line and not corrected to the true-line mid-point position. All such unusual problems should be brought out in the special instructions, as the diversity of the questions arising on the subject and the very limited applicability of many of the answers precludes Manual treatment. Manual, Appendix V, section 376.

**465.** Where special methods are unavoidable the steps should be made to conform as nearly as may be with the rules for the subdivision of sections as based upon the Acts of February 11, 1805 (2 Stat. 313), and April 5, 1832 (3 Stat. 566), already fully exemplified in chapters I and III.

**466.** The special requirements in connection with the subdivision of sections are few. Generally, the areas involved conform to legal subdivisions and in such cases the lines are run in accordance with the rules for the subdivision of sections. The special instructions will provide for the procedure if the areas do not conform to the rectangular system of surveys.

**467.** All corners are marked in the usual manner. Chapter IV, and section 499, chapter VII.

**468.** If a section is to be subdivided, the center quarter-section corner will always be monumented, and likewise if a quarter-section is to be subdivided the sixteenth-section corners on the quarter-section boundaries and at its center, will be monumented. No other monuments of lower order will be established except where necessary to mark the actual boundaries of the tract or tracts of land involved.

**469.** Figure 70 is an illustration of a type of plat showing the subdivision of sections. It is essential to furnish a field note record to support the subdivisional survey and to supply the descriptions of the established monuments.

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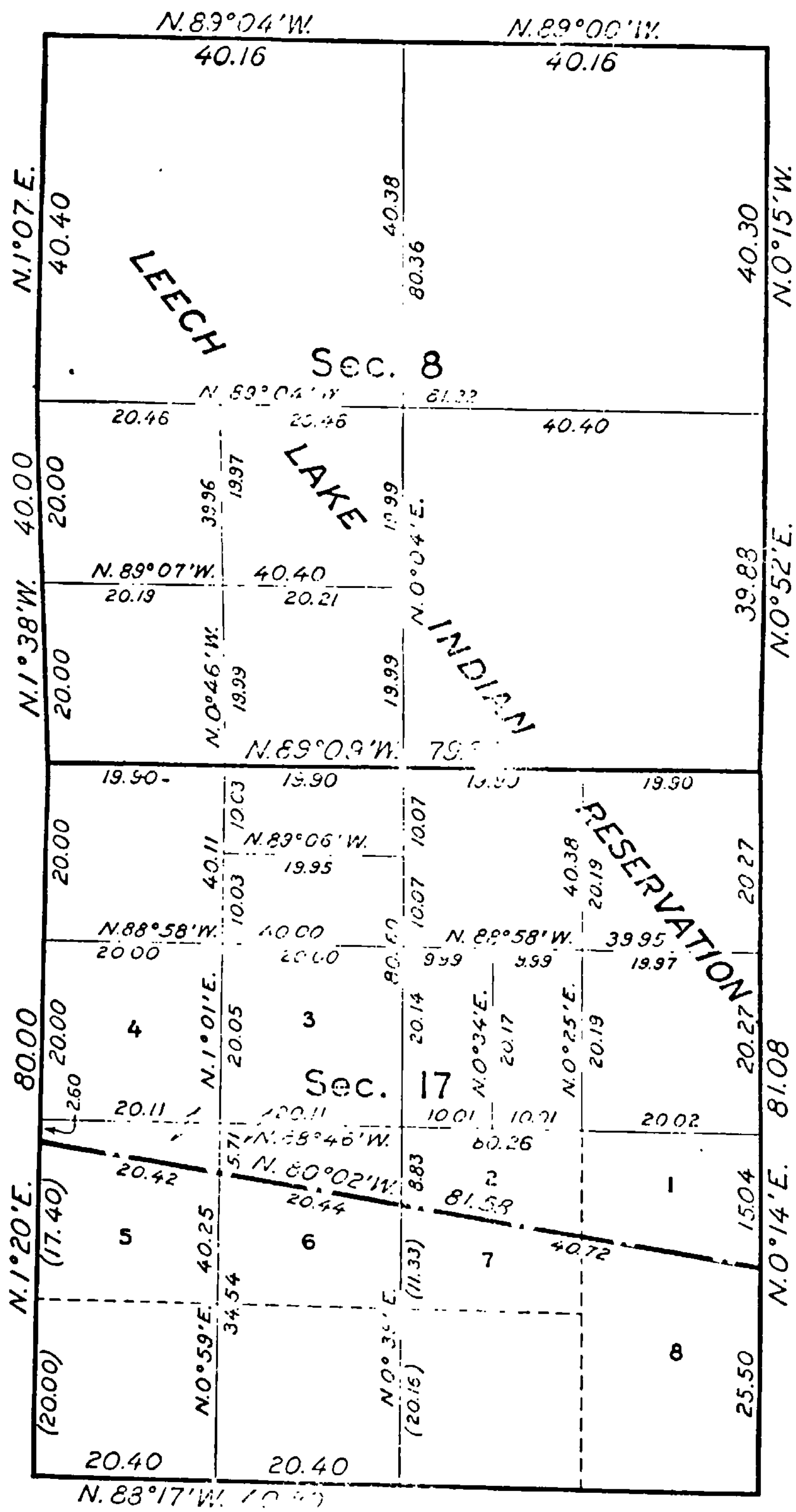



**FIGURE 70.**—Subdivision of sections. This includes a limited dependent resurvey of the section-line boundaries and the subdivision of the sections as needed.

**470.** The authority for the assignment of land to individual Indians is found in both the general and special allotment acts, under which it has been the practice of making awards in some cases in units of less than the usual quarter-quarter section. One act provides that where the improvements of two or more Indians have been made on the same legal subdivision of land, unless they shall otherwise agree, a provisional line may be run dividing said lands between them, and the land to which each is entitled shall be equalized in the assignment of the remainder of the land to which they are entitled, while in another act it was provided that not less than 2½ nor more than 10 acres of timber land be included in any one allotment. There will be no question in regard to the treatment of those cases where the allotment descriptions are in terms of aliquot parts of the section, but in some cases it is apparent that the descriptions can be stated only in terms of metes and bounds in some way definitely correlated with the section-line boundaries, to which included tract there will be assigned a lot number within the parts of the one or more sections involved, the lotting numbers thus resulting to be independent of the serial allotment number.

Status diagrams which show the Indian allotment awards are furnished with the special instructions for the survey.

**471.** In some cases where the sections to be subdivided border meandered bodies of water, it will be found that due to the processes of erosion or accretion, or to the construction of a dam which holds the water at a higher level, or to the recession of the water during the years intervening between the date of the subdivision of the township and the date of the subdivisional survey, material changes in the shore line will have taken place. In some cases it is the practice to remeander the body of water in order to amend the plat to show the true conditions at the date of the subdivision of the sections, making new lottings within the fractional sections. A demonstration of the methods employed for the amendment of the plat in such cases is contained in sections 639 to 643, chapter IX. If the situation is one within the class of erroneous meanders, the rules to be followed will be found in sections 511 to 529, this chapter. Whatever needs to be done in this type of work should be brought out clearly in the special instructions for the survey, or in supplemental instructions where the facts were unknown in the first instance.

## METES-AND-BOUNDS SURVEYS

**472.** Metes-and-bounds surveys are required to define the boundaries of irregular tracts which are nonconformable to legal subdivisions. This type of survey ordinarily involves the establishment of the boundaries of claims, grants, or reservations, such as mineral claims, small-holding claims, private-land grants, forest-entry claims, national parks and monuments, Indian reservations, lighthouse reservations, trade and manufacturing sites, homestead claims in Alaska, etc.

The survey procedure is similar for each type of claim, grant, or reservation having irregular boundaries. Monuments are required at each angle point of the tract boundary, which are given serial numbers beginning with No. 1 at the initial point. This is the only monumentation necessary when the lengths of the boundary courses do not exceed 45 chains. Monuments on the boundaries of a tract should not be more than 45 chains from each other and, when the lengths of the courses exceed that distance, witness points will be established on the tops of ridges, at stream and road crossings, or other accessible and prominent places. In the survey of the boundaries of large grants or reservations, mile corners in addition to angle points and witness points will be established. The establishment of witness points at the intersection of the boundary with roads, trails, streams, and other natural features in surveying national forests, national parks and monuments, Indian reservations, etc., is exceedingly helpful in determining the position of the line. Examples of the usual marks for angle points, witness points, and mile corners are given in sections 249, 279, 280, 346, and 347, chapter IV. The plan for monumentation will be designated in the special instructions for the survey.

Tracts located upon surveyed land will be connected to a regular corner of the subdivisional survey, as required in section 190, chapter III, but if the location is within an unsurveyed township, specific advice regarding the running of a connecting line or the establishment of a location monument (sec. 719, ch. X), or the determination of the geographic position of the initial point, will be supplied in the special instructions for the survey.

The subject relating to the survey of mineral claims by metes and bounds is covered in chapter X. A description of the special surveys executed in Alaska and more detailed instructions governing the survey of forest-entry claims within national forests, is contained in Appendix VII.

## TOWN-SITE SURVEYS

**473.** The name "town-site survey" in the public-land surveying practice is applied to the marking of lines and corners 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 parcels known as village or town lots.

In many cases there have been few or no prior improvements to be dealt with, affording considerable freedom in the site selection. Ordinarily this type has resulted in maximum regularity as to the plan.

Numerous examples are found in the towns and villages where the Indian lands have been opened to settlement, also in the prairie States in those cases where the Federal town-site laws have been invoked.

Quite a different class includes those villages, towns, and cities that became realities prior to the making of the town-site survey, by reason of trading posts, mission sites, Indian schools, etc., or some special military or other reservation such as the one at Hot Springs in Arkansas. Quite frequently these resulted in an irregular lay-out, where much care was required in the planning of the lot boundaries and the street lines to protect the existing improvements, and to bring good order out of the inherited situation.

In more recent years, as a consequence of the continuing administrative interest in the development of some Federal project, the town site is a base for the larger plan, including the improvements to be made, which set up more or less definite limitations. Accordingly, in these cases, the greatest care is needed in the selection of the location, with comprehensive planning as to the needs, thus to insure suitability in all respects. The conditions to be met vary so greatly that the elements which enter into the problem must first be ascertained; this necessarily calls for preliminary studies, and a reconnaissance to precede the planning for the marking of the lines and corners.

Many valuable examples may be secured through a study of approved town-site plats, particularly those that embody similar elements. If some of these developed areas are visited, the good and bad planning may be more plainly demonstrated; the best features will be apparent; poor planning may be corrected.

A complete acceptance of the problem, as such, immediately carries the planner beyond the scope of what can be covered by Manual rules, and may even show the need for consultation with specialists in architectural and industrial planning, landscaping, and the various branches of city engineering, such as water supply, sewage disposal, street, highway and railroad location. Provision is needed for public school grounds, other needed public buildings, park areas, and the usual elements of the prospective community. All are interdependent. The subjects have been treated in many carefully prepared articles [1] and books, which invite the attention of the planner of the new town site.

The Manual rules that follow are designed principally to set out the minimum specifications as to the running and measuring of the lines, according to the plan, the monumentation, and the elements of

[1] By way of suggestion, see Manual No. 16, Land Subdivision, American Society of Civil Engineers; address, Secretary, 33 W. 39th St., New York, N. Y. The Manual is devoted particularly to the planning, with many examples and illustrations; it gives a bibliography of 24 authorities.

the plat construction by which the blocks and the lottings may be identified. The detail of the plan will be set out in the special instructions. Secs. 461 and 462, par. 7.

Revised Statutes, secs. 2380 and 2381 (43 U. S. C. secs. 711, 712), and numerous special acts, make provision for the Executive withdrawal of public lands for subdivision into town-site blocks and lots, both urban and suburban, and for disposal in such units.

A preliminary examination is made in order to ascertain a layout which will afford the best use of the ground available for improvement, with suitable grades for streets, give proper regard for existing locations where rights have already been acquired, and provide for railroad or other rights of way, station grounds, lake-shore frontage, natural park areas, and other important conditions which should have consideration.

**474.** Only the fundamental requirements of town-site surveys can well be presented here as the character of the area, the topography, its location, and whether it is a new town site or an addition to an old one, will to a large extent determine the detail of the street and block system. A topographic survey will be of the greatest value as an aid to ascertaining the layout best suited to the situation; the special instructions will call for the appropriate contour interval.

**475.** In the typical town site the blocks may be made 300 feet square, and usually not over 320 feet by 400 feet, with a 20-foot alley running the long dimension of the block. The principal streets are usually made 80 feet in width, though frequently as much as 100 feet where the greater width appears to be needed or desirable, and the less important intersecting streets are seldom given a width of less than 60 feet. An alley is usually placed in each block, 20 feet in width and paralleling the principal street system. The normal frontage of the lots is 50 feet, which run back in rectangular form to the alley. Unless planned differently, the whole system is laid out on cardinal, and in all town sites the blocks are given serial numbers, usually beginning with the northeast block and proceeding with the numbers alternately to the west and to the east. The lots are given serial numbers within the block.

**476.** It will be noted that the foot unit is employed on all town-site surveys, and long steel tapes graduated in that unit are furnished for the purpose. In most cases the necessary accuracy can be secured only with the use of a spring balance for the maintenance of the proper tension, and with allowance for temperature corrections to the degree at which the tape is standard.

**477.** In making the town-site survey the greatest care will be exercised to identify the original section-line boundaries and to execute the subdivision of the section or sections in the proper legal manner for the ascertainment of the assigned town-site boundaries. Permanent monuments will be placed at each turning point of the town-site boundary lines. These may be the 2-inch iron post, or a tablet seated in a concrete block as large as 8 inches square and 36 inches long, marked with the usual subdivisional identification marks, the capital-letter initials of the town-site name, and the letters "T S," in the appropriate quadrant. The boundary streets, and the other streets, blocks, and lots are then laid out, permanent control monuments established, and connecting line measurements made, as may be necessary to afford an exact relocation of any point; and to secure all data respecting true bearings and deflection angles, both for the center lines of the streets and for the block lines, the connecting lines to the permanent monuments, and the dimensions of all streets, blocks, and lots. All of this sort of data is carried to the town-site plat, and its sufficiency may be tested by the ability readily to ascertain the position of any given point, and to calculate the area of any individual lot. If there are curved lines to be dealt with, the elements thereof will be indicated on the plat.

**478.** A number of permanent monuments will be placed at the intersections of the street center lines and connections made to the block corners so as fully to insure a complete and ready restoration of any block corner. The 2-inch iron post, or a tablet seated in a concrete block as large as 6 inches square and 24 inches long, may be employed for this purpose. These should be subsurface monuments, placed as much as 1 foot below the probable grade line of the street, and marked only for the point of intersection.

Where the street center-line intersections are intervisible, the markers may be placed at the alternate intersections; along the boundaries, and within the town site where the intersections are not intervisible, the markers will be placed at each center-line intersection.

**479.** Where the street center-line intersection is not marked, the adjacent block corners will be monumented with the 2-inch iron post, set with the top flush with the ground, and guard stake; but if the intersection is monumented, hardwood stakes are employed for the block corners, and to mark the front corners of each lot, also to mark the intersections of the alley side lines with the block lines. The points here called for are always to be monumented, and a more durable marker, such as a galvanized-iron pipe will be employed where the site conditions are unfavorable to the preservation of a wooden stake. The block corner and alley stakes are usually made 2 inches square and 24 inches long; the lot corners 1 by 2 by 24 inches; the latter are set only on the block lines and not on the alley lines. The block corners only are marked with the appropriate numbering.

A 2-inch iron post will be 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.

**480.** The field traverse of the town-site boundaries will ordinarily be made to close within an error of not to exceed 1/5000, and never to exceed 1/2000. The determined lengths of lines and their bearings will be balanced, so as to secure a perfect closure for the data which are to be carried to the plat. The required accuracy can always be secured by the method of repetitions for the turning of angles, and by the method of measurement herein authorized, due regard being given to the reduction of lengths of lines to the true horizontal distances. This class of data, as well as that hereinafter mentioned, should be such as to leave no discrepancy whatever in any calculated position, whether working from one permanent monument to another, or between any two points.

**481.** Lengths of lines and all angles or bearings will be determined in the field for all irregular blocks and lots; and the side lines of the lots, and their back lines, will always be measured in the field, and the dimensions carried to the plat, wherever needed, as when said lines can not readily be located by the method of intersections.

**482.** The field notes of the town-site survey will show the retracement of the old section-line boundaries, the restoration of any needed corners, and the subdivision of the sections, all complete as may be needed for the ascertainment of the townsite boundaries, and for the description of the controlling monuments. All important connecting lines and measurements between the boundary monuments and the corners of the block lines, or to the permanent monuments marking the street center lines adjacent to the boundaries, will be given in the field notes. The plan followed in the town-site survey will be explained, and a general statement made as to the monumentation; beyond this it will be noted that the further detail of all directions and lengths of lines has been carried to the plat, but is omitted in the field-note record. If there are any improvements unavoidably left in conflict with the town-site layout the information will be brought out in the field notes, but omitted from the plat.

**483.** The town-site plats are usually published at a scale of 200 feet to an inch, but they are frequently drawn at a somewhat larger scale, subject to reduction when published. A marginal diagram is usually supplied in order to show the relation of the town-site boundaries to the local section-line control, with directions and lengths of lines here given in the chain unit; tenths and hundredths of links will be supplied where appropriate for making reduction to the lengths of lines shown on the main drawing.

**484.** On the main drawing all lengths of lines will be shown in the foot unit, with tenths where needed. All directions and lengths of lines, intersection angles, and connecting lines to monuments will be given on the plat with a view to the ready location of any point by calculation from the points of permanent control, and for the ascertainment direct from the plat of the area of any individual lot. Sec. 643, last paragraph.

**485.** The block and lot numbers will be shown, areas of all lots to the nearest square foot, and the streets will be given designating letters, or numbers, or names. In the drafting of the data for the regular blocks some of the figures which would be applied in each lot of the block may be omitted if it is left clear within the block that the lottings are regular for dimension and area.

**486.** All permanent monuments will be shown on the main drawing and connecting data supplied. The widths of the streets and alleys will be plainly shown, but not repeated needlessly. Where all of the lots in any block are of the same dimensions, it will be sufficient to show the measurements only along the block lines, as the depth of each lot will be indicated by the length shown from the block corner to the alley corner. A memorandum will be supplied to note the general plan of monumentation, with an outline description of the monuments.

**487.** If there are reservations for public-school grounds, or of ground for other public buildings or parks, the provision therefor will be stated in the special instructions. The designated blocks will be shown upon the plat, numbered regularly and titled, but not subdivided.

**488.** References will be made to chapter IX for the usual requirements regarding the title and the certificates which are to appear on the town-site drawing.

## SURVEY OF PARTS OF SECTIONS

**489.** In sec. 253, chapter IV, there is a statement of conditions where portions of the section boundaries are inaccessible, impassable, or so insecure that acceptable monumentation is impracticable, which if found to prevail will necessitate the elimination of parts of sections. The situations thus assumed are so rare, if allowance is made for increase of cost of survey where warranted, that general rules can not well be announced. The questions to be considered are more particularly administrative, and ordinarily will be given attention in the special instructions. The subject matter here set out pertains only to the technical processes which are new to the survey of rectangular boundaries of parts of sections. Figures 71, 72, 73, and 74 show examples.

**490.** The west boundary of section 27 (fig. 71) is shown discontinued at the regular place for the south sixteenth-section corner, which is

490

Fig. 71

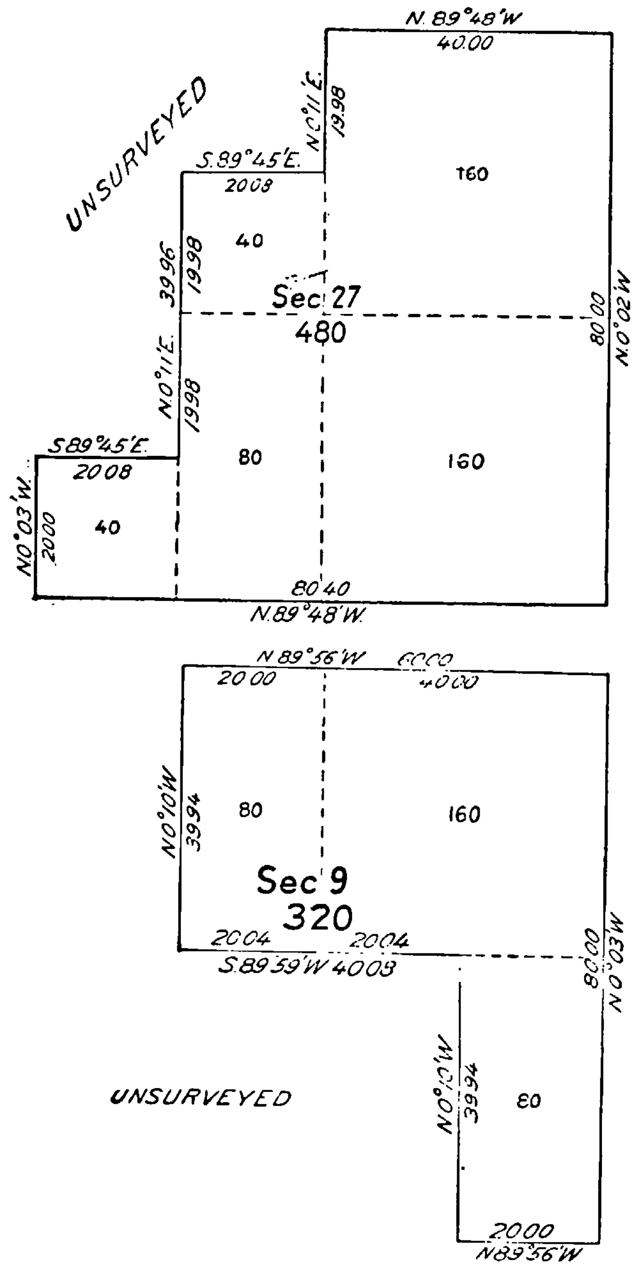



FIGURE 72.—Rectangular boundaries of parts of sections.

A random subdivision-of-section line is run closing the area to be surveyed, each course parallel to the governing section boundary, with lengths in multiples of 20-chains; the closing error is then distributed, and monuments established.

monumented, and the north boundary at 40.00 chains, established parallel to the south boundary. The subdivision-of-section lines are run random on theoretical courses and distances, and closing error distributed, with final results (assumed) as shown on the drawing. The several interior sixteenth-section corners on the lines run are all to be monumented, including the one on the east and west center line of the section.

**491.** The south boundary of section 9 (fig. 72) is shown discontinued at the east sixteenth-section corner, and the north boundary at the west sixteenth-section corner, both of which are monumented, both lines having been established parallel to the nearest completed latitudinal line southward in that range of sections. The subdivision-of-section lines are run random on theoretical courses and distances, and closing error distributed, with final results (assumed) as shown on the drawing. Here the center quarter-section corner and the two sixteenth-section corners on the east and west center line are all to be monumented.

**492.** In the illustration showing section 3 (fig. 73) the process is similar, excepting that the closing error in latitude is all placed in the west line of lot 2. All of the turning points are monumented, also the south sixteenth-section corner on the north and south center line, and the west sixteenth-section corner on the east and west center line.

**493.** In section 18 (fig. 74) the closing error in departure is all placed in the south line of lot 3, it having been assumed that (*a*) the corner of sections 7, 8, 17, and 18 was fixed by survey from the east or north, or (*b*) if from the west, that the fractional length of the north line of lot 1 had been determined by appropriate calculation.

**494.** The several processes are summarized in the following rules:

1. Complete the survey of all regular exterior boundaries and subdivisional lines normally, as far as accessible under the Manual rules and special instructions.

2. Where an exterior boundary is to be discontinued the line will be established on a cardinal course and on the last mile monumented regularly to the nearest 20.00, 40.00, or 60.00 chain point.

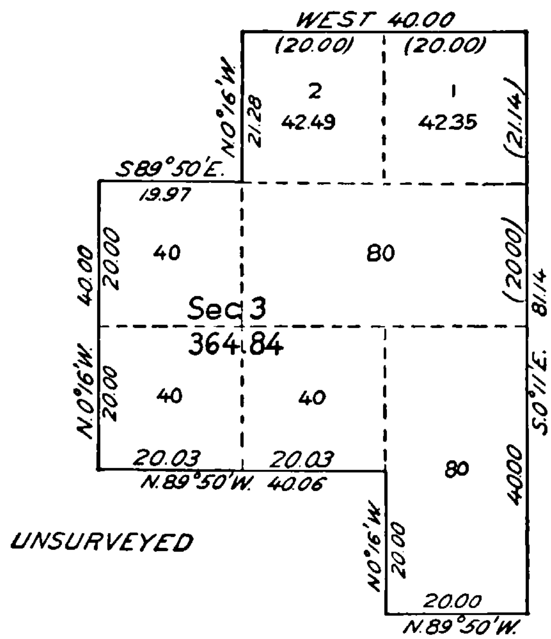
3. Where a subdivisional line is to be discontinued, it will be established (for alinement) parallel to the governing exterior or section boundary (and for length) 20.00, 40.00, or 60.00 chains, as the situation may be.

4. The terminal sixteenth or quarter-section corner will be monumented; the quarter-section corner will be monumented in every case where the point has been attained.

5. Assign theoretical bearings to the subdivision-of-section lines closing the area to be surveyed within a section, each line parallel to the governing section boundary, with the lengths ordinarily employed for the calculation of areas, as 20.00, 40.00, 60.00, or 80.00 chains,

*disregarding* the ordinary allowable excess or deficiency in the length of the latitudinal boundary of the section.

FIGURE 73



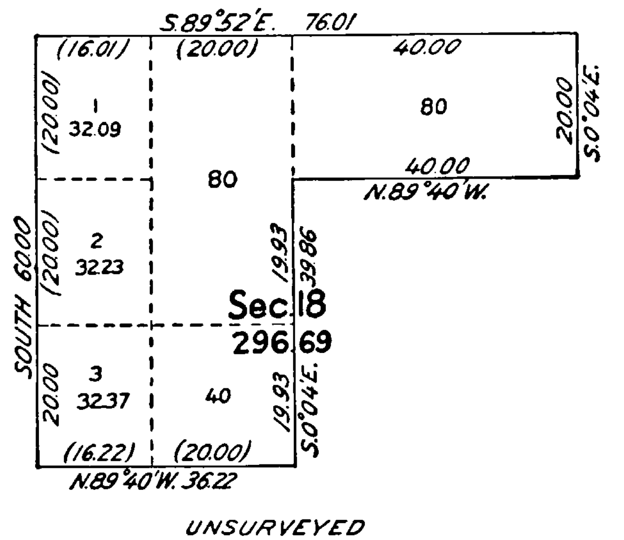




FIGURE 74.—Rectangular boundaries of parts of sections.

Fractional lottings are shown. In Figure 73 the whole closing error in latitude is placed as normally in the north tier of lots, and in Figure 74 the whole closing error in departure is placed as normally in the west range of lots.

6. Run a random line closing the area to be surveyed, on the courses and distances derived in rule No. 5, and set a temporary interior sixteenth or quarter-section corner at each turning point and at the intersections of the center lines of the section.

7. Except as noted in rule No. 10, the closing error will be distributed as provided in section 380, chapter V, and the interior sixteenth and quarter-section corners called for in rule No. 6 will be monumented.

8. The interior sixteenth and quarter-section corners thus established, together with the usual points on the regular section boundaries, will be employed to control the position of the center lines of the section and of the several quarter sections.

9. If the length of a boundary of any resulting quarter-quarter section differs from 20.00 chains in excess of 12½ links, or if its direction deviates from cardinal in excess of 21′ (by reason of disregarding the ordinary allowable excess or deficiency in the length of the latitudinal boundary of the section), a lot number will be assigned to such quarter-quarter section; the lot area will be derived under the usual rule applicable to the calculation of areas of fractional quarter-quarter sections.

10. In the north tier of sections the closing error in *latitude* will be placed as normally in the north tier of lots, and in the west range of sections the closing error in *departure* will be placed as normally in the west range of lots, unless the subdivisional survey may be made from north to south or from west to east under the rules which permit that procedure.

**495.** The field notes will show the complete random and true line courses and distances, the usual topography on the true lines, the description of all monuments, and a description of the difficulties which warranted an elimination of parts of the section or sections.

**496.** Reading R. S. sec. 2396 (43 U. S. C. sec. 752), wherein it is stated that "all the corners marked in the surveys, returned by the surveyor-general, shall be established as the proper corners of sections, or subdivisions of sections, which they were intended to designate; and the corners of half and quarter sections, not marked on the surveys, shall be placed as nearly as possible equidistant from two corners which stand on the same line," 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," it is apparent that to complete the subdivision-of-section lines in any section where the above-described practice has been invoked, leaving the section-line boundaries more or less uncompleted, the position of the said remaining subdivision-of-section lines within the surveyed area will be determined first by running straight lines between the nearest established control for the sectional center lines, with the position for the center quarter-section corner at the intersection of the latter lines, unless previously marked, placing the remaining interior sixteenth-section corners on the sectional center lines at mid-points between the exterior quarter-section corners and the center quarter-section corner, except within the sections normally fractional; and, second, the center lines of the several quarter sections will then be completed separately on a similar plan based upon the control as developed. In all sections normally fractional the usual regard will be given for the placing of the fractional unit in proper relation to the regular or proportional 20-chain units.

**497.** The running of a traverse line as a boundary along the margin of omitted mountainous areas, and sometimes in the omission of other areas classed as impassable, was frequently practiced at one time, but was later discontinued owing to the large number of fractional lots thus unnecessarily created, as sooner or later, in a large majority of cases, the advance of settlement demanded the completion of the subdivisions across the omitted lands. However, occasionally a survey of this type may be desirable in order to meet a peculiar situation where the rectangular boundaries can not be completed within the section, but the examples are decidedly infrequent, and the method should be authorized in the special instructions only when supported by ample justification. In such surveys the angle points of the traverse line are given serial numbers in each fractional section, and the points are monumented. The subdivision-of-section lines are protracted only, unless a definition upon the ground should be required for some good reason.

## ELONGATED SECTIONS

**498.** The rule (sec. 200, ch. III) for numbering the lots within elongated sections is illustrated by figures 75 and 76. The examples show 12 instead of the 4 normal lots. Cases of this type, though infrequent, are sometimes even more exaggerated. The condition may occur when closing along either the northern or western township boundary, or anywhere within a township on completing fragmentary subdivisions.

**499.** Additional monuments are required on such section boundaries where the length of the closing line exceeds 85 chains (secs. 161, 177, 178, and 198, ch. III); these will be placed at intervals of 40 chains counting from the regular quarter-section corner. The plan for the special marking is based upon the distance each monument is established from the regular governing boundary, generally the south or the 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 75 and 76. Special attention will be required on the section boundaries as to whether the markings are to show minimum or maximum control.

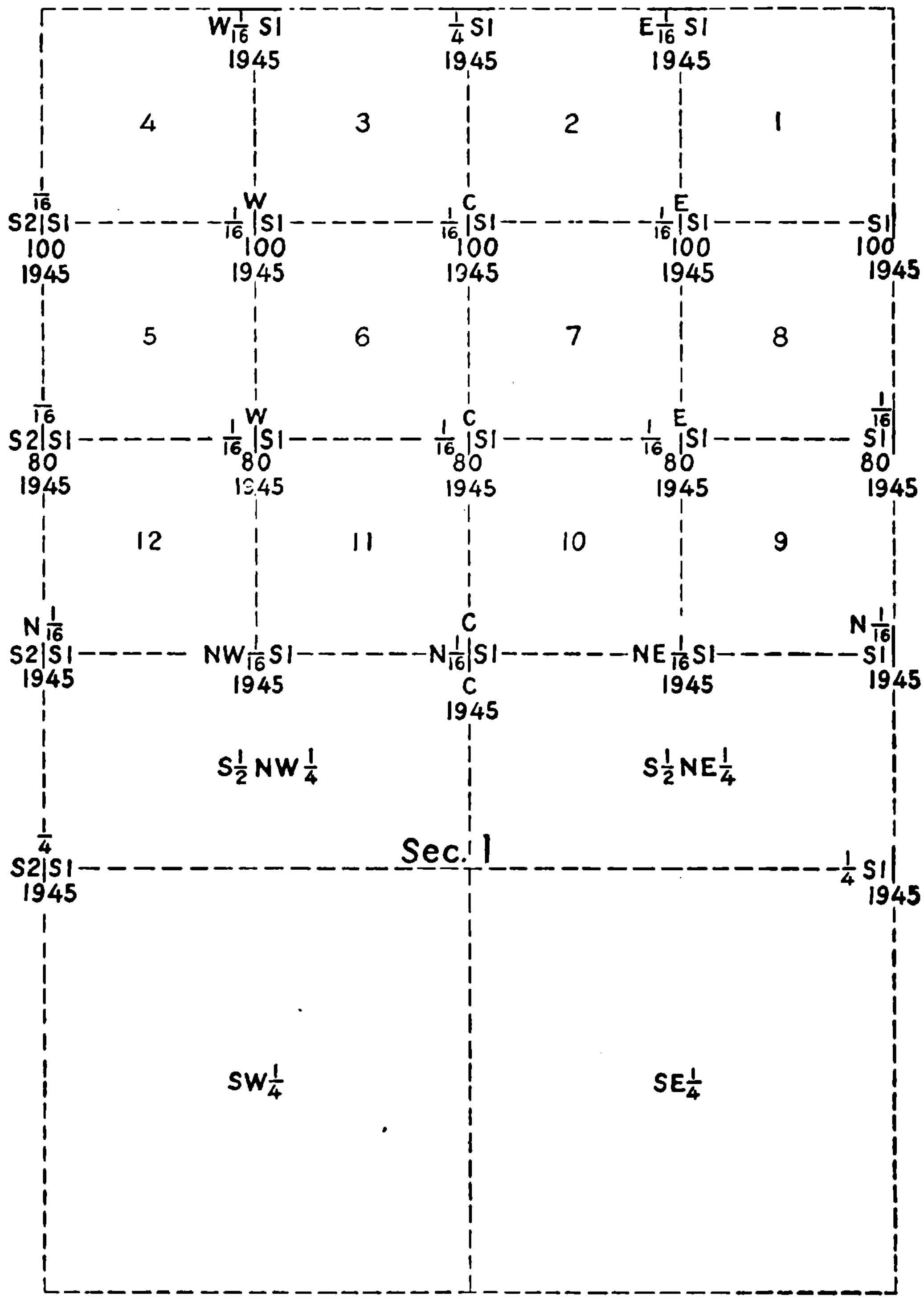



FIGURE 75.– Elongated section.

Plan for marking the special monuments.



700004°—47——24

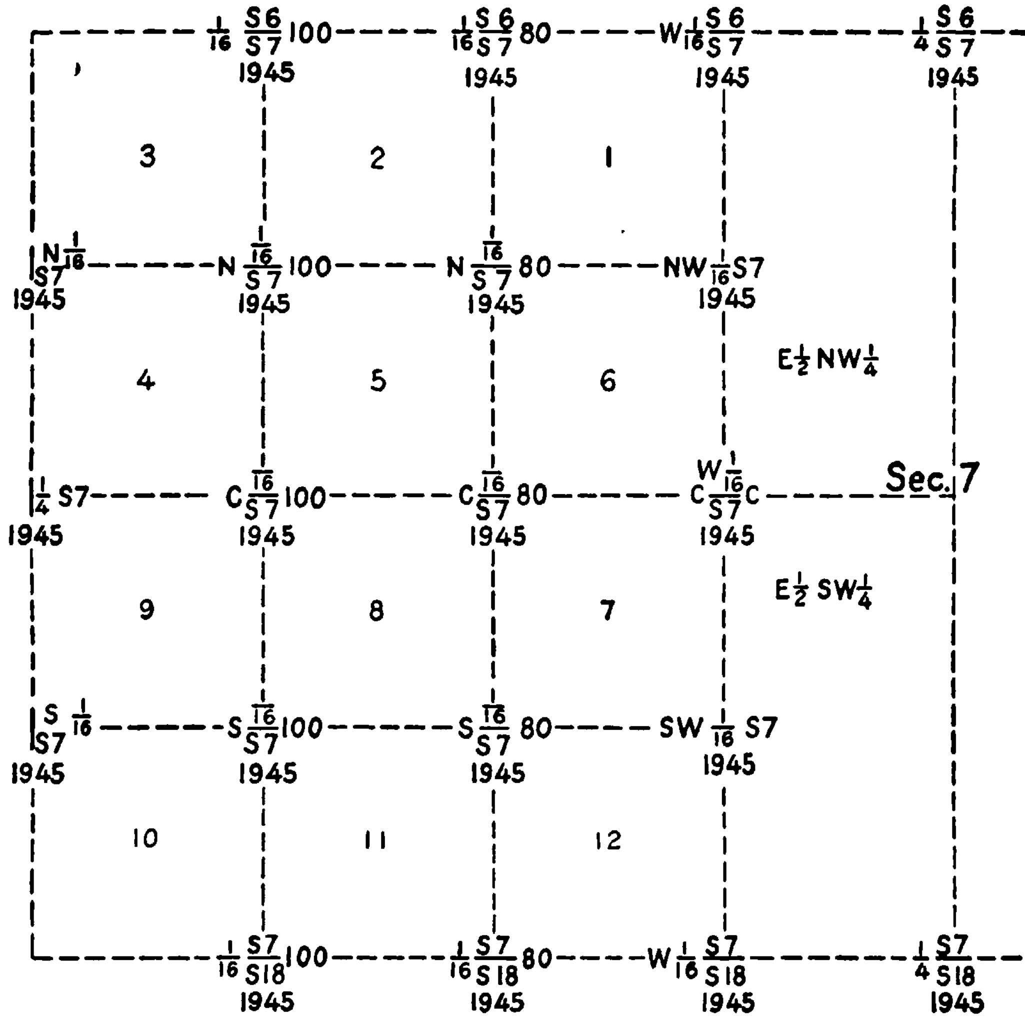



FIGURE 76.—Elongated section.
Plan for marking the special monuments.

**500.** In the very unusual situations where the distance between the regular position for the township boundaries is so great that elongated sections in excess of 120 chains would result from the application of the above rules, it is better that new half-township (or half-range) numbers be created in order to cover the area located between a new normal exterior at 480 chains and the next regular township boundary.

**501.** The numbering of the sections within a half township (or half range) will depend upon the selection of the governing boundaries to be employed. Preference will be given to normal procedure, where conditions warrant. The survey and monumentation will follow the usual rules for fragmentary subdivision of townships.

**502.** It is obvious that where elongated sections occur within the interior parts of a township, growing out of partially completed but grossly irregular subdivisions, new half townships cannot be created. In such cases the rules stated in sections 498 and 499 will be applied.

If the situation is unknown at the time when the special instructions are being prepared, and therefore not fully treated therein, the chief of field party will report the facts and await the receipt of definite instructions as to the procedure.

## BEDS OF NONNAVIGABLE LAKES AND STREAMS

**503.** Title to the beds of nonnavigable bodies of water remains in the United States until the shore lands have passed into private ownership. *United States* v. *Oregon*, 295 U. S. 1 (1935); and sec. 512, ch. VII. In connection with the administration of the public lands it is necessary at times to survey the beds of nonnavigable lakes and streams or the portions of the beds owned by the Government. Generally the survey, due to the area being covered by water, cannot be monumented in the regular manner and many of the lines cannot be actually surveyed on the ground. The plat, therefore, when prepared represents in fact a survey primarily made by protraction, based upon a sufficient number of monuments on the ground to insure adequate control for the reestablishment of all the subdivisional lines.

The field work usually consists of a dependent resurvey of the lands bordering upon the area to be surveyed, the subdivision of the upland sections when necessary to determine the boundaries between the privately owned riparian subdivisions and those belonging to the Government, the monumentation of as many corners as possible, and a sufficient number of connections across the stream or lake-bed area on the section lines for the purpose of making the necessary computations.

When title to some of the riparian subdivisions in a section has passed from the Government, partition lines will be run and monumented if possible, segregating the portions of the lake bed in private ownership from the public land areas. The method of procedure depends in a large measure on the shape of the shore line. It is clear from the court decisions that no hard or fast rule can be applied. The courts have held generally that the bed of a round lake should be divided among the riparian owners by ascertaining the center point and then connecting that point by straight lines to the established boundary corners on the shore, and that when a lake is long in comparison with the width, the method applied to rivers and streams with converging lines only at the two ends, makes the proper division. It should always be borne in mind in considering riparian rights that each riparian proprietor is entitled to that part of the water-covered area lying in front of his basic holdings. *Oklahoma* v. *Texas*, 261 U. S., 345

(1923). When the dividing line cannot be drawn to a center point or normal to the medial line without cutting "in front of" some riparian proprietor, the rule of proportionate measurement outlined in the case of *Johnston* v. *Jones*, 1 Black, 209, 222, 223 (1861), should be adopted (sec. 529, ch. VII). The main consideration is one of equity and fairness.

Where there is occasion to define the partition lines *within the beds* of nonnavigable streams, the usual rule, under Federal surveying practice, is to begin at the property line at its intersection with the bank, and from that point run a normal to a medial line that is located at midpoint between the banks. Where the normals to the medial line are deflecting rapidly, owing to abrupt changes in the course of the stream, suitable locations are selected above and below the doubtful positions where acceptable normals may be placed, then the several intervals along the medial line are apportioned in the same ratio as the frontage along the bank. Precaution should be exercised to modify this rule to conform to the State law.

The laws of the State in which the work is to be executed and the decisions of the courts of that State should be studied in preparing the special instructions in order to determine the procedure required to protect the rights of the riparian owners. The method of procedure will be outlined in detail in the special instructions.

## MINERAL SEGREGATION SURVEYS

**504.** The type of work here described is one which involves a metes-and-bounds survey of a body of land classified as mineral bearing, but an area which has not been covered by a mineral-patent survey. The field work in these cases will include a retracement and remonumentation of the section boundaries, with attendant restorations of obliterated corner positions where required. The authority for this class of work will issue, as needed in conformity with office regulations, as stated in section 631, chapter IX.

Mineral segregation surveys are required where the subsisting records do not furnish the necessary information for a proposed segregation of mineral claims from the public lands. Such 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 application. 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.

**505.** The segregation survey is not a mineral survey in the usual accepted sense as defined in chapter X, as it confers no permanent rights upon the mineral claimant. Though the purpose is to ascertain the boundaries and position of one or more mining claims, it is not made primarily to define the mining claims, but rather in order to determine the limits and appropriate description of the adjoining agricultural land, where the latter is covered by pending entry. No survey of this kind is required except as needed to supply data for the accomplishment of the necessary fractional lotting, or where a showing has been made of obliteration of monuments, or distortion of lines belonging to the subdivisional survey, or both. The condition of the section-line boundaries will always be verified in this type of survey.

**506.** Where regular conditions are found the mineral segregation survey will consist only in running not less than two connecting lines from identified corners of the subdivisional survey to a corner or corners of the mineral location as segregated, followed by a survey of the outboundaries of the mining claim or group of claims, thus supplying the data equivalent to those ordinarily furnished by a mineral-patent survey.

**507.** Monuments, usually 2-inch iron posts, will be placed at the angle points along the boundary of the mining claim, or out-boundaries of a group of claims, and within the section or sections which include the pending agricultural entry, as may be needed in order to complete the marking of the limits of the latter. The monuments so established will be marked with the initials of the name of the mining claim or claims to which it belongs, and with the corner number or numbers counted as an angle point of the mining claim or claims, all in a manner similar to the practice directed for making mineral-patent surveys, chapter X. If the monument at the corner of the mineral location is in proper position, constructed of durable material, and suitably marked, the monument may be adopted without any alterations, and a description thereof will be entered in the field notes.

**508.** In townships where there appears to be an extensive obliteration of monuments, or where the condition of the lines does not conform to the original plat and field notes, the survey needed will consist of such retracements and restorations of the corners of the section-line boundaries as may be necessary to define the pending agricultural entries. If the distortion of the section lines is so great as to warrant the subdivision of one or more sections, the work authorized will be described in the special instructions.

**509.** The retracement of the lines of the mineral location should be made with the same degree of accuracy which is demanded in a mineral-patent survey, chapter X. All measurements are to be returned in the chain unit. It is essential that the requirements regarding the legal length and width of the mineral claims be observed, including parallelism of end lines, that is, to confine the claim to the legal length along the mineral lode, placing the side lines within the legal width as determined from the center of the vein at the surface, and that the end lines of each claim shall be parallel. The segregated claim is to be made identical with, or be embraced within, the boundaries of its location, as provided in the mining regulations. If not identical, a bearing and distance will be given from each established corner of the survey to the corresponding corner of the location. See chapter X.

All rules for the plat construction will be found in chapter IX.

## MINE SURVEYS

**510.** This class of surveys 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-sections lines within the mine which divide private and public lands.

A plat showing the subdivisions of the section or sections will be prepared with an additional diagram added showing 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 operator 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.

## ERRONEOUSLY OMITTED AREAS

**511.** This title is employed to denominate lands that are not shown upon the original township plat, which are so situated as to have been excluded from the survey by some gross discrepancy in the location of a meander line as given by the field-note record. In the typical cases the unsurveyed land is found to be situated between the actual bank of a lake, stream, or tide water, and the meander line as given by the field-note record, though a considerable number of cases of erroneous meanders have been found in the older surveys of the south where temporarily overflowed lands, or swamp and overflowed lands (strictly classified as such), were mistakenly traversed as if they were permanent meanderable bodies of water; and a few cases have developed where no bodies of water ever existed in fact. All are treated in the same manner as those where the discrepancy is traceable directly to a grossly erroneous position for the record meander line. The converse is found in those cases of areas of water surface that were erroneously included, where the record meander line is found to depart from the actual bank line in the opposite direction so as to extend into the body of water, thus representing an included area to be land instead of water. The term is not applicable where the differences can be traced to changes in the water level, or to erosion or accretion subsequent to survey.

**512.** The question of the ownership of the marginal areas and of the legal boundaries of the fractional subdivisions that have been disposed of by the United States can be determined only through a consideration of the rights of the proprietors who have acquired title based upon the representations of the original township plat. The marginal discrepancies fall at once into two classes, those that may be regarded merely as technical differences, and those that constitute *erroneous omission*, as where in the latter class the plat and field notes of the original survey are so grossly in error as to bear no reasonable conformity with the bank line. These principles are laid down in the leading court and departmental decisions on the subject, and have been referred to previously in sections 223, 226, and 229, chapter III.

The right of the owner of a fractional lot to the possession of the land which fronts upon the actual bank line, in all ordinary cases, is derived from the principle that a meander line is not a boundary in the usual sense, it being the intention of the Government to convey title to the water's edge. If there should be changes in the position of the bank line, as by accretion, or by recession of the water, the ownership may, in many States, include the new land, but this is a claim of an entirely different character, being one that has its origin in the State or common law, and is called a riparian right. The law, in many States, grants additional exercise of authority within the bed of the body of water, with which the text here is not concerned.

The Government conveyance of title to a fractional subdivision fronting upon a nonnavigable stream, unless specific reservations are indicated, either in the patent from the Federal Government or in the laws of the State in which the land is located, carries ownership to the middle of the stream.

The above principles are set out in the syllabus in *Rust Owen Lumber Co.*, 50 L. D. 678 (1924), as follows:

Public lands—Courts—Vested rights—Statutes: Whenever the question arises in any court, State or Federal, as to whether the title to land, which had once been the property of the United States, has passed, that question must be resolved by the laws of the United States; but when, according to those laws, the title shall have passed, then that property, like other property in the State, is subject to the laws of the State, so far as those laws are consistent with the admission that the title passed and vested according to the laws of the United States.

Navigable waters—Riparian rights: Upon the admission of a State into the Union the title to all lands under the navigable waters within the State inures to the State as an incident of sovereignty, and the laws of the State govern with respect to the extent of the riparian rights of the shore owners.

Public lands—Patent—Riparian rights: With respect to public lands bordering on nonnavigable bodies of water, the Government assumes the position of a private owner, and when it parts with its title to those lands, without reservation or restriction, the extent of the title of the patentee to the lands under water is governed by the laws of the State within which the lands are situated.

Survey—Fraud—Lake—Boundary—Public lands—Riparian rights: Where a survey was fraudulent or grossly inaccurate in that it purported to bound tracts of public lands upon a body of water, when in fact no such body of water existed at or near the meander line, the false meander line and not an imaginary line to fill out the fraction of the normal subdivision marks the limits of the grant of a lot abutting thereon, and, upon discovery of the mistake, the Government may survey and dispose of the omitted area as a part of the public domain.

**513.** The first thing to be established, where the principle of erroneous omission is to be set up, is to show affirmatively that the area was *land in place* at the date of the original subdivision of the township and at the date of the admission of the State into the Union, so that if found similar to the surveyed lands the usual inference that the official survey was correct may be set aside, and the conclusion substituted that the land should have been covered by that survey; but, before looking upon a discrepancy as one constituting erroneous omission, or an omission in the contemplation of the controlling decisions on the subject, a convincing showing is needed on the fact that the representations of the original plat and field notes are grossly in error.

**514.** The applications for the extension of the subdivisional lines so as to include the areas erroneously omitted from the original survey are in most cases initiated either by settlers upon the omitted land or by the owners of the adjoining land. The owner of the surveyed land, or a claimant who has purchased from said owner, may apply for the survey of the omitted area as a preliminary to proceeding with steps to quiet the title. In the latter event the possibility of an adverse claim may or may not be present, but the immediate question is the merit of the application under the acts of Congress which grant relief in these cases. In nearly all cases the points to be determined require a field examination to verify the showing made in the application, and to safeguard the action of the department upon it. It should be understood that it is objectionable in principle to amend a plat in any of these cases except upon the showing of large and unwarranted discrepancies, or by demonstration of equitable title in the Government, as otherwise the making of the corrective survey is frequently at the hazard of interference with private rights; and it should be understood that no proof is required to show the whys and wherefores of an erroneous meander line, but rather that the line as run and as represented on the plat and in the field notes is in effect grossly in error. The rule is concisely stated in *John McClellen*, 29 L. D. 514, 521–522 (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, incompetence, or fraud on the part of the men who made the former survey.

**515.** The general procedure in the survey of lands erroneously omitted is outlined in section 223, chapter III, and section 380, chapter V. The angle points of the original record-meander courses are given serial numbers, avoiding duplication of the numbers where there are two or more of such record-meander lines within a section. The adjusted positions for the angle points are monumented, and marked as shown in sections 279 and 346, chapter IV.

**516.** The requirements for making the plats to represent this type of survey are outlined in sections 639 to 644, chapter IX.

**517.** It is important that the plat should carry a memorandum precisely stating the situation with reference to the survey represented thereon, as:

> The position of the original record-meander courses of the so-called Moon Lake is shown by an irregular line with numbered angle points. This line as thus originally reported was grossly in error, and has therefore been marked as a fixed boundary, with the directions and lengths of the several courses adjusted to the record of the original survey.
>
> The position of the original record-meander courses of Ferry Lake fronting along lot 4, section 9, and lots 2, 3, and 4, section 10, is shown by an irregular line with numbered angle points. This line as thus originally reported was grossly in error, and has therefore been marked as a fixed boundary, with the directions and lengths of the several courses adjusted to the record of the original survey.
>
> The position of the original record-meander courses of a lake reported as having been located in section 36 is shown by an irregular line with numbered angle points. This line as thus originally reported was grossly in error, and, with the exception of certain courses fronting along lots 1, 2, and 9, has therefore been marked as a fixed boundary, with the directions and lengths of the several courses adjusted to the record of the original survey.

**518.** A memorandum will also be supplied with reference to the dependent resurvey of the several section-line boundaries, as required in section 425, chapter VI.

**519.** If there should be substantial areas of accretion to be dealt with that fact will be brought out in the special instructions, with an outline of the governing procedure, and the surveying work in reference to all accretion areas will be distinctly mentioned in the field notes and so shown upon the plat.

**520.** Accretion is a term in general use to denote the lands formed by the deposit of material along the bank of a body of water, or to denote land uncovered by the recession of the water as by the lowering of its level, and the right to such newly made land, unless reserved to the State, attaches to the ownership of the ground along which the accretion is formed. Where the title to the original subdivisions along nonnavigable bodies of water is still in the Government, and where there is similar title along navigable waters in those States where there is no legal reservation to the State, such title carries the right of the Government to subdivide the lands formed by accretion, or by the recession of the water, and to administer the same under the public land laws. If the original subdivisions were disposed of prior to the formation of the accretion, or if the accretions that are formed along navigable waters are reserved by State law, the Government has no jurisdiction.

**521.** A few examples of the survey of erroneously omitted areas, with a review of the facts, will serve to illustrate the practice:

**522.** *Moon Lake case:* The plat of T. 12 N., R. 9 E., fifth principal meridian, Arkansas, approved October 27, 1845, shows a meandered lake occupying the greater part of sections 22 and 27, and extending a short distance into section 26. The field notes of the line between sections 26 and 27 call for an intersection with the southeast side of "Sunk Lake," here classed as impassable and navigable. The surrounding fractional subdivisions as surveyed were all patented to the State under the provisions of the swamp land grant.

The case originated on the report of the removal of timber from portions of the area, under the color of title arising through the ownership of the adjoining land, but it was indicated clearly in the report that practically all of the area was high, dry land, covered with a growth of large timber, with no difference in the character of the land from that which had been included in the original subdivision, and that the topography, elevation, and timber all revealed little if any change since the date of the subdivision of the township.

The greater part of the tract was found to be covered with various species of oak, maple, cottonwood, hickory, sycamore, hackberry, cypress, and willow, many of the trees being of great age, 300 years or more, and many of them indicating strictly upland site conditions. Altogether the area was found to be level land, at about the same elevation and in some places higher than the surrounding lands, though there was evidence of what had been a slough along parts of the edge of the so-called lake.

**523.** By decision dated November 30, 1909, bearing departmental approval, the Commissioner of the General Land Office held that the area, 853.25 acres, was not a navigable lake on June 15, 1836, the date

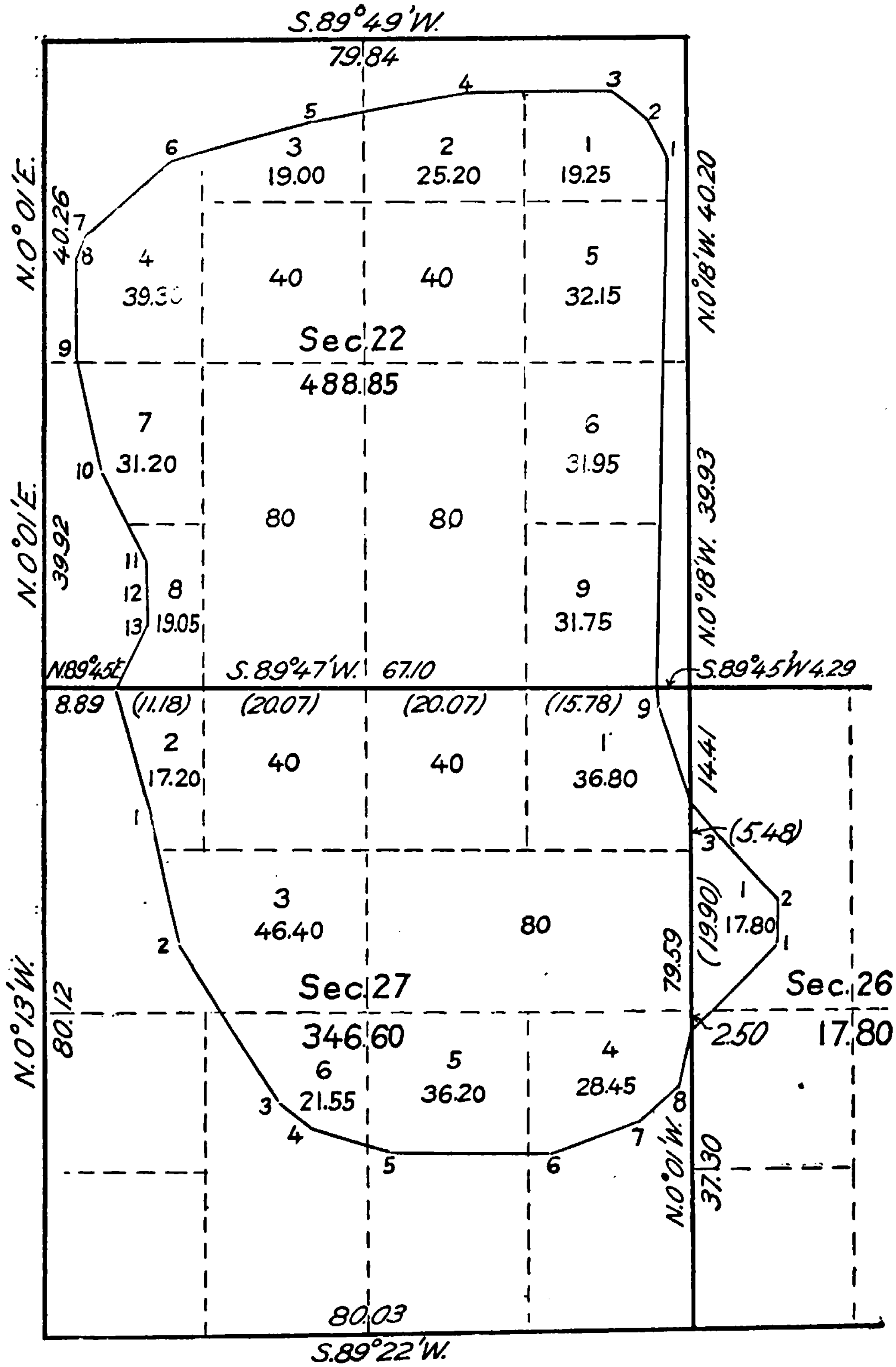



FIGURE 77.—The Moon Lake case.

As no such body of water was ever present, riparian rights do not attach (sec. 523).

when Arkansas was admitted into the Union, nor in 1841 at the date of the subdivision of the township, but as the land was in place at that period and not having been permanently covered by water, it was part of the public domain, and that title had not passed from the Government.

On November 5, 1917, the Supreme Court 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; *Kean* v. *Calumet Canal Co.*, 190 U. S. 452, 459; *Hardin* v. *Shedd*, 190 U. S. 508, 519.

*Second.* But where upon the assumption of the existence of a body of water or lake a meander line is through fraud or error mistakenly run because there is no such body of water, riparian rights do not attach because in the nature of things the condition upon which they depend does not exist and upon the discovery of the mistake it is within the power of the Land Department of the United States to deal with the area which was excluded from the survey, to cause it to be surveyed and to lawfully dispose of it. *Niles* v. *Cedar Point Club*, 175 U. S. 300; *French-Glenn Live Stock Co.* v. *Springer*, 185 U. S. 47; *Security Land & Exploration Co.* v. *Burns*, 193 U. S. 167; *Chapman & Dewey Lumber Co.* v. *St. Francis Levee District*, 232 U. S. 186.

Other important points in this and similar cases are found summarized in the syllabus:

If, in the making of a survey of public lands, an area is through fraud or mistake meandered as a body of water or lake where no such body of water exists, riparian rights do not accrue to the surrounding lands, and the Land Department, upon discovering the error, has power to deal with the meandered area, to cause it to be surveyed, and lawfully to dispose of it.

The fact that its administrative officers, before discovery of the error, have treated such a meandered tract as subjected to the riparian rights of abutting owners, under the State laws, and consequently as not subject to disposal under the laws of the United States, 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 actions and representations of Federal officers carrying assurance that such riparian rights existed, the United States may equitably correct the mistake and protect its title to the meandered land. The equities of the abutting owner, if any, in such circumstances are not cognizable judicially, but should be addressed to the legislative department of the Government.

The swamp land act of September 28, 1850 (ch. 84, 9 Stat. 519), did not convey land of its own force, without survey, selection, or patent.

**524.** The surveying work to be done in the Moon Lake case consisted of a retracement of the boundaries of the several sections, a restoration of the obliterated corners, a remonumentation of all of the corners, a retracement of the record meander line with monumentation of the angle points, and a completion of the fractional section lines. Section 515.

**525.** *Ferry Lake case*: The plat of T. 20 N., R. 16 W., La. Mer., Louisiana, approved August 31, 1839, shows the north boundary of the township discontinued on the bank of Ferry Lake. The line between sections 10 and 11, in harmony with the remaining subdivisions, was discontinued on the lake bank, but the line between sections 3 and 10, instead of being extended to the main lake front was stopped on an arm or bay of the lake. The meander line through section 3 could be, and was run with reasonable conformity, but in section 10, owing to the failure to extend the northern section boundary to the main lake front, there was no possibility of running a true meander line; and excepting the end courses, the record line, as developed, bears no proper relation to the actual bank.

The plat of fractional sections 4, 9, and 10 of the same township, approved August 18, 1871, represents an extension of the lines between sections 3 and 10, and between sections 4 and 9, to the main lake front. The corner of sections 3, 4, 9, and 10 was established in this survey, also a meander corner on the west side of a narrow bayou which drains out of the north part of section 9; but again, for no apparent reason, in running south on the line between sections 9 and 10 the survey was terminated at a point more than 3,400 feet north of the bank of Ferry Lake. A part of the meander courses in sections 4 and 9 were accurately run, but the remaining courses, particularly those which connected with the terminal point on the line between sections 9 and 10, were merely a traverse line through the woods, though represented in the field notes and shown on the plat to be the bank of the lake.

Such was the situation in this township until oil and gas were discovered in large quantities, when in the years 1909 and 1910 applications were filed with the department to make mineral locations, not only on the areas that had been erroneously omitted from the official surveys, but within the bed of the lake, it being alleged that large errors had been made in the running of the meander lines, that the lake itself was merely a temporary body of water, and that it had not been in existence as a navigable lake, such as would belong to the State by right of sovereignty, and reserved to the State on admission into the Union on April 30, 1812. In 1910 all of the fractional lots adjoining the omitted area had been disposed of by the United States.

The report of the field investigation included a review of considerable historical data, expert studies of the geology of the lake

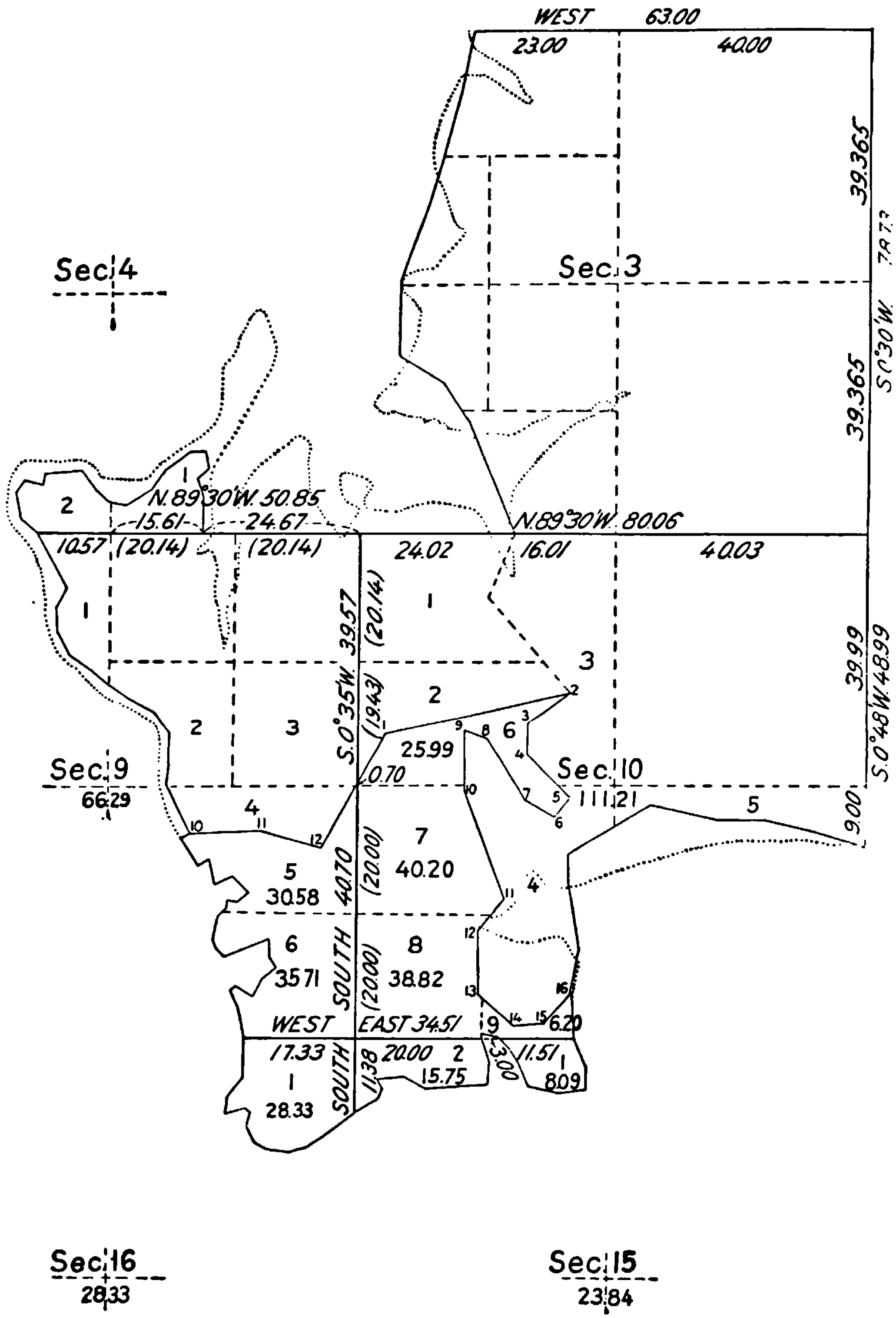



**Figure 78.**—The Ferry Lake case.

The contour representing the mean high-water elevation of the lake in the year 1812, when Louisiana was admitted into the Union, and in 1839, when the township was subdivided, is shown thus: .............
The circumstances, as well as the extent and character of the lands, necessitate the conclusion that the omission was of deliberate purpose or the result of such gross and palpable error as to constitute in effect a fraud upon the Government (sec. 526).

basin, expert examination of the forest trees, and the surveying situation, all leading to corroborative conclusions that Ferry Lake was in fact present in 1812 as a navigable body of water, though there had been a marked recession of the lake by 1910, and that in neither of the surveys made in 1839 and 1871 had the lake been correctly meandered in sections 9 and 10, either as it was at the dates of the surveys or as it was in 1812.

The soil, topography, and timber on the omitted area were identically the same as found on the surveyed land, and for the greater part of the length of the record meander line there was not the slightest indication of there ever having been a lake bank or water-washed escarpment of any kind. The forest growth on the omitted land, which in the one body in sections 9, 10, 15, and 16 amounted to 229.67 acres, included overcup oak, sweet gum, and red gum on the lower levels, and on the remainder post oak, black-jack oak, Spanish oak, hickory, pine, and other varieties, many of them of great age, and clearly the descendants of a mixed forest that had occupied the situation for many centuries. The overcup oak was found to occupy a belt immediately above a belt of cypress timber principally, but with some other varieties, which were found occupying the plain terraces above and below an escarpment, easily traceable, which had been made by the waters of Ferry Lake, and which continued, without interruption, around the entire basin. A contour survey showed the elevations in the omitted area in sections 9 and 10 to range up to 17 feet above the former lake level.

**526.** Upon a review of the record, the Attorney General of the United States, in a letter to the Secretary of the Interior, dated September 11, 1916, concluded—

> That no action should be taken to enforce or assert any claim by the Government to that portion of the area involved which is covered by the waters of the lake because if the State's title by virtue of its sovereignty should fail for any reason, I see no way of successfully resisting her claim under the swamp land grant.
>
> However, in so far as concerns the land lying between the old meander line and the waters of the lake, I entirely agree with you that it constitutes unsurveyed public land of the United States, and * * *.

On January 2, 1923, the Supreme Court of the United States announced an opinion (*Jeems Bayou Fishing & Hunting Club* v. *United States*, 260 U. S. 561, 563–564), denying the claims to the land in sections 9, 10, 15, and 16, adverse to those of the Government, and commented:

> The inaccuracy of the plat is plainly apparent upon a like inspection. Why ——— made the survey and returned the plat as he did is a matter of speculation, but the facts demonstrate that no survey of the large, compact body of land, which includes the tract in controversy, was ever made. The circumstances,

**as well as the extent and character of the lands, necessitate the conclusion that the omission was of deliberate purpose or the result of such gross and palpable error as to constitute in effect a fraud upon the Government.**

**527.** The surveying work to be done in the Ferry Lake case consisted of the steps already noted in the Moon Lake case, sections 515 and 524; also a monumentation of the contour which agreed with the evident mean high-water elevation of the lake as it was in the year 1812. The contour line, owing to the recession of the waters, was needed to mark the boundary of the public land; thus recognizing, in principle, not only the sovereignty of the State over the bed of the lake, but as well the reservation to the State, under her law, of the land uncovered by the recession of the water.

**528.** *Crooked Lake and Bear Lake case:* The plat of T. 43 N., R. 6 E., 4th Prin. Mer., Wisconsin, approved April 6, 1863, shows a meandered lake in section 36. Meander corners were established regularly on the south and east boundaries of the section. The field notes show the running of meander courses through the section on opposite sides of the lake, and call for high banks, along timbered land. No mention is made of an arm of a lake extending northwesterly into section 25. The fractional lottings were disposed of according to the representations of the plat.

By letter dated April 16, 1923, the Commissioner of the General Land Office advised the Secretary of the Interior of an application to make a forest lieu selection for the NE ¼ SW ¼ sec. 36 (lot 15, fig. 79), which according to the representations of the township plat would be located entirely within the bed of the meandered lake as above described. This letter contains a review of the facts as developed by a field examination, and concludes with a recommendation that the land theretofore shown as a meandered lake be surveyed and a proper plat constructed. The proposed action bears departmental approval.

The report of the field examination showed the following facts:

The south and east boundaries of the section cross two lakes instead of one, the lakes being separated by a body of land amounting to 236.90 acres contained within the lines represented on the original plat as the banks of the one meandered lake. This area is rolling upland ranging up to 50 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

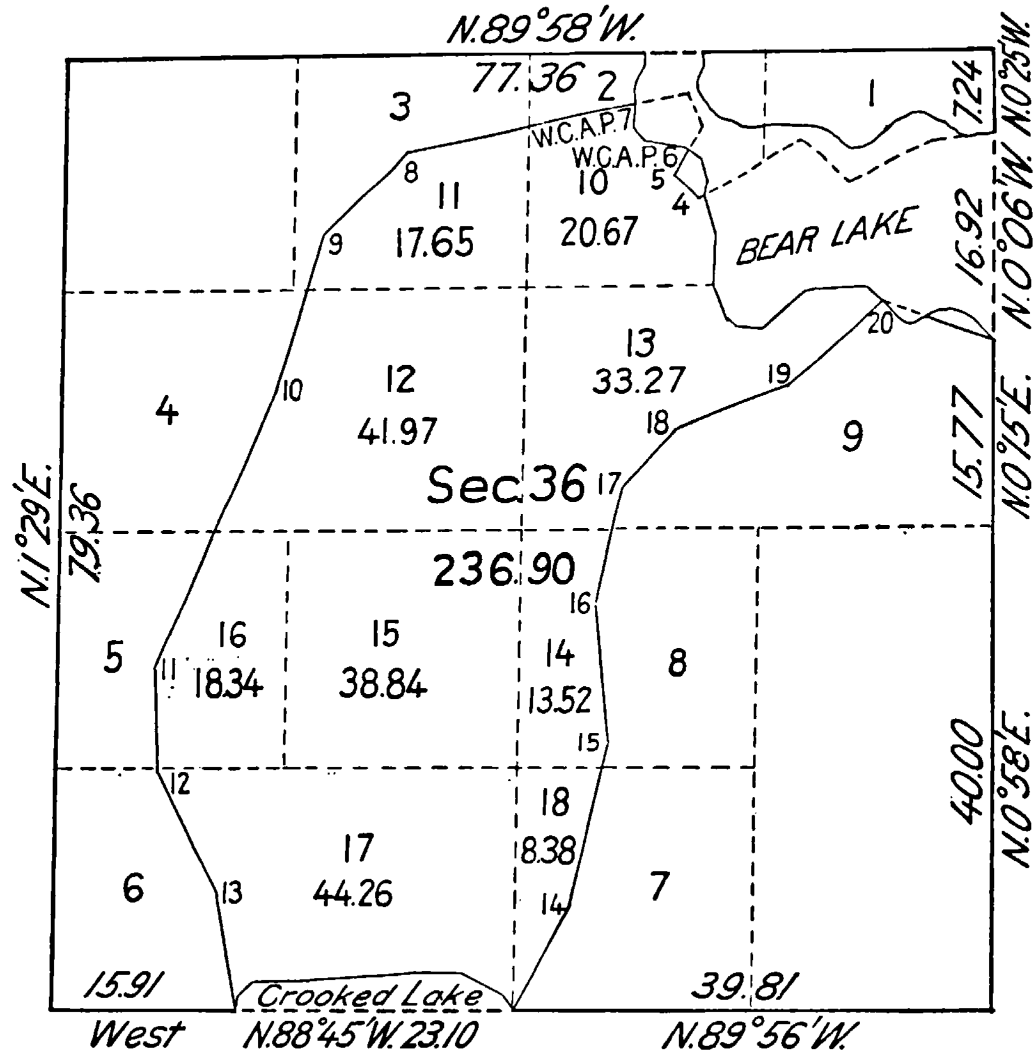



FIGURE 79.—The Crooked Lake and Bear Lake case.

The south and east boundaries of the section cross two lakes instead of one, the lakes being separated by a large body of land, ranging up to 50 feet above the level of either lake, and heavily forested, while the shores of the lakes are well defined.

Witness angle points Nos. 6 and 7 are established on the bank in order to show the directions of the lines running from angle points Nos. 5 and 8.

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. Sections 515, 524.

**529**. 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



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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 invoked 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 those subdivisions, partition lines should be run and monumented segregating the public land from the area belonging to the private owners. Generally it is necessary in such cases to subdivide the sections in the regular manner, reestablish the original meander line and re-meander the body of water. Lot numbers and areas will be shown on the official plat for the public land being surveyed for the first time. In those cases where title to all the land in a section based upon the plat of the original survey has passed from the Government, it will not be necessary to reestablish the original meander line. This line will be 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 (fig. 88, ch. IX). A marginal note should be added to the plat stating that the ownership of the areas, which are not public land, shown in front of the patented lots, is governed by the laws of the State.

Partition lines dividing areas omitted from survey between the Government and the private owners should be run in the same manner as partition lines dividing areas formed by the process known as accretion. The rule applied by the United States Supreme Court in the case of *Johnston* v. *Jones*, 1 Black 209, 222, 223 (1861), results in an equitable and just division and should be followed unless it is contrary to the law of the State in which the work is being executed. This rule, stated briefly, is to apportion the new frontage along the water boundary in the same ratio as that along the line of the record meander course.

## SWAMP AND OVERFLOWED LANDS

### TIDE LANDS

**530.** References are made in sec. 4 to the coastal limits of the public domain as defined by mean high tide, and in sec. 5, Chapter I, to the several acts of Congress which granted to certain States the swamp lands within their respective boundaries. The references are continued in secs. 226 to 233, and in paragraph 10, sec. 236, Chapter III, under the general subjects of the meandering of bodies of water and classification of land.

Tide lands include all coastal areas that are situated above mean low tide and below mean high tide, particularly as such areas are alternately uncovered and covered by the ebb and flow of the ordinary daily tides. Overflowed lands include essentially the lower levels within a stream flood plain as distinguished from the higher levels, according to the characteristic effect of submergence where long continued. Swamp lands include all other marshes and intermittent ponds which do not have effective natural drainage, particularly where such conditions are long continued.

**531.** The Supreme Court of the United States in *Baer* v. *Moran Bros. Co.*, 153 U. S. 287 (1894), states that tide lands are those which are uncovered at low tide and are covered at ordinary high tide. In *Pollard's Lessee* v. *Hagan*, 15 Curtis, 391, 403 (1844), the Supreme Court held:

> The shores of navigable waters and the soil under them were not granted by the Constitution of the United States, but were reserved to the States, respectively—

and in *Mumford* v. *Wardell*, 6 Wall. 423, 436 (1867), the court said:

> The settled rule of law in this court is that the shores of navigable waters and the soil under the same in the original States, were not granted by the Constitution to the United States, but were reserved to the several States, and that the new States, since admitted, have the same rights, sovereignty, and jurisdiction in that behalf as the original States possess within their respective borders.

In *San Francisco* v. *LeRoy*, 138 U. S. 656 (1891), the court stated:

> The lands which passed to the State upon her admission to the Union were not those which were affected occasionally by the tide, but only those over which tidewater flowed so continuously as to prevent their use and occupation. To render lands tidelands, which the State by virtue of her sovereignty could claim, there must have been such continuity of the flow of tidewater over them, or such regularity of the flow within every twenty-four hours, as to render them unfit for cultivation, the growth of grasses or other uses to which upland is applied.

**532.** In the light of the decisions it is clearly indicated that coastal "salt marshes" that are covered by the daily tide belong to the States by right of sovereignty, and such areas are not subject to survey. Coastal marshes that are not covered by the daily tide are subject to survey, but being low in elevation and usually saturated will be classified as swamp and overflowed within the meaning of the several grants.

**533.** Riparian rights, as defined by the laws of the several States, which are applicable within the beds of lakes, streams, and tidal waters, are not enforceable over the swamp and overflowed lands granted to the States.

**534.** Where surveys or field examinations are to be made covering or relating to swamp and overflowed lands, the special instructions should point out the particular questions which are presented, and in general, in aid of the adjustments which are required by the swamp land granting acts, the following rules will be observed:

1. According to R. S. sec. 2481 (43 U. S. C. sec. 984), any legal subdivision the greater part of which is "wet and unfit for cultivation," shall be included in the list, but when the greater part of a subdivision is not of that character the whole of it shall be excluded. The "legal subdivision" mentioned herein is the usual quarter-quarter section or lot as shown by the plat of survey.

2. In order to bring land within the definition of the several swamp land granting acts, the greater part of any quarter-quarter section or any lot must have been so swampy or subject to overflow during the planting, growing, or harvesting season, in the majority of years at or near the date of the grant, as to be unfit for cultivation in any staple crop of the region in which it is located, without the use of some artificial means of reclamation, such as levee protection or drainage ditches.

3. A subdivision which becomes swampy or overflowed at a season of the year when this condition does not interfere with the planting, cultivating, or harvesting of a crop at the proper time and by the ordinary methods, and so not being "made unfit thereby for cultivation," does not pass to the State under the swamp-land grant.

4. Tame grass or hay, when produced by the ordinary methods of preparing the ground, will be considered a staple crop, as well as the cereals, or cotton, or tobacco.

5. In the administration of the several acts granting the swamp lands, the States have been allowed optional methods of preparing the lists of the subdivisions that are to be identified as swamp and overflowed within the meaning of said acts, but in every survey, the duty devolves upon the engineer to determine with accuracy the position and extent of the swamp and overflowed land within the area under survey, regardless of the methods employed by the States in asserting claims.

6. The States of Alabama, Indiana, Louisiana, Michigan, Minnesota (excepting as to lands within the Indian reservations), Mississippi, Ohio, and Wisconsin have elected to base their swamp-land lists on the field-note record, and in these States it is imperative that the field notes of the survey include a specific list of the subdivisions each of which is more than 50 per cent wet and unfit for cultivation, regarding such character as at the date of the passage of the granting act.

Arkansas, by the Act of April 29, 1898 (30 Stat. 367; 43 U. S. C. sec. 991), relinquished all right, title, and interest to the remaining unappropriated swamp and overflowed lands within its boundaries.

7. In California, under R. S. sec. 2488 (43 U. S. C. sec. 987), the swamp-land lists are based upon the representations of the plat of the survey, and in this State it is imperative that the plats correctly show the conditions in this respect.

8. The selection of the swamp lands within the States of Florida, Illinois, Iowa, Missouri, and Oregon, and within the Indian reservations in the State of Minnesota, is based upon investigations and reports by representatives of the State and of the Bureau of Land Management, but this does not set aside the Manual requirements for the usual complete showing of the character of the land.

**535.** It is always of importance to note any marked changes in the water level and drainage conditions of the region, and to ascertain the situation which obtained at the date of the granting act, and in all such inquiries it is proper to secure the testimony of persons who have known the lands for the longest periods. The most convincing evidence relative to the character of the land at the date of the granting act will be afforded by the older native forest trees, if any are present, or where their stumps remain, as these will reflect their site conditions with great certainty.

This line of investigation will require an inquiry into the habitat of the forest species which are found, particularly as to whether the usual range of the tree is within low wet ground, as for example the cypress, tupelo, sweet gum, water ash, water locust, and red bay of the southern latitudes, and the tamarack, white cedar, black spruce, swamp spruce, and black ash of the northern latitudes of the United States. The presence of any of the species named indicates the possibility of swamp land, and while conclusive with some of them, others of the species named have a wider range and may be found associated with upland varieties. If upland varieties are present the plain inference will be that the site conditions are that of upland, even though a forest species may favor moist rich soil.

## SOIL CLASSIFICATION

**536.** The subject of soil classification is referred to in paragraphs 8 and 20, section 236, chapter III. It is one of considerable importance when related to the development of the public domain, not only to the prospective settler but for the value to be found in this field-note information for use in all general soil surveys and in the administration of forest lands. While it is beyond the purpose of the Manual to go into a subject which belongs properly to another scientific branch, yet it is apparent (R. S. sec. 2395; 43 U. S. C. sec. 752; Manual, sec. 6), that the general laws require the engineer to note and to report upon the soil types.

**537.** The objective to be stressed in this line of observation is to report upon the characteristic soil types, which when considered in relation to the normal moisture conditions, including precipitation and drainage, the possibility of irrigation at reasonable cost, the climatic conditions, elevation above sea level, and latitude, will bring out the adaptability of the soil for farming purposes, grazing or forestry, or whether it is desert or waste rocky land.

**538.** An outline of the various soil types, their make-up, and their use, is presented below to the end that it may serve as a guide to the engineer, both in the field and for his inquiry into technical books on the subject:

1. Soil types, based on texture: Gravel, coarse and fine; sand, coarse and fine; sandy loam; silt loam; loam; clay, heavy and light; and muck.
2. Structure: Single grained, pulverulent, and lumpy.

 

3. Color: Surface soil and subsoil, both when dry and when wet.
4. Depth: Surface soil and subsoil.
5. Location: River bottom or flood plain, bench, slope, plateau, prairie, and mountain.
6. Topography: Level, rolling, broken, hilly, and mountainous; and elevation above sea level.
7. Drainage: Direction, depth to water table, and quality, as poor, good, or erosive.
8. Mode of formation: Water laid, glacier laid, wind laid, and residual.
9. Chemical properties: Acidity, alkalinity, and humus content.
10. Geological derivation:

(*a*) Sedimentary rocks: (1) Formed of fragments of other rock transported from their sources and deposited as conglomerate, sandstone, and shale; and (2) formed by simple precipitation from solution, as limestone, or of secretions of organisms, as some coastal rocks.

(*b*) Metamorphic rocks: Formed through change in constitution, expecially 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-porphyry; and (third, granular rock) granite, diorite, and porphyry.

Soil studies: Manual Appendix VII.

**539.** The soil has its origin in the material which comes from the disintegration of the rocks. Roots and other vegetable matter in the soil are by decay gradually converted into humus, which is found only in the surface soil, and in quantities which vary with the activity and profusion of plant life. Plant food comes from the chemical elements contained within the rock and the humus, one is the product of the inorganic, the other a product of the decomposition of the organic matter. There are four elements that the plants mainly need in soils—phosphorus, potassium, nitrogen, and calcium—the others usually being present in plentiful supply and so of less importance in considering the fertility. The physical properties of the humus are of the greatest importance in relation to the fertility of the soil, and the humus confers upon the soil the power of absorbing and retaining the moisture.

The soil bacteria thrive best in one which is rich in decaying vegetation, with favorable proportions of lime, air, light, warmth, and moisture, and through their presence much nitrogen is taken from the air for storage in the ground. The relation of these things leads to the notable observation that soils seem to select their plants, or vice versa. There is found in a certain soil type one class of grasses or forest cover, in another soil very different plant life. These are the keys to a study of the soils, and when all are considered in connection with the moisture, climatic, and other conditions of the environment, will very largely determine its value for agriculture, stock grazing, or forestry.

**540.** The following is an illustration of a general description of the land and soil types found within a selected township, designed to bring out rather minute references to the soil structure:

Land, level, and gently rolling plateau, with elevation from 500 to 700 feet above sea level. Soil, fine sandy loam; surface soil dark gray to black, rich in humus, from 10 to 15 inches deep; subsoil, light brown loam, 36 inches deep, resting on gravel bed; sedimentary origin, lake laid. Drainage good, the stream system being the ——— river and its tributaries. The normal precipitation of the region is ordinarily deficient for general farming, but the soil is well adapted to any of the cereals usually grown in this latitude by dry-farming methods, and it produces excellent grasses, both native and tame.

## Chapter VIII

# FIELD NOTES



## PURPOSE AND STYLE

**541.** The field notes are the written record of the survey. It is essential that this record show an appropriate identification of the lines previously established from which the survey has been extended, with suitable "calls" referring to the alinement and measurements, description of topography along the lines surveyed, and monumentation of the work. All new subdivisions to be platted and the quantity of land in each unit are derived from the field notes, and this record will be, in turn, the basis for the identification of the boundaries. The early laws on public-land surveys comprehended the importance of the field notes, and this chapter of the Manual is devoted to outlining the requirements, with examples of the various forms of record.

**542.** The initial notes are kept in pocket field tablets. The final field notes for filing are transcribed from the field tablets, and are typewritten upon regulation field note paper. It is desirable that the final field notes be made to conform to the general arrangement and phraseology set out in the Manual. It is obvious, for practical reasons, that a large part of the final field notes must be extended from an abbreviated field record, and equally apparent that much of the minute detail of the initial notes may be appropriately summarized into a form of record which will refer directly to the completed survey. This distinction in the two stages of the record is carried through the text. The subject in hand is that of the transcribed field notes, the record that is extended from the field tablets; this record is termed the "*field notes*."

**543.** There will be entered in the *field tablets* all appropriate notes of the method and the order of the procedure; the dates will be shown when engaged upon each part of the work; and the division will be noted if the work is divided between two or more parties. These notes will also show the minute detail of all observations for time, latitude, and azimuth; the resulting directions of the lines run; the measurements; and all necessary descriptions. The preceding chapters contain explicit instructions on these subjects which do not need to be repeated. It suffices to state that the record made in the field tablets should supply, along the plan already laid down in the preceding chapters, all information which may be needed for a complete verification of the final transcript record.

**544.** The need for choice of methods in handling the great variety of survey types makes it desirable that judgment be exercised as to whether part of the work of entering the initial record in the *field tablets* shall be allotted to one or more assistants, and how the notes are to be arranged. The chief of field party is necessarily charged with responsibility for the accuracy and sufficiency of this record, all subject to the approval of the regional or public survey office.

The work of transcribing the record usually receives the personal attention of the engineer, but as that is not always the case, it is important that the arrangement of the notes in the tablets and the use of abbreviations be such as to be readily understood by others who are familiar with the technical processes. It follows that due regard should be given to the Manual requirements and form, though it is intended that set forms of expression be used flexibly and modified when necessary to conform to the survey procedure. The work of the reviewing officers will be directed to the fundamental requirements of the Manual and the written special instructions, and the comments, if any, *as to the form* of the transcribed field notes, will be based upon broad grounds.

Random lines with fallings will be shown in the field tablets but will be omitted from the transcribed field note record except where needed to show the detail of a triangulation, offset, traverse, or stadia measurement. Sections 16, 23, 33, 35, 38, 154, 181, and 555.

**545.** The township will be considered as the unit in compiling the field notes and normally the field notes of all classes of lines pertaining to a township, when concurrently surveyed and not previously compiled, will be 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.

## TITLES

**546.** Each book of field notes will be included in a regulation cover, with appropriate title setting out general information as follows:

1. The description of the lines recorded in that book;
2. The principal meridian to which the survey refers;
3. The State in which the survey is located;
4. The name or names of the engineers by whom the work was executed;

5. The date of the special instructions, with serial group number, and date of approval;

6. The date of the assignment instructions; and,

7. The dates of the beginning and completion of the work included in that book.

## Examples of Titles

Field Notes
Of the Survey of the
Tenth Standard Parallel North,
Along the South Boundary of Township 41 North,
Through Ranges 13, 14, 15, and 16 West;
and the
Fourth Guide Meridian West,
Through Townships 41, 42, 43, and 44 North,
Between Ranges 16 and 17 West.

(Or)

East and North Boundaries of
Townships 41 and 42 North,
Ranges 15 and 16 West.

(Or)

Subdivisional and Meander Lines of
Township 41 North, Range 15 West.

(Or)

West and North Boundaries
and
Subdivisional and Meander Lines of
Township 41 North, Range 13 West.
(All)
Of the Sixth Principal Meridian
In the State of Wyoming,
Executed by
Wm. C. Jones, Cadastral Engineer.

(Or)

John B. Smith and Fred A. Brown,
Cadastral Engineers.
(All)

Under special instructions dated June 30, 1945, which provided for the surveys included under Group No. 205, approved July 10, 1945; and assignment instructions dated July 15, 1945.

Survey commenced July 25, 1945.

Survey completed October 10, 1945.

**547.** The descriptive portion of the title will be appropriately modified if there is a fractional portion of a township included in a survey, and for all resurveys and fragmentary surveys, as for example:

Field Notes
Of the Dependent Resurvey and Survey of
A portion of Subdivisional Lines
Completing (or continuing) the
Subdivision of
Township 39 South, Range 18 East.

(Or)

Field Notes
Of the Survey of
Four Islands in Burntside Lake,
In Sections 13, 20, and 29,
Township 63 North, Range 13 West.

(Or)

Field Notes
Of the Survey of
Fiddlers Island in Venice Bay,
In Section 1,
Township 39 South, Range 18 East.

(Or)

Field Notes
Of the Dependent Resurvey of the
Exterior and Subdivisional Lines of
Township 18 South, Range 59 West.

(Or)

Field Notes
Of the Dependent Resurvey of the
Eleventh Standard Parallel North,
Along the South Boundary of Township 45 North,
Through Range 79 West;
The East Boundary of
Township 45 North, Range 80 West;
and the
South Boundary of
Township 46 North, Range 79 West.

(Or)

Field Notes
Of the Independent Resurvey of the
East Boundary and Subdivisional Lines of
Township 45 North, Range 79 West,
and
Metes-and-Bounds Survey of Private Claims.

(Or)

Field Notes
Of the Dependent Resurvey of the Boundaries of the
Anastasia Island Lighthouse and Military Reservations,
In Sections 21, 22, 27, and 28,
Township 7 South, Range 30 East.

(Or)

Field Notes
Of the Dependent Resurvey and Extension of Lines
Subdividing the so-called Moon Lake,
In Sections 22, 26, and 27,
Township 12 North, Range 9 East.

(Or)

Field Notes
Of the Dependent Resurvey and Extension of Lines
Subdividing Land Bordering 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 of Lines
Subdividing Accretion Area Bordering Red River,
Including Riverbed Tracts,
In Sections 4, 5, and 8,
Township 5 South, Range 14 West.

(Or)

Field Notes
Of the Dependent Resurvey of the Section Boundaries,
The Subdivision of the Sections,
and
The Establishment of Corners of Indian Allotments,
Sections 9, 10, and 15,
Township 143 North, Range 30 West.

(Or)

Field Notes
Of the Dependent Resurvey of the Section Boundaries,
The Subdivision of the Sections,
and
The Establishment of the Boundary, Block and Lot Corners,
And Street Center-Lines of the
Town site of Lac du Flambeau, in
Sections 5 and 8,
Township 40 North, Range 5 East.

(Or)

Field Notes
Of the Dependent Resurvey of the Section Boundaries,
And the Metes-and-Bounds Survey of a body of land 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

**548.** Upon the completion of the field notes of each book there will be prepared a small-scale index diagram of the lines included in that book. A form diagram will be employed ordinarily, but it is frequently necessary to construct a special diagram to suit the work; in the latter case a sheet of regulation field-note paper, or a sheet of the same size, will be employed, and a scale adopted that is suited to the available space. It is usually preferable to orient the diagram with north to the top of the page, though sometimes the outline of the work is such that it is better to orient the diagram with north to the left-hand (or binding) edge. The index diagram should show all of the lines the record of which is included within the book, with page numbers referring to such record to be shown upon the lines of the diagram. Meanders and other irregular lines will be drawn and indexed. The index sheet will be inserted in the book on the inside of the front cover, to appear on the right-hand side, without page number; no field notes will be written on the index sheet.

Where two or more engineers execute a survey the portion surveyed by each engineer will be indicated by symbol on the index diagram as indicated in appendix VIII.

## Page Headings

**549.** Each page of the field notes will be given a heading. Such heading will be a short summary of the title of the field notes to be continued on that page. New headings will be employed within the body of the field notes where changes are made to a new division of the survey; this will become the heading of the pages that follow. Examples will be found in the specimen field notes.

## Abbreviations

**550.** The following abbreviations, especially suited to field notes of surveys and designed for brevity, are permitted in the final transcript record, and are employed generally in the field notes where repetitions in the form of the record and the expressions used are such as to make the abbreviations readily understood. These abbreviations are employed in the field-note record in addition to those shown in chapter II for analytical notation of observations, and those shown in chapter IV for marks upon monuments. Some of these abbreviations, as appropriate, are employed upon the township plat. An extended explanation of the use of the trigonometric formulas frequently employed is contained in tables 24 and 25, Standard Field Tables. All abbreviations will be given capital or lower-case letters the same as would be proper if the spelling were to be completed.

## Table of Abbreviations

| | | | |
|---|---|---|---|
| **A.** | for acres. | mer. | for meridian. |
| **alt.** | for altitude. | Mi. Cor. | for mile corner. |
| **a. m.** | for forenoon. | mkd. | for marked. |
| **Am.** | for amended. | M. S. | for mineral survey. |
| **ang.** | for angle. | nat. | for natural function. |
| **app. noon.** | for apparent noon. | N. | for north. |
| **app. t.** | for apparent time. | NE. | for northeast. |
| **asc.** | for ascend. | NW. | for northwest. |
| **astron.** | for astronomical. | No. | for number. |
| **B. M.** | for bench mark. | obs. | for observe. |
| **bet.** | for between. | obsn. | for observation. |
| **bdy., bdrs.** | for boundary, boundaries. | orig. | for original. |
| | | p. m. | for afternoon. |
| **ch., chs.** | for chain, chains. | pt. | for point. |
| **cor., cors.** | for corner, corners. | Prin. Mer. | for principal meridian. |
| **corr.** | for correction. | ¼ sec. | for quarter section. |
| **decl.** | for declination. | R., Rs. | for range, ranges. |
| **dep.** | for departure. | red. | for reduction. |
| **desc.** | for descend. | rev. | for reverse. |
| **diam.** | for diameter. | s. | for second, seconds. |
| **diff.** | for difference. | sec., secs. | for section, sections. |
| **dir.** | for direct. | S. | for south. |
| **dist.** | for distance or distant. | SE. | for southeast. |
| **E.** | for east. | SW. | for southwest. |
| **e. e.** | for eastern elongation. | sq. | for square. |
| **elev.** | for elevation. | Stan. Par. | for standard parallel. |
| **elong.** | for elongation. | sta. | for station. |
| **ft.** | for foot, feet. | tele. | for telescope. |
| **frac.** | for fractional. | temp. | for temporary. |
| **Gr.** | for Greenwich. | t. | for time. |
| **G. M.** | for guide meridian. | T., Tp., Tps. | for township, townships. |
| **hor.** | for horizontal. | tri. | for triangulation. |
| **h.** | for hour, hours. | u. c. | for upper culmination. |
| **h. a.** | for hour angle. | U. S. L. M. | for United States location monument. |
| **in., ins.** | for inch, inches. | | |
| **lat.** | for latitude. | U. S. M. M. | for United States mineral monument.[1] |
| **lk., lks.** | for link, links. | | |
| **l. m. noon.** | for local mean noon. | vert. | for vertical. |
| **l. m. t.** | for local mean time. | w. corr. | for watch correction. |
| **log.** | for logarithmic function. | w. t. | for watch time. |
| **long.** | for longitude. | W. | for west. |
| **l. c.** | for lower culmination. | w. e. | for western elongation. |
| **m.** | for minute, minutes. | x. | for separating dimension values. |
| **meas.** | for measurement. | | |

[1] A term formerly employed; it has been discontinued as the term "location monument" is preferred.

## THE DETAILED FIELD-NOTE RECORD

**551.** Coming now to the body of the field notes, attention is again directed to those sections of the preceding chapters which deal with the preliminaries of the field work and to the Manual requirements in regard to the field-note record.

**552.** The purpose of the record, in reference to the introductory statements, is to qualify the survey structure; the data to be supplied are as follows:

1. A description of the instruments employed, and the adjustments and tests (a reference to where the record will be found may be supplied if it is contained in another book of field notes of the same series);
2. A description of the measuring tapes, and their test for accuracy;
3. A description of any special methods employed;
4. A description of the point of beginning and its geographic position; and,
5. The observed magnetic declination.

**553.** The following *list* will assist in locating many *specific requirements* in regard to the field-note record, often with examples of forms of record:

Measurements: Descriptions required, sections 16, 23, 35, 141, 142, 575; examples, sections 18, 20, 27, 29, 32, 38.

Instruments, and requirements as to their adjustment: Descriptions required, sections 42, 43, 44, 45, 46.

Magnetic declination: section 40.

Observations for time: Descriptions required, section 91; examples, sections 51, 70, 71, 75, 108, 111, 113, 114, 116, 123.

Observations for latitude: Descriptions required, section 73; examples, sections 74, 75, 76, 113, 115, 116, 123.

Observations for azimuth: Descriptions required, sections 40 to 46, incl., 81; examples, sections 81, 87, 88, 90, 97, 98, 108, 109, 110, 112, 113, 114, 115, 120, 122, 123.

Standard lines: Sections 141, 142, 143, 146.

Township exteriors: Sections 151, 154, 160, 163, 167.

Subdivisional lines: Sections 180, 187, 190, 192, 215, 228, 230, 232, 233, 235, 236.

Subdivision of sections: Sections 463 to 471.

Monuments: Sections 238, 241, 254, 324, 325.

Resurveys: Sections 420, 422, 423, 424, 445, 447, 452, 458, 459.

Town-site surveys: Section 482.

Rectangular boundaries of parts of sections: Section 495.

Mineral segregation surveys: Section 507.

Erroneously omitted areas: Section 519.

Retracements: Section 555.

**554.** A full description of all monuments belonging to the established survey, upon which the new lines are to be initiated or closed will always be furnished with the written special instructions. Upon the identification of such monuments, if in good condition, the new field-note record may take the form, "which is a ------, firmly set, marked and witnessed as described in the official record"; but if a monument does not conform to the record, or any changes are made, a complete description will be supplied. When necessary to refer to a reconstructed corner monument, which is described in another book of field notes, the reference should be given to the particular field notes in which the description of that monument will be found.

The complete description of a monument will be entered once only. In subsequent notes the expression "heretofore described" may be employed when referring to a point of a previous survey already occupied in the new survey; all new corners recorded in the same book of field notes will be referred to by name only, without repeating the description of the monument, as for example: "the cor. of secs. 2, 3, 10, and 11"; or "the standard cor. of secs. 33 and 34"; or "the cor. of secs. 5, 6, 31, and 32, on the S. Bdy. of the Tp."

**555.** The field notes of *retracements* can usually be brought within the practice outlined below, but will require special consideration before being transcribed into final form, giving attention to their usefulness as a record or report of the conditions that obtained on the ground prior to the reconstruction or extension of the older survey. The Manual references to what is required in the making of retracements have been associated with the text of the subject of the new surveys or resurveys, and the field examinations that belong with the public land surveying work; these are treated in sections 159, 160, 166, 183, 351, 361, 362, 412, 413, and 429.

An enlargement and explanation of the subject of retracements, addressed to county and local surveyors and others who may have occasion to retrace the lines of the public land surveys, a recontained in sections 1054 to 1080, inclusive, of the Manual supplement on the Restoration of Lost or Obliterated Corners and Subdivision of Sections.

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, which in the majority of the work can be done by adherence to the following rules:

(*a*) Complete descriptions will be given in those cases where the retracement is not followed by resurvey procedure or the subdivision of a section.

(*b*) Where the retracement is followed by resurvey procedure such as remonumentation; new monuments of minimum control for the old or for the new surveys; the usual dependent resurvey; fragmentary surveys; identification of grant and other broken boundaries; and the identification of section-line boundaries for the subdivision of a section, the detail of the descriptions will be omitted from the general statement respecting the lines retraced and the manner of the retracement, and no description is required that concerns only the technical steps of running the trial or random lines of the retracement.



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(*c*) The directions and lengths of the true lines; the descriptions with respect to the calls of the field notes of the prior survey regarding natural objects, stream crossings, principal slopes, etc., and other needed topographic entries; the descriptions of the physical, collateral, and record evidence or testimony concerning the old monuments and the accessories; and all new monumentation, will be given in the true-line field notes.

(*d*) The descriptions with respect to the closing corners of the exterior and subdivisional surveys originally placed on the standard parallels and on the township exteriors where the record calls for two sets of corners, and similarly within partially subdivided townships where there are offsets to deal with, will be given in the field notes of closing lines of the exterior or subdivisional survey that is being retraced or resurveyed.

(*e*) 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.

(*f*) 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 (see sec. 163), and will be connected by course and distance, and fully described in the field notes of the closing line.

(*g*) 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 and a cross reference will be entered in the field notes of the retracement or resurvey of the line closed upon.

(*h*) 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.

(*i*) 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 regarded as necessary.

(*j*) 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.

**556.** The character of the land, soil, and forest cover upon the lines surveyed will be summarized at the conclusion of the field notes of each mile. The record of the mile will be closed by a line drawn across the page. A general description of a township as a whole, with regard to topography, soil, forest cover, merchantable timber, native grasses, water supply and drainage, minerals, settlement, and improvements, will be supplied at the conclusion of the subdivisional notes.

**557.** The record of the names of the assistants and the certificates of the engineer and of approval will take the forms given in the specimen field notes.

## SPECIMEN FIELD NOTES

**558.** In the specimen field notes (appendix VIII) there are shown the several forms of description of the approved types of corner monuments. The types that are employed ordinarily are given prominence, but those that are used in exceptional circumstances are included in order to supply a form of description. The indicated departures from the usual type of monumentation (iron post corners) are not to be construed as an authorization to disregard the standard practice which is outlined in chapter IV.

In the specimen field notes some page headings are shown in italics in order to conform with printing style, and in the paragraph entries which give the descriptive calls along the lines surveyed the second and following lines are indented one space to conform with printing style; the italics as mentioned will not be indicated in the typewritten field notes, nor will the indentation referred to be made. Descriptions of bearing trees and other accessories will be indented as indicated. In the ordinary descriptive style as printed the proper names of the principal meridians are not capitalized unless abbreviated. In tabulations no period is shown after an abbreviation if the latter is followed by a leader. Such differences in printing from the approved typewritten style employed in writing field notes are noted here as unavoidable.

**559.** Other specimen field notes as needed to show the miscellaneous forms of record which relate to the general and specialized class of surveys and resurveys to be found in the usual work of a surveying district will be supplied by the regional or public survey office. A liberal assortment of such specimen field notes, with their accompanying plats, all carefully considered, should be at hand for reference purposes.

**560.** The specimen field notes are carried in Manual Appendix VIII, beginning on page 523; the appropriate graphic indexes are supplied on pages 525 and 543.

# Chapter IX

# PLATS



## THE IMPORTANCE OF THE PLAT

**561.** The term "*plat*," as employed technically, refers to the drawing which represents the lines surveyed, established, retraced, or resurveyed, showing the direction and length of each of such lines; the relation to the adjoining official surveys; the boundaries, description, and area of each parcel of the land; and, as far as practicable, a delineation of the topography of the region, including a representation of the culture and improvements within the limits of the survey. The purpose of the plat and its relation to the survey have been pointed out in sections 193, 194, and 210, chapter III. Upon acceptance of the survey by the Director, Bureau of Land Management, it may be termed officially established or completed, and accordingly it does not attain official or legal status until thus completed.

**562.** The importance, and legal significance, of the plats and field notes is set out in *Alaska United Gold Mining Co.* v. *Cincinnati-Alaska Mining Co.*, 45 L. D. 330, 336 (1916), as follows:

> 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 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 were

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 to be deemed surveyed or identified until approval of the survey and filing of the plat thereof in the district land office by direction of the Bureau of Land Management (*United States* v. *Cowlinshaw,* 203 Fed. 317 [1913]), and no subdivisions are to be "disposed of" until so identified, *United States* v. *Hurlburt,* 72 Fed. (2d) 427, 428 (C. C. A. 10, 1934).

**563.** Ordinarily an original survey of public lands does not *ascertain* boundaries; it *creates* them. Hence, the running of lines in the field and the laying out and platting of townships, sections, and legal subdivisions are not alone sufficient to constitute a survey. Until all conditions as to acceptance have been complied with, the public lands are to be regarded as unsurveyed. It follows that although a survey may have been physically made, if it be disapproved by the duly authorized administrative officers, the public lands which were the subject of the survey are still to be classed as unsurveyed. In other words, a survey does not become official until it is accepted by the Director.

**564.** The subdivisions are based upon and are defined by the monuments and other evidences of the controlling official survey, and so 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.

**565.** 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.

**566.** 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 to those sections.

Latitude and longitude, sections 47 and 73.
Retracements that require platting, section 160.
Amended monuments to be platted, section 163.
Direct tie, computed from traverse to be platted, section 190.
Subdivision of sections to be protracted on plat, section 193.
Lots and some 40-acre subdivisions to be shown, section 196.
Protractions against segregated areas, section 197.
Size and shape of lots, section 198.

Numbering of lots, section 199.
Lotting elongated sections, section 200, 498.
Lots adjoining defective south and east boundaries, section 201.
Subdivision of sections, section 205, 206, 208, and 210.
Lots adjoining defective boundaries, section 212 and 213.
Protraction of outlying areas, section 214.
Completion of partially surveyed sections, section 216.
Lottings resulting from fragmentary surveys, section 224.
Platting meanders, section 229.
Showing of tie to A. M. C. and outline of artificial bodies of water, section 232
Platting of islands, section 233.
Summary of items to be shown, section 236.
Witness corner to be shown on plat, section 254.
Adjustment of broken boundaries, section 380, 381.
Memorandum on plat of independent resurvey, sections 401, 448, 449, 450, and 460.
Memorandum on plat of dependent resurvey, section 425.
Conformed entries and conflicts to be shown on plat, section 445 (pars. 5 and 6), see figure 90.
Showing of claims on plat of an independent resurvey, section 448.
Showing of topography on plats of independent resurveys and metes and bounds, section 451.
Resurvey lottings, no duplication, sections 455 and 456.
New lots adjacent to meanders, section 471.
Townsite plats, sections 477, and 481 to 488, inclusive.
Lot numbers in sections partially surveyed, section 494, paragraph 9.
Lots in elongated sections, section 498.
Plats of omitted lands, sections 516 to 518, inclusive.
Plats of accretion, section 519.
Showing of swamp land on plats, section 534, par. 7.
Abbreviations on plats, section 550.

## SPECIMEN TOWNSHIP PLAT

**567.** This is a revision of the specimen township plat which accompanied the Manual of 1930. See Insert No. 1. An effort has been made to secure maximum clarity of the essential features of the survey with a standardization of the lettering which refers to section numbers, lot numbers, areas, and lengths and directions of lines, in suitable styles and gages, all in conformity with relative importance. The style of lettering which has been selected is intended to combine the greatest possible simplicity of execution with minimum liability of loss of definition in reproduction.

**568.** There has been added the detail of lengths of lines pertaining to fractional subdivisions in order to reveal the basis of the computation of all areas in harmony with the plan of subdivision of each section as shown. The distances noted in parentheses are those regular and fractional portions of lines which constitute the boundaries of the quarter-quarter sections and fractional subdivisions bounded thereby; the parentheses are employed where the record is not supplied by the field notes; the lengths indicate what was used in the calculation of areas. The same lengths are to be adopted proportionately whenever there is a need for an establishment of sixteenth-section corners on the section boundaries, and for control points for the subdivision of sections. See Insert No. 1.

**569.** Most township plats are in reality 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 thereon. The base drawing will always be 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. It is intended that the arrangement of data on all base drawings be made as nearly uniform as possible and in harmony with the specimen drawing (Insert No. 1), subject only to the need for modification where irregular lottings are made. Section 190 gives the practicable plan for relating patented irregular tracts to the rectangular system as a basis for their segregation. A variety of conditions are presented where the tracts are numerous, particularly where there is a network of patented mineral surveys to be segregated. The important plat feature in this connection is the resulting fractional lottings and for this purpose it is generally unnecessary to show the courses and distances of the boundaries of the mineral surveys or their connections, a mere outline as shown on the specimen township plat being sufficient. Frequently this will permit their complete showing on the base drawing.

Occasionally it is feasible to letter the number and name of each claim on the base drawing but 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 will be shown on the face of the drawing. Where by reason of the number of mineral surveys to be segregated, large scale drawings on additional sheets are required for any or all of the sections invaded, no outline of the mineral surveys will be shown on the base plat for the sections involved but a marginal reference will be made on the base drawing calling attention to the sheets upon which the segregations in the various sections will be found. In many instances an enlarged diagram on the base plat will obviate the necessity for additional sheets. Figure 81 is an example of a drawing which should be shown as an enlarged diagram on the base plat.

**570.** Transparent color overprints will be 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

**571.** 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 ratio unit such as 1/31680 and the bar or graphic scale stating only the unit of measurement will be shown on all plats. The size of the sheets will always be made 19 x 24 inches, regardless of the scale or area to be shown; this is important on account of the need for uniformity in the dimensions of filing devises. A borderline rectangle 16½ x 20 inches is right for the normal township plat; the size of the rectangle may be varied slightly when necessary. Generally the drawing will be 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.

**572.** The plat subject should be compiled or laid out with a good grade, medium hard drawing pencil, one which will make a clean mark, but not so hard that it will engrave the lines.

**573.** The township will be drafted as a plane, without allowance for reduction from the spheroid, as is required in the making of small-scale topographic maps showing large areas. All *regular* townships may be laid out as a rectangular grid, with allowance for fractional measurements along the north tier and west range of sections.

**574.** In the case of *irregular* townships, or those containing meanderable bodies of water, 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.

**575.** Elements of triangulation figures and offset lines will not be shown on the plat when the field procedure results in duly ascertaining, indirectly, the course and length of the line sought to be established. Such diagrams should be shown in the field notes if needed for a clear understanding of the procedure, but are not required on the plat.

**576.** Plats of entire townships will show the complete condition of all exteriors, including all closing and standard township and section corners, with connecting courses and distances (fig. 80). The connecting courses and distances will be omitted in those cases where the scope of the work is not sufficient to determine the relationship accurately. A line common to two townships will be drawn with equal completeness for both, as far as approved surveys will permit. The relative position of and the data for nearby corners of one or two townships and closing township corners, if established, will be shown. Corners of maximum control will be shown only as referring to the subdivisional survey on that plat. Separate diagrams of township exteriors are not required when the townships are subdivided.

**577.** A township adjacent to or invaded by the boundary of a State, or a surveyed reservation or private land grant, will have the boundary properly lettered, and the mile posts and connecting distances shown.

**578.** Where only a portion of a township is being surveyed, the condition of the adjacent areas will be shown clearly by words lettered thereon, such as "Unsurveyed," "Rancho San Luis," "Surveyed by John Smith, 1877," or "Waste Lava Bed".

**579.** On plats of fragmentary surveys, areas previously surveyed will not have the sections and lots drawn in blank unless needed to show the relation of the old and new work along the common boundary.

**580.** The line of demarcation between areas previously counted in the total acreage surveyed and the new surveys will be distinctly shown. A light diagonal shading with black ink on the side previously surveyed is recommended to distinguish such a line.

**581.** Each regular section will show the center lines only and the area as 640 acres. In all other sections where lottings are required, each subdivision must be distinctly shown. Where a section contains one or more fractional lots, its regular parts will show the usual areas as 40, 80, or 160 acres; the fractional lots will each show the

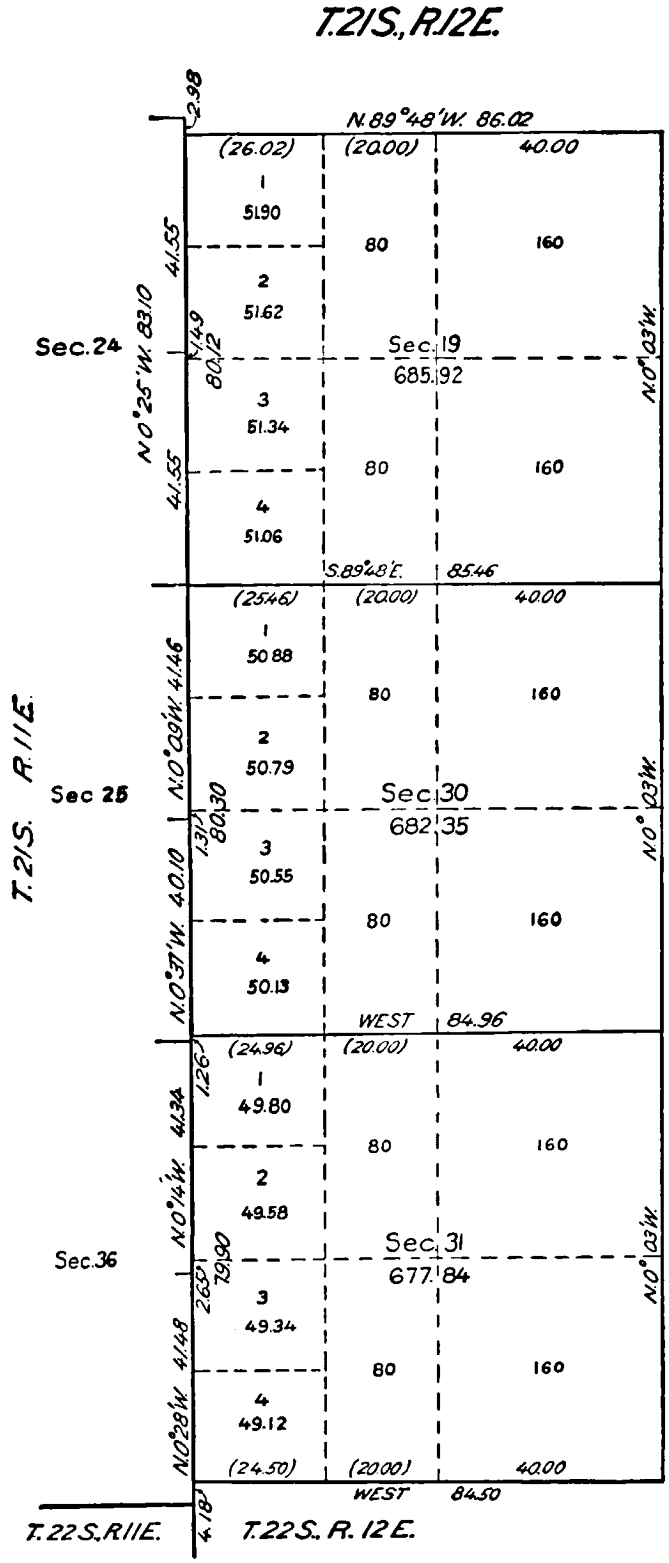



FIGURE 80 —Two sets of corners on an irregular township boundary

**The directions and distances along a line common to two townships will be shown with equal completeness for both, as far as approved surveys will permit**

assigned lot number and quantity computed to the nearest 1/100 of an acre. The total area of public land within each irregular section will be shown as equal to the sum of the several parts, as identified by the plat, and disregarding parts omitted.

**582.** The complete technique of laying out the regular and fractional subdivisions of sections and the designations of the same by reference to aliquot parts and serial lot numbers is covered by sections 193 to 233, inclusive, chapter III.

**583.** With reference to plats which are to show the completion of remaining parts of sections not previously surveyed, particularly in regard to sections where parts have been shown as outlying areas protracted as surveyed (secs. 214 to 222, inclusive, ch. III), it is the practice, where irregular conditions are found on the ground and no entries have been made, to effect an annulment of the showing on the former plat. The special instructions should provide that such unentered, protracted subdivisions need not be protected, thus simplifying the execution and platting of the new surveys.

## COMPUTATION OF AREAS

**584.** The deficiency in area which results from the convergency of meridians is placed normally in the fractional lots adjoining the west boundary of the township. Here sections 7, 18, 19, 30, and 31, each usually contains lots 1 to 4, inclusive, whose meridional dimensions are all an even 20.00 chains; the dimensions of the latitudinal boundaries of these lots are computed proportionately from the fractional measurements ascertained on the section lines. The area, in acres, of each lot is then found simply by adding the lengths, in chains, of its north and south boundaries.

**585.** For example, taking section 30, shown on the specimen plat, the dimensions of the latitudinal boundaries, and the areas are found as follows:

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| N.............. | 18. 21 | 18. 245 | 18. 28 | 18. 315 chs. |
| S.............. | 18. 245 | 18. 28 | 18. 315 | 18. 35 " |
| | 36. 455 | 36. 525 | 36. 595 | 36. 665 acres |
| | 36. 45(+) | 36. 53(−) | 36. 59(+) | 36. 67(−)" |

**586.** The areas of lots 5, 6, and 7, section 6, are ascertained similarly, making due allowance, when calculating the length of the north boundary of lot 5, for any material variation from 20.00 chains in the *meridional* dimension of lot 4.

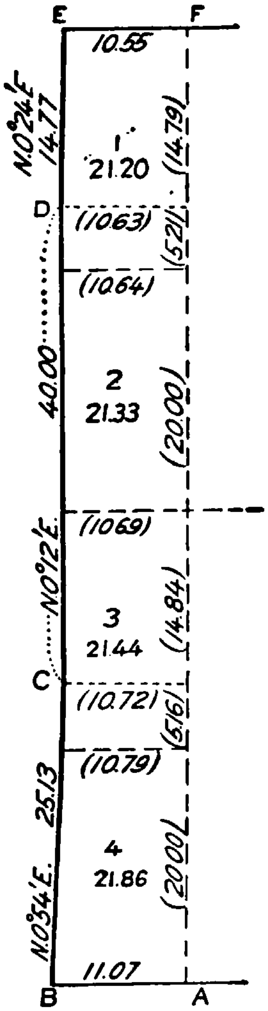
**587.** The surplus or deficiency in area which results from the discrepancy in the meridional measurements between the exterior boundaries and the subdivisional lines is placed normally in the fractional lots adjoining the north boundary of the township. Here sections 1 to 5, inclusive, each usually contains lots 1 to 4, inclusive, whose dimensions on their latitudinal boundaries are all treated as an even 20.00 chains; the meridional dimensions of these lots and their areas are computed on the plan heretofore described for the fractional lots adjoining the west boundary of the township.

**588.** The areas of lots 1, 2, and 3, sec. 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, sec. 6, in acres, may be ascertained by taking the product of its mean dimensions in chains, divided by 10.

**589.** The following is an example of ascertaining the areas of the fractional lots in sec. 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 | " |
| | 40.087 | 40.061 | 40.035 | | acres |
| | 40.09 | 40.06 | 40.03 (+) | | " |
| | | | | 20.005 | mean |
| | (5) | (6) | (7) | | |
| N | 17.78 | 17.81 | 17.84 | 17.75 | chs. |
| S | 17.81 | 17.84 | 17.87 | 17.78 | " |
| | 35.59 | 35.65 | 35.71 | | acres |
| | | | | 17.765 | mean |
| | $2.0005 \times 17.765 =$ | | | 35.539 | acres |
| | | | | 35.54 | " |

**590.** For purpose of computation of areas, where three sides of a section are regular and only one side irregular, the irregular boundary may be treated as a straight line if there is no break in alinement in that boundary in excess of 21′ of arc; in such sections, if the field notes show that the cardinal length of the irregular boundary is within the usual limit of 50 links in 80.00 chains, the regular dimensions will be treated as having values in multiples of 20.00 chains. In the event that portions of the irregular boundary differ in course by more than 21′ of arc, the break in alinement will be recognized and such adjustment of the lengths of lines which form the basis for the computation of the areas will be made as to bring all dimensions to a proper closing with the field measurements, taking into consideration the direction of the opposite governing boundary with respect to the areas of the regular portions of the section. The elements which enter into the computation of the areas will be derived from the balanced closure.




**591.** Example, figure A–B–E–F. As the section is otherwise regular, the areas of the E½ and E½W½ are based on the assumption that the line A–F is 80.00 chains in length and parallel to the governing east boundary, disregarding the allowable error in closure. The lengths of the lines A–B and E–F are given by the field measurements: the intervening dimensions are obtained by the following calculations:

| | | N. | E. | W. |
|---|---|---|---|---|
| Westing A–B | | | | 11.07 |
| | | (.03) | | |
| N.0° 54′ E | 25.13 | 25.13 | .39 | |
| | | (.05) | | |
| N.0° 12′ E | 40.00 | 40.00 | .14 | |
| | | (.02) | | |
| N.0° 24′ E | 14.77 | 14.77 | .10 | |
| Easting E–F | | | 10.55 | |
| | 79.90 | | | |
| Add to B–E | .10 | | | |
| | | 80.00 | 11.18 | 11.07 |
| | | | 11.07 | |
| Line A–F | | 80.00 | .11 | |

| | N. | | E. | | W. | | | |
|---|---|---|---|---|---|---|---|---|
| Line A–B | | | | | 11.07 | 11.07 | | S. bdy. lot 4. |
| Line B–C | 20.00 | | .31 | | | −.31 | | |
| | | | | | | +.03 | .03 | For line A–F. |
| | | | | | | 10.79 | | S. bdy. lot 3. |
| | 5.16 | | .08 | | | −.08 | | |
| | | | | | | +.01 | .01 | For line A–F. |
| | | 25.16 | | .39 | | 10.72 | | Lot 3 at C. |
| Line C–D | 14.84 | | .05 | | | −.05 | | |
| | | | | | | +.02 | .02 | For line A–F. |
| | 20.00 | | .07 | | | 10.69 | | S. bdy. lot 2. |
| | | | | | | −.07 | | |
| | | | | | | +.02 | .02 | For line A–F. |
| | | | | | | 10.64 | | S. bdy. lot 1. |
| | 5.21 | | .02 | | | −.02 | | |
| | | | | | | +.01 | .01 | For line A–F. |
| | | 40.05 | | .14 | | 10.63 | | Lot 1 at D. |
| Line D–E | | 14.79 | | .10 | | −.10 | | |
| | | | | | | +.02 | .02 | For line A–F. |
| Line E–F | | | 10.55 | | | 10.55 | | N. bdy. lot 1. |
| | | 80.00 | 11.18 | | 11.07 | | .11 | |

The areas are then computed as follows:

Lot 1: 10. 55
10. 63

21. 18×14. 79=313. 25

10. 63
10. 64

21. 27× 5. 21=110. 82

424. 07 to be divided by 20
= 21. 20 acres.

Lot 2: 10. 64
10. 69

=21. 33 acres.

Lot 3: 10. 69
10. 72

21. 41×14. 84=317. 72

10. 72
10. 79

21. 51× 5. 16=110. 99

428. 71 to be divided by 20.
= 21. 44 acres.

Lot 4: 10. 79
11. 07

=21. 86 acres.

**592.** In all 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."

**593.** In order to proceed with a computation by double meridian distances, the closing error of the figure is first to be eliminated, or the traverse of its boundary to be balanced, by the most applicable rule. The general rule is that the correction to be applied to the $\begin{Bmatrix}\text{latitude}\\ \text{departure}\end{Bmatrix}$ of any course is to the total error in $\begin{Bmatrix}\text{latitude}\\ \text{departure}\end{Bmatrix}$ as the length of the course is to the perimeter of the figure. Another method of balancing the closing error will be applicable if the purpose is to apply a uniform correction to the directions and lengths of lines. Section 381.

The double meridian distances of the several courses, or D. M. D's are then computed by the following rules:

(1) The D. M. D. of the first course equals the departure, or the increment in easting or westing, of the course itself;

(2) The D. M. D. of the second course, and each of the succeeding courses in turn, is ascertained by taking the D. M. D. of the preceding course, plus the departure of the preceding course, plus the departure of the course itself; and,

(3) The D. M. D. of the last course is numerically equal to its departure, but with opposite sign, thus verifying the value of each preceding D. M. D.

For convenience in making the computations, the differences in $\begin{Bmatrix}\text{latitude}\\ \text{departure}\end{Bmatrix}$ to the $\begin{Bmatrix}\text{north}\\ \text{east}\end{Bmatrix}$ are treated as of positive sign, to the $\begin{Bmatrix}\text{south}\\ \text{west}\end{Bmatrix}$ as of negative sign. The point of beginning is taken at the westernmost salient of the figure, and the direction of the traverse is run counterclockwise. On this plan each D. M. D. and the algebraic sign of the final result are of positive sign.

The next step in the process is to multiply the latitude of each course by the double meridian distance of the course; the positive products are arranged in a column for "north areas," and the negative products in a column for "south areas." The sum of the negative products is to be subtracted from the sum of the positive products. The area, corresponding to the unit of measurement that is employed, is ascertained by taking one-half of the last result. Where the unit of measurement is the chain, the area in square chains is to be divided by 10 to give the area in acres.

The field closing sheets may be readily adapted to the calculation of areas by the method of double meridian distances; two examples follow:

**594.** Tabling and calculations of T. 15 N., R. 20 E., Diamond Rock, in Lins Lake, in section 18:

| No | Course | Distance | Latitudes: North | Latitudes: South | Departures: East | Departures: West | D. M. D's | N. areas | S. areas | Totals: Lat. N | Totals: 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 | +.005<br>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 | | | 2.62 | 7.70 | 17.86 | | 10.785 | 22.10 |
| 2 | S. 61° 15′ W | 2.90 | | 1.395 | | 2.54 | 2.54 | | 3.54 | 9.39 | 19.56 |
| 1 | S. 16° 30′ E | 2.70 | | 2.59 | .77 | | .77 | | 1.99 | 6.80 | 20.33 |
| | | | 4.165 | 4.165 | 5.155<br>.005 | 5.16 | | 34.69<br>6.38 | 6.38 | | |
| | | 14.49 | 4.165 | 4.165 | 5.16 | 5.16 | | 28.31 | Double area. | | |

Begin total lats. and deps. at M. C. on W. bdy. sec. 19, for purposes of platting.

Numbering of courses as taken from field notes, order reversed to counterclockwise.

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.

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.

**595.** Tabling and calculations of T. 15 N., R. 20 E., right bank of Yellowstone River, in section 25:

| No | Course | Distance | Latitudes: North | Latitudes: South | Departures: East | Departures: West | D. M D's | N. areas | S. areas | Totals: Lat. N | Totals: Dep. E. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | S. 0°01′ E | 5.36 | | 5.36 | 0.00 | | 0.00 | | | 0.00 | 0.00 |
| | S. 89°56′ E | 79.96 | | .09 | +.04<br>79.96 | | 80.00 | | 7.20 | −.09 | 80.00 |
| | North | 23.20 | 23.20 | | | | 160.00 | 3,712.00 | | 23.11 | 80.00 |
| 1 | S. 85°00′ W | 13.00 | | −.01<br>1.13 | | +0.01<br>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 |
| 3 | S. 64°30′ W | 13.00 | | −.01<br>5.60 | | +.01<br>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 |
| 5 | S. 77°45′W | 7.00 | | −.01<br>1.49 | | 6.84 | 83.24 | | 123.20 | 8.62 | 38.20 |
| 6 | N. 76°00′ W | 7.40 | +.01<br>1.79 | | | 7.18 | 69.22 | 124.60 | | 10.42 | 31.02 |
| 7 | S. 80°00′ W | 12.00 | | −.01<br>2.08 | | 11.82 | 50.22 | | 103.96 | 8.35 | 19.20 |
| 8 | S. 81°08′ W | 19.43 | | −.01<br>3.00 | | +.01<br>19.19 | 19.20 | | 57.41 | 5.36 | 0.00 |
| | | | 24.99<br>+.01 | 25.05<br>−.05 | 79.96<br>+.04 | 79.97<br>+.03 | | 3,836.60<br>1,728.37 | 1,728.37 | | |
| | | 84.33 | 25.00 | 25.00 | 80.00 | 80.00 | | 2,108.23 | Double area. | | |

Begin traverse and D.M.D's at M. C. on W. bdy. of sec. 25.
Begin total lats. and deps. at point for S. 1/16 sec. cor. on W. bdy. of sec. 25, for purposes of platting.
Numbering of courses as taken from field notes.

1,054.11 Square chains.
105.41 Acres, sum of lots 5 to 8, incl.



700004°—47——27

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<br>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<br>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<br>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<br>63.30 | 63.30 |
| | | | | | | | | 277.10 | |
| | | | | | | | | 13.85 | Lot 8 |

## INKING THE DRAWING

**596.** The best *black* drawing ink should always be employed, and the ink should never be diluted. The drafting work should be sharp and clear, uniform in density of color, and the lettering standardized as to gage and style. It is important to bear in mind that if the drafting is done with a diluted ink or otherwise left gray in appearance, it will be lost in varying degrees during the process of reproduction.

**597.** The drafting work should be *open*, making reasonable allowance for needed separation of detail. This will help to avoid a tendency for work to close across narrow spaces during reproduction. Where necessary, the detail of improvements, works, or structures should be discontinued in order to avoid overlapping or obscuring the more essential features of the plat. The arrangement of some of the more minute data on the specimen township plat illustrates the minimum to which the work may be condensed safely. Attention is directed to the space allowed between the lettering and the adjacent lines; this is never less than the space between the upper two points of the gage for the lettering; this is the rule where the drawing is to be reproduced at the same scale; proportionately more space should be allowed on special drawings where a reduction of scale is to be made on reproduction. The same safeguards should be applied in spacing the adjoining letters, and it will be noted that the spacing between letters bears a definite relation to the gage employed.

**598.** An experienced draftsman will endeaver to keep the drawing as clean as possible, so as to avoid needless erasing. A cover sheet, with an opening, is recommended. The sharp, black lines must be preserved in their original clear-cut effect, or else, unless carefully retouched, there will follow a certain loss in the process of reproduction. If uniformity is lacking, such as a mixture of heavy and pale letters and figures or a varying degree of density, the photographing has a tendency to exaggerate the differences and the reproduction will be unsatisfactory. Sections 567 and 596.

## LETTERING

**599.** Generally all letters and figures are drafted in the pure Gothic, or simple block style. In the smaller gages the letters and figures are drawn as single lines; it is ordinarily called single-stroke lettering. In the larger gages double parallel lines are required, usually made by single stroke, after which the form is filled in. The same gages and similar styles will be selected if lettering devices are employed. If the lettering is accomplished by direct type impression or by the stick-up process with type printing on adhesive cellophane, corresponding sizes will be used.

**600.** The following table shows the usual styles and sizes to be followed in preparing a plat on the usual scale of 1 inch equals 40 chains; the gage is stated in tenths of a millimeter and the number of the guide refers to thousandths of an inch.

| Class | Gage | Guide | Style |
|---|---|---|---|
| Title | 60 | 240 | Vertical, caps. |
| Subtitle | 40 | 175 | Vertical, caps, or cap. and l. c. |
| Sections | 20 | 120 | Vertical, cap. and l. c. |
| Total areas | 15 | 100 | Vertical. |
| Lot numbers and areas, usually | 12 | 80 | Do. |
| Proper names of land objects, towns, works structures and tabular data. | 20–10 | 120–80 | Vertical, caps, or cap. and l. c. |
| Proper names of water areas and streams | 20–10 | 120–80 | Slanting, caps, or cap. and l. c. |
| Directions and lengths of lines and other technical data. | 15–10 | 90–80 | Slanting, caps. |
| Explanatory notes, kinds of timber and similar data. | 15–10 | 90–80 | Slanting, cap. and l. c. |
| Certificates | 15 | 90 | Do. |

**601.** At this stage of the drafting work attention should be given to the showing of the directions and lengths of all necessary connecting lines, in addition to the data which ordinarily appears on the

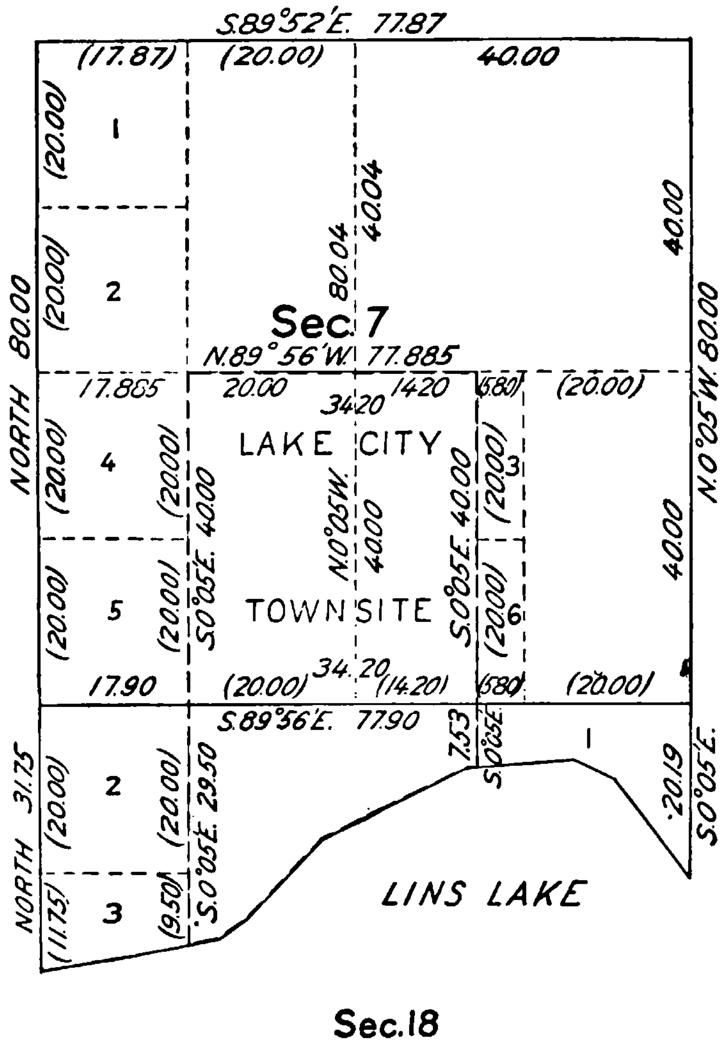



FIGURE 81.—Enlarged diagram. Boundaries of Lake City town site.

section boundaries. The requirements are set out in sections 163, 190, 232, 233, and 254, chapters III and IV. Additional sheets, drawn to a larger scale, are employed in order to show the detail of complicated situations. Section 569.

## TOPOGRAPHY

**602.** Coming now to a consideration of the *map features* of the plat, it is thought best to point out first that generally only the most essential topographic data need be shown upon the plat. All classes of topography are encountered in practice. Some plats may not require the showing of any topography, others may require the showing of many different features, where the drawing in addition to being a plat may be a complete topographic map. Whatever may be the requirements of the situation, it is intended that the important map features be delineated by the standard symbols adopted by the Board of Surveys and Maps of the Federal Government.[1] A summary of what is required is contained in section 236, chapter III.

**603.** In the preparation of the drawing the first question to be considered, after the completion of the base and before adding the topography, is how the important map features are to be shown without obscuring the base data. In simple cases all work may be done readily in black ink on the base drawing. In the difficult cases several overprints in transparent colors may be required. Good judgment should be exercised regarding what is essential, and how the essential things may be shown without unwarranted cost.

**604.** If the situation requires a transparent overprint of a certain conventional color all of the group of map features which are usually shown in that color will be included. The specimen plat is intended as an example where all map features, with the exception of certain improvements, works, or structures are shown in conventional transparent overprints.

**605.** Where colors are not required, as in the more simple cases, all map features or groups of features will be delineated upon the base drawing in black ink, following the conventional symbols, and with the exercise of the greatest care that the map features do not interfere with or overlap, or too closely approach the base data. In

[1] Standard symbol sheet may be obtained from the Director, U. S. Geological Survey, Washington 25, D. C.

all such simple cases the topography will be shown as in the following outline:

### Simple Drawings, All Black

| | |
|---|---|
| Low relief | Black hachure. |
| Wagon roads and highways | Black lines, parallel. |
| Pack trail | Black line, broken. |
| Culture | Black pattern. |
| Alkali flats | Black depression-contour and pattern. |
| Sand dunes | Black pattern. |
| Water surface, large rivers and lakes | Black meander line, without water lines. |
| Minor drainage | Black line, or broken line and dots. |
| Wide sandy bottomed draws | Black pattern. |
| Ponds | Do. |
| Marsh | Do. |
| Timber | Black pattern or marginal note. |

**606.** Where groups of important map features are extensive or complicated, or are of such a character that it is impracticable to execute the drawing in black without detriment to the base, transparent overprints will be employed as shown in the following outlines:

### Brown Overprint

| | |
|---|---|
| Low relief where important, and all heavy relief | Brown hachure. |
| Wagon roads and highways | Brown lines, parallel. |
| Pack trail | Brown line, broken. |
| Culture | Brown pattern. |
| Alkali flats | Brown depression-contour and pattern. |
| Wide sandy bottomed draws | Brown pattern. |
| Sand dunes | Do. |

### 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 | Do. |

### Green Overprint

| | |
|---|---|
| Timber on level and gentle slopes | Green pattern. |
| Timber on steep slopes | Kind, lettered in black, or green pattern (to be transferred from a special overlay.) (See secs. 608, 609, 612, and 616.) |

**607.** In making the drawing, where overprints are required, separate sheets are employed, known as overlays, upon each of which will be drawn in *black ink* all natural features which are to be shown by overprint in the same color. It is important that these sheets be of the same quality, well-seasoned drawing paper as that used for the base, using the same exact scale and making provision for exact "register" when combined with the base drawing.

Before cutting large sheets of drawing paper the draftsman should mark parallel pencil lines on each unit to be cut, on the proper face, and thereafter execute all work on the face of the paper, and see that companion sheets are not turned at right angles. This will avoid much trouble in registration of companion sheets through unequal expansion or contraction due to moisture conditions or changes of temperature.

**608.** Usually it will be best to transfer the section boundaries accurately from the base drawing to the overlay, by carefully pricking through, then showing the lines in pencil only, excepting that for purposes of assembling the positions of a few section corners should be indicated by very short intersecting fine black lines. The township corners and the center point of the township will generally serve best for purposes of registration. Additional points may be employed if the work is complicated. The several groups of map features as may suit the situation will then be drawn on the overlay, all to be in black ink.

Each color employed requires a separate overlay.

**609.** Generally the description of the timber throughout the township may be covered by a marginal note but in cases where it is desirable to show the margin of the timber an overlay for green overprint will be required.

**610.** Ordinarily, the hachure is utilized to show abrupt changes in elevation within level and gently rolling regions, such differences as the eye would quickly note on the ground and readily follow. The hachure is also employed to show all important mesas, peaks, ridges, spurs, and heavy slopes, in such a manner as to portray the bold relief without attempting to show unimportant and minor detail. Only the most important slopes will be shown in a gently rolling country, and care will be needed in drafting to avoid giving a rolling mountainous region the appearance of abrupt or high mountainous slopes.

**611.** The blue overprint is intended where there are streams and lakes of importance, or where the drainage features, if shown in black, would tend to obscure the base, as where there are numerous lakes and streams, or extensive ponds or marshes to be shown in areas of swamp and overflowed lands.

**612.** The green overprint is intended for use only where distinctions must be shown between forested and nonforested areas and where the cost of the overprint is justified, as in the case of important forest areas.

## FIELD SKETCH

**613.** Preference should be given to the use of form lines on the field sketch plat to show relief. The form lines are intended to be approximate contours, but are largely sketched without an exact interval or precise elevation above sea level. The form lines carry a much better portrayal of relief than can be shown by the hachure alone, and readily indicate to the engineer and draftsman the position and outline of abrupt changes in slope and the extent of ascents and descents. The hachure is fundamentally dependent upon the approximate contour line for relative slopes and forms. All available data for elevation above sea level and extent of ascents and descents along the surveyed lines may be incorporated in the form-line sketch. Relief can be shown more readily and accurately by using the form-line method for field sketching. The draftsman will transfer the form lines to the overlay in pencil and then supply the artistic hachuring for the finished plat.

**614.** A well-executed and reasonably accurate field sketch plat is a necessity, if the draftsman is to obtain a representative result, and the engineer is expected to exercise good judgment in doing what is required in the field. A choice of methods is available for ascertaining the map data within the interior of sections, to be accomplished always with regard for the practical value of the work for the purpose of the plat and the economic manner of obtaining the data. The crest or divide forms, slope forms, stream or drainage lines, and meander lines of the larger bodies of water, together constitute the natural skeleton of the map, and when carefully drawn may be readily and correctly interpreted.

In areas where aerial photographs are available, copies will be secured and supplied with the field data. While the survey is in progress, connecting lines will be run to selected points in order to secure control for use of this highly important mapping information. Points that can be positively identified on adjoining pictures should be selected and a half dozen such points fairly evenly spaced along each flight across the township will afford ample control for laying out the section or other lines of the survey on the photographs.

The following statement, when applicable, will be placed on the plat below 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.**

612

**615.** The special instructions for each survey will outline any exceptional methods which are to be employed in the field in the ascertainment of the topographic data, and how the data are to be shown upon the field sketch or map, particularly where the situation requires special consideration, and where it can be foreseen that one or more groups of map features so predominate the situation that overprints will be required on the completed plat, as heretofore described. The field sketch becomes the draftsman's guide and, together with the field notes, the record to be followed. It suffices to state that such record should be truly representative of the situation on the ground, with an accuracy in its various details which will reflect the practical relative importance.

**616.** Occasionally, in connection with resurveys, for example, the development of the map data of the region may even precede other parts of the survey work, for its great value in making restorations of lost or obliterated corners, and for ascertaining the location of roads, improvements, and cultivated tracts upon patented and entered lands. Additional examples of the enlarged importance of the map features of the plat will be found in certain classes of surveys within Indian and forest reservations, coal fields, mineral areas, water-power sites, reservoir sites, irrigation projects, and other regions of relatively large prospective value. In these cases, which frequently embrace regions of extremely bold relief, coordinated cadastral and topographic surveys are made if and when deemed to be advisable for administrative purposes. The relief is shown by brown contour lines, and the timber by green pattern, as conventional for topographic maps.

**617.** The names of natural features will be correctly given according to accepted usage. Engineers are not authorized to report names of their own selection, but in case of doubt will submit the question through official channels for reference to the United States Board on Geographical Names.

## TITLE

**618.** Every plat will be given a title similar to that on the specimen plat. This shows the township, the principal meridian, and the State. Portions of townships showing original subdivisional surveys may usually be given the same title without confusion, and it is usually desirable to do so in order to identify the plat in the simplest possible manner. Where supplemental plats and fragmentary subdivisional surveys are necessary, and for all resurvey plats, some appropriate subtitle, to qualify the nature of the survey, is usually desirable. The subject is again referred to in sec. 668. The title and date of approval usually suffice to identify a plat; the subtitle, if employed, will explain the special purpose of the plat.

## MEMORANDA

**619.** A memorandum is required on each plat, intended to correlate and consolidate the record of the subsisting surveys so far as shown on that plat. This memoranda will have a wide variety of references. The simple form that is shown on the specimen township plat will be extended as required. The practice heretofore, on strictly original surveys, was to reduce this data to a box-form of tabulation; that form will be discontinued.

A conventional symbol is shown to indicate the line of the true meridian. The mean magnetic declination will be given as related to the southeast corner of the township, or the southeast point of the survey for areas less than the normal township. Sections 40, and 236, item 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 will be 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 seconds if the field notes give a tie to a geodetic station of known accuracy. Sections 47, 73.

Each plat of an original survey will carry 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 section 662.

The scale of the plat will be shown by the true fraction, also by bar-scale as a precaution for the interpretation of the scale in those cases where the plat may be enlarged or reduced on reproduction.

Other marginal or tabular data will be shown to facilitate the drafting and usefulness of the plat, as indicated in many sections of the Manual, always with due regard for *correct interpretation*. The following list will serve as a reference to those sections:

Retracement of prior surveys, section 215
Magnetic declination, section 236
Witness corners, section 254
Dependent resurvey, memorandum, section 425
Independent resurvey, conformation of claims, section 448
Independent resurvey, memorandum, sections 449, 450, 460
Townsites, monumentation, section 486

## CERTIFICATES

**620.** The executive duties pertaining to surveying the public lands is vested in the Director, Bureau of Land Management, under the direction of the Secretary of the Interior (R. S. sec. 453; 43 U. S. C. sec. 2). It is proper for the Director, acting under this authority, to specify how surveys shall be made and plats constructed.

**621.** Under the current plan of organization, the returns of surveys are prepared in the regional or public survey offices, and transmitted to the Director, Bureau of Land Management, by the regional administrator with recommendation for approval of the field notes and acceptance of the survey. The administrative details of the technical examination of the work prior to the approval and acceptance of surveys are prescribed by departmental regulations. 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

**622.** The usual practice is to secure a photolithographic edition of the plat with three copies printed on hard paper which are designated as the official original, duplicate, and triplicate plats. The original is transmitted to the proper regional or public survey office, the duplicate is retained in the Washington office, and the triplicate is transmitted to the proper district land office. A few copies printed on map paper are transmitted to the regional or public survey office and the remainder of the edition is retained in the Washington office for official use and to supply the public. The drawings from which the photolithographic edition is secured are returned to the proper field office.

**623.** 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 duplicates of the plat and field notes of such surveys are furnished to the proper State office, noted in section 10, chapter I.

**624.** The original, duplicate, and triplicate plats which are not reproduced by photolithographing will be distributed in the same manner as prescribed in section 622.

## SUPPLEMENTAL PLATS

**625.** 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.

**626.** 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.

**627.** All supplemental plats should show a proper reference to the former plat, the purpose of and the authority for its 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.

**628.** The new lots will be numbered as required in sections 199 and 224, Chapter III, and proper areas returned. The computation of the areas of the lots will be based upon the subsisting record. No revision of the total area within the section is required and generally there is no occasion for showing topography.

**629.** The revised lottings on supplemental plats resulting from the segregation of mineral surveys, as well as those resulting from mineral segregation surveys (section 504) will be confined to the subdivisions embraced within the pending entry as there is generally no way of foreseeing the scope of subsequent entries or additional segregations that may be made in the vacant areas.

**630.** 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 thus requiring the conversion of one of the units for platting purposes. Whenever the segregation of mineral claims is involved, except when shown in outline only on the base plat, the scale of the plat will be shown by a stated ratio and bar scales for both the foot and the chain units, but the values on the face of the drawing will be given in the chain unit only. Although both units are indicated, the use of one unit only is practicable for platting and scaling. Where the mineral surveys predominate, less conversion is required for the drafting and the finished plat lends itself more readily to scaling where the foot scale is used in the protraction even though values are expressed in chains.

**631.** The authority for the preparation of supplemental plats issues only from the Director, Bureau of Land Management. The specific purpose to be served and the details involved are included in the letter of authorization. In every instance the status of the surrounding subdivisions must be examined prior to authorization and care exercised that no changes are contemplated which will affect any adjoining entry or patent. If field work is necessary in order to prepare the plat, the regular procedure outlined for executing a resurvey will be followed.

**632.** The certificates of approval and acceptance will follow the arrangement shown on the specimen township plat and the memoranda will include the pertinent data involved in the preparation of the plat.

Following are examples for supplemental plats:

**633.** Illustration, figure 82.

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: Stated ratio (1/15840) and 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, based upon the plat approved October 8, 1880, is prepared to accommodate homestead entry Los Angeles 035503, in accordance with General Land Office instructions "E" dated April 20, 1945.

Certificate: Heading similar to that shown on the specimen township plat.

This plat, showing amended lottings, is based upon the official records and, having been correctly prepared in accordance with the regulations, is hereby accepted.

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*Director.*

**634.** Illustration, figure 83.

A modified lotting made subsequent to two forest homestead entry surveys, based entirely upon the public land and forest entry survey records on file in the Bureau of Land Management, Washington, D. C., and without additional field work.

Title: Township 5 South, Range 5 East, of the Black Hills Meridian, South Dakota. Subtitle: Supplemental Plat.

Scale: Stated ratio (1/7920) and bar scale in chains.

Memorandum:

This plat of sec. 15, Township 5 South, Range 5 East, of the Black Hills Meridian, South Dakota, based upon the plat approved May 23, 1899, showing amended lottings created by the segregation of forest homestead entry surveys Nos. 263 and 477, is prepared to accommodate additional homestead entry Pierre 024993.

Certificate:

UNITED STATES DEPARTMENT OF THE INTERIOR,
BUREAU OF LAND MANAGEMENT,
*Washington, D. C., November 23, 1946.*

This plat showing amended lottings, having been correctly prepared in accordance with the regulations, is hereby accepted.

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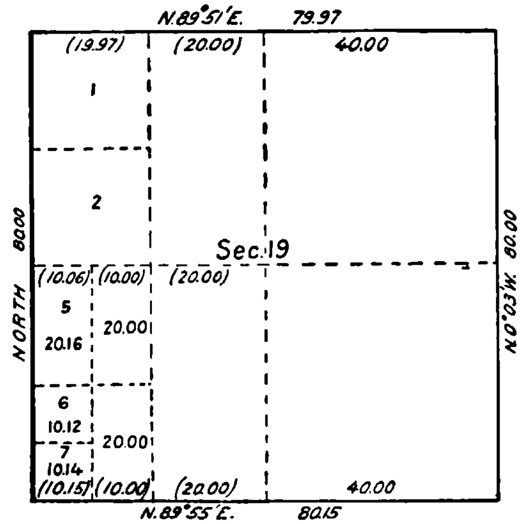
*Director.*

FIGURE 82.—Explanation on opposite page.



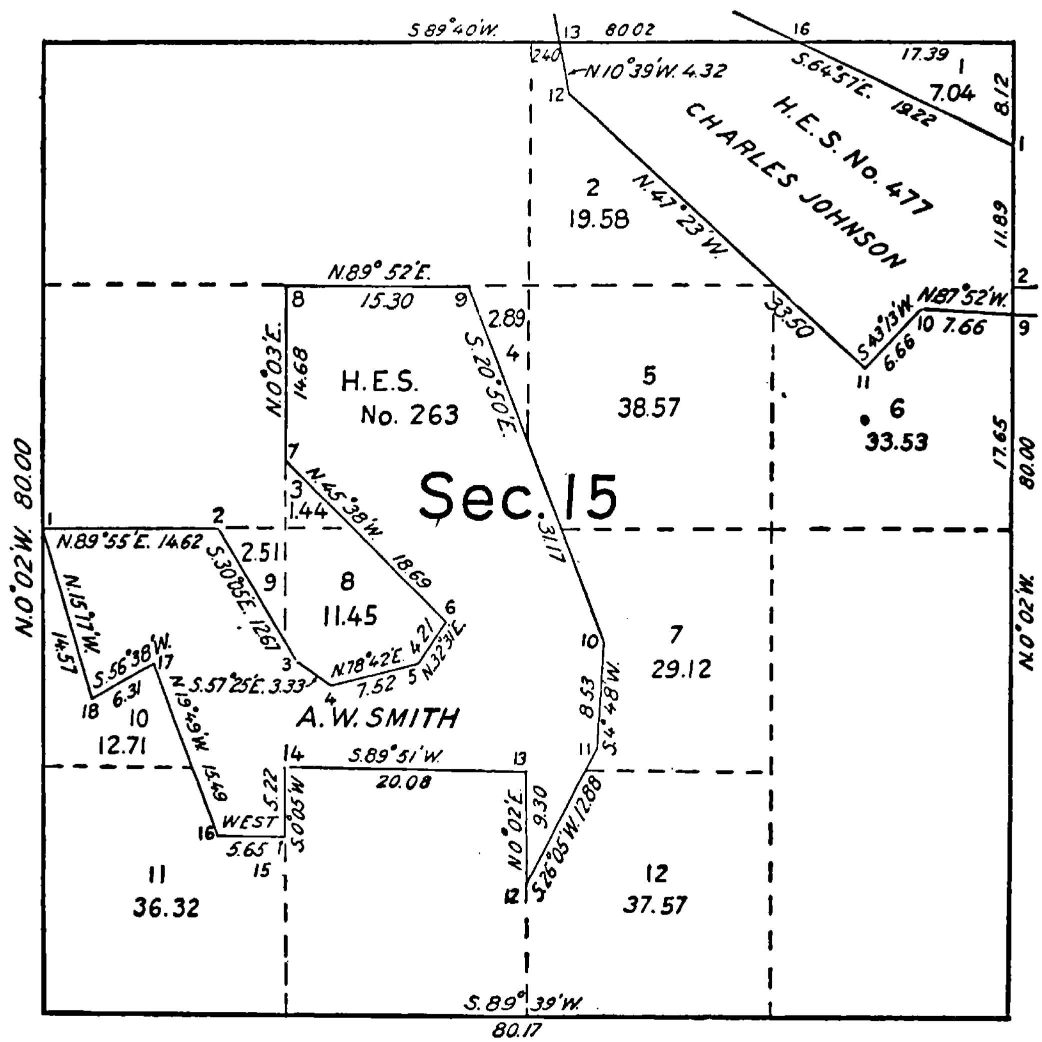




FIGURE 83.—Explanation on opposite page.

**635.** Illustration, figure 84.

Segregation of patented mineral claims, based entirely upon the public land and mineral survey records on file in the public survey office, and without additional field work. The data shown in parentheses along the boundaries of lots 2 and 3 are derived by calculation.

Showing one-half of original drawing.

Title: Township 13 South, Range 41 East, of the Willamette Meridian, Oregon. Subtitle: Supplemental Plat.

Scale: Stated ratio (1/7920) and bar scale in chains.

Memorandum:

This plat showing amended lottings created by the segregation of the Red, White, and Blue; Red, White, and Blue No. 4; Belfast; and Champion lodes of mineral survey No. 759 in sec. 29, T. 13 S., R. 41 E., W. M., Oregon, based upon the plat approved December 13, 1871, is prepared to accommodate homestead entry Vale 08873, in accordance with General Land Office instructions "N" dated April 12, 1945.

Certificate: Heading similar to that shown on the specimen township plat.

This plat, showing amended lottings, is based upon the official records and, having been correctly prepared in accordance with the regulations, is hereby accepted.

------------------------------
*Director.*

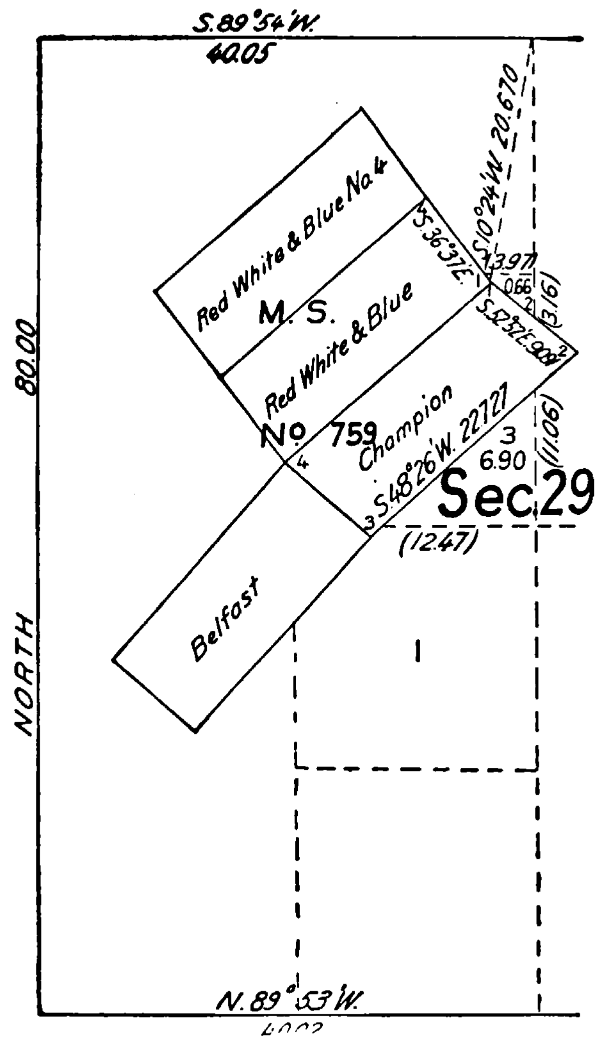



FIGURE 84.—Explanation on opposite page.



700004°—47——28

**636.** Illustration, figure 85.

Elimination of unpatented mineral claims, based entirely upon the public land and mineral survey records on file in the public survey office, and without additional field work. This is an amendment of a prior supplemental plat. The claims shown invade original lots 1, 2, 3, and 4; the same numbers were improperly duplicated on the supplemental plat approved February 6, 1904. Lots 4 to 11, inclusive, excepting lot 10, shown on the latter plat, all vacant, are eliminated and their areas are inclined in the amended lottings. However, since lot 1 is unentered public land it is assigned a new lot number with area in order to eliminate the duplication.

Showing one-half of the original drawing.

Title: Township 14 South, Range 81 West, of the Sixth Principal Meridian, Colorado. Subtitle: Supplemental Plat.

Scale: Stated ratio (1/7920) and bar scale in chains.

Memorandum:

This plat showing lottings restored to the status of vacant public land, caused by the elimination of the unpatented Hillerton and Vanadium placer claims covered by mineral surveys Nos. 439 and 440, in sec. 31, T. 14 S., R. 81 W., 6th P. M., Colorado, based upon the plats approved August 22, 1882, and February 6, 1904, is prepared to accommodate forest homestead entry Glenwood Springs 026705, in accordance with Bureau of Land Management instructions "N" dated September 8, 1946.

Certificate: Heading similar to that shown on the specimen township plat.

This plat, showing amended lottings, is based upon the official records and, having been correctly prepared in accordance with the regulations, is hereby accepted.

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*Director.*

636

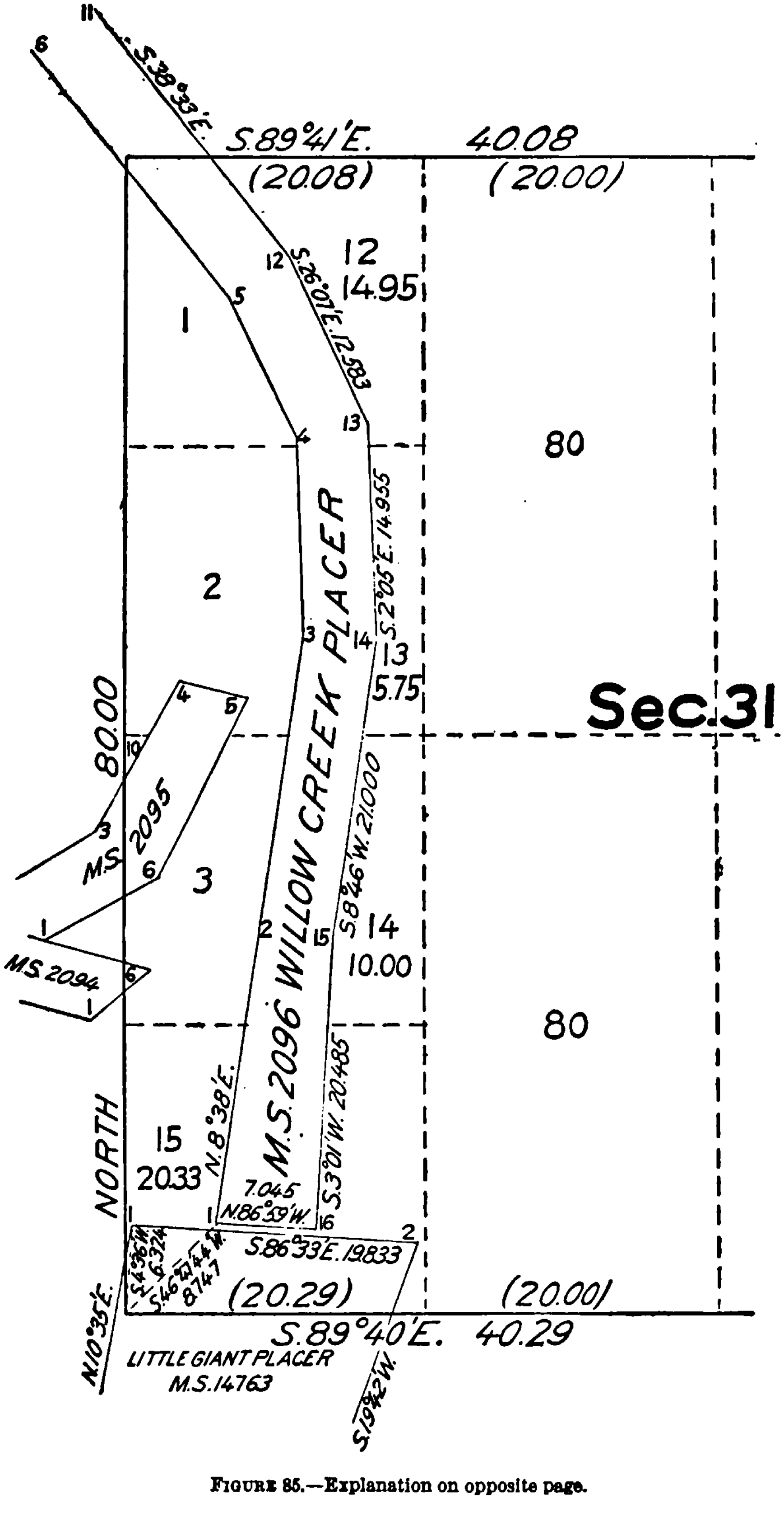


FIGURE 85.—Explanation on opposite page.

## PLATS OF MINERAL SEGREGATION SURVEYS

**637.** Plats of mineral segregation surveys are similar to supplemental plats that segregate patented mineral surveys but are based upon data obtained by a field survey rather than solely from office records. Consequently all field data must be shown and will be used in the computation of the amended lottings.

Such plats are also accepted by the Director, as indicated by the following examples.

Illustration, figure 86.

Segregation of patented mineral claim, including a resurvey of the section boundaries. Field work required to secure connecting line from the public land net to the location monument and other data for the accurate showing of the new lots.

Showing one-half of original drawing.

Title: Township 20 South, Range 10 East, of the Gila and Salt River Meridian, Arizona. Subtitle: Mineral Segregation.

Scale: Stated ratio (1/7920), bar scale in chains, and bar scale in feet.

Memorandum:

Dependent resurvey of section 24, and survey of connecting line to U. S. M. M. No. 6 for segregation of the Lillie lode of mineral survey No. 562, to accommodate indemnity school selection Phoenix 039024; executed by Roger F. Wilson, Associate Cadastral Engineer, December 20 and 21, 1946, under special instructions dated August 29, 1946, for Group 133 Arizona, authorized by Bureau of Land Management memorandum "E" dated August 8, 1946.

E. bdy. surveyed by Lewis Wolfley, D. S., in 1885, and subdivision by G. J. Roskruge, D. S., in 1886, as shown on the plat approved March 27, 1888.

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.

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*Director.*

637

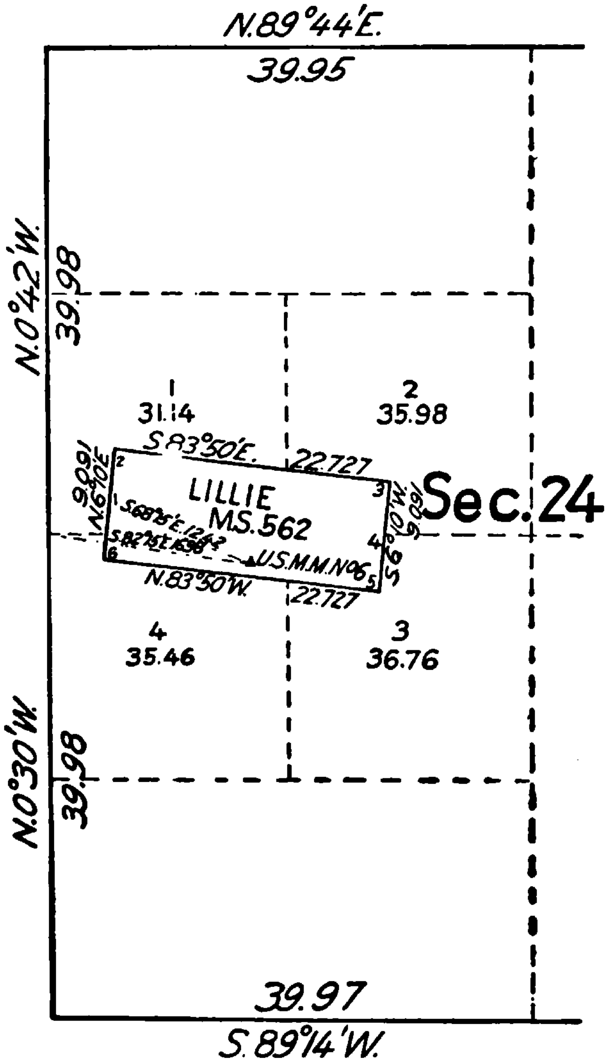


**Figure 86.—Explanation on opposite page.**

**638.** 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.

Showing one-half of original drawing.

Title: Township 21 South, Range 70 West, of the Sixth Principle Meridian, Colorado. Subtitle: Mineral Segregation.

Scale: Stated ratio (1/7920), 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, to accommodate homestead entry Pueblo 044617, executed by Roy E. Chase, Cadastral Engineer, October 7 to 12, 1946, inclusive, under special instructions dated September 14, 1946, for Group 203, Colorado, authorized by Bureau of Land Management memorandum "E" dated July 25, 1946.

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.

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*Director.*

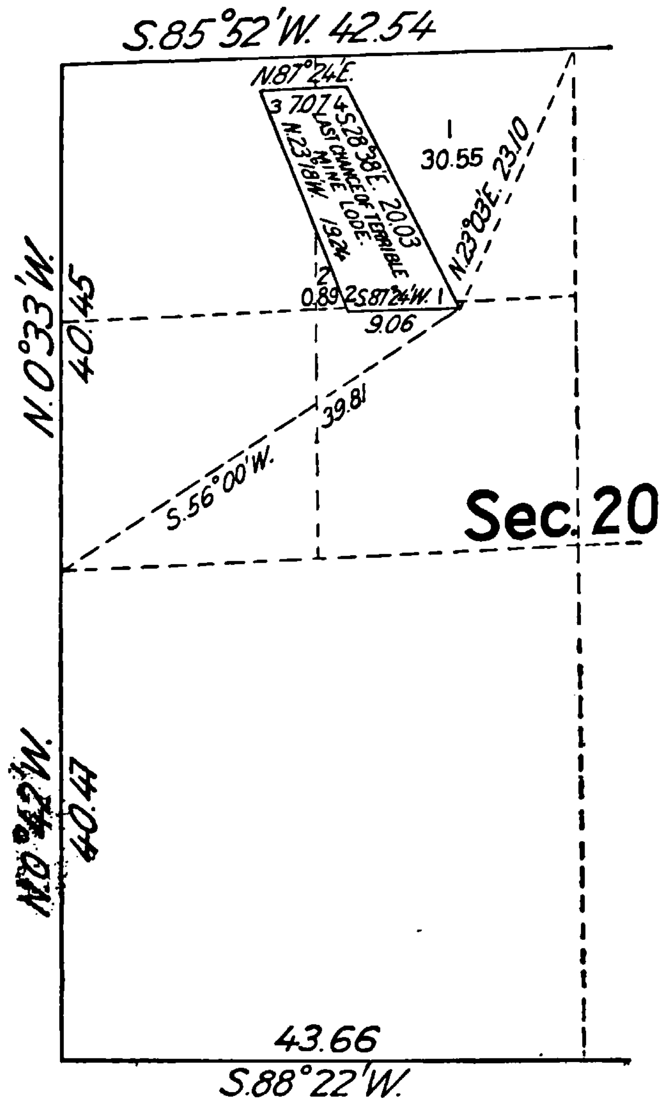
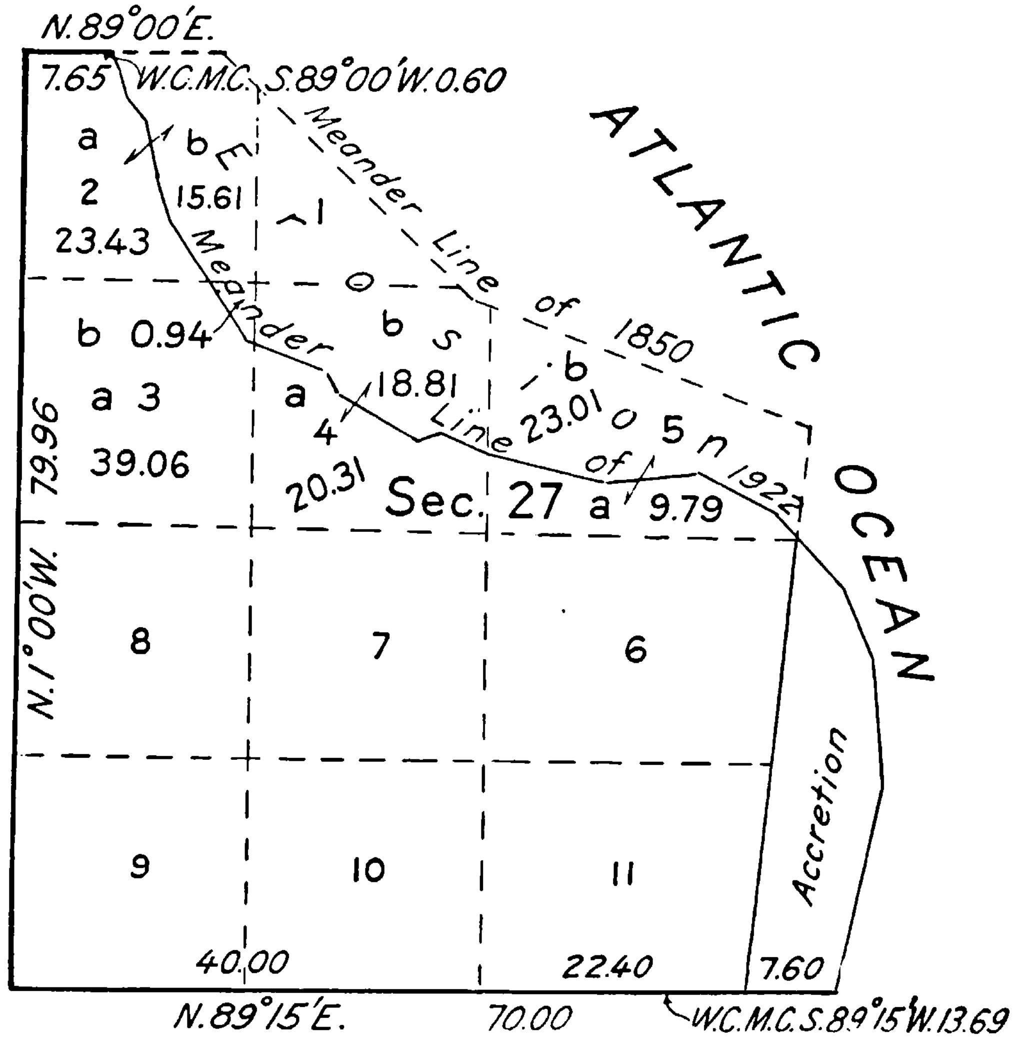



FIGURE 87.—Explanation on opposite page.

## PLATS OF FRAGMENTARY SURVEYS

**639.** The term "fragmentary survey" may be appropriately applied to all surveys that are required to identify parts of townships and sections that were not completed in the first instance. In this class may be included partially surveyed sections; omitted islands, if title is in the United States; such areas as lands in place at date of original subdivision situated between a grossly erroneous or fictitious meander line and the actual bank of a stream or lake, where riparian rights do not obtain as under the usual doctrine; and other lands of substantial value and extent that for various reasons were not included in the original surveys. Sections 211, 214–225, 233, and 511.

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, in order to make the sum of "a" and "b" equal to the original total.

**640.** These types of surveys frequently require consideration of the question of title involved preliminary to the extension of the former surveys.

**641.** 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.

**642.** A notable exception to the principle that no changes should be made in the former lottings is found in those cases which involve retracements or resurveys where *erosion* has occurred along the bank of a stream or lake or other body of water which substantially changes the configuration of the former lots, and where it may be desirable to show the quantity of land remaining and that destroyed. Similar problems in platting are found in those cases of erroneous meandering where the record position of the original meander line is found to fall within the body of water. In these cases the former lot boundaries where situated within the water area are indicated in light broken lines, and the quantities of each subdivision affected are shown in two parts: part "a" denoting land area and part "b" denoting water area; these areas are computed proportionately according to the amount shown for the original subdivision, the sum of "a" and "b" being made equal to the original total. A memorandum to this effect should appear upon the plat.

**643.** All technical data in reference to the retracement, reestablishment and extension of the section boundaries and connecting lines, and the complete topographical representation over the additional areas, will be shown upon the plats of fragmentary surveys. If the retracements and remonumentation assume the character of a dependent resurvey of the boundaries of one or more sections, that fact will be indicated on the plat together with a proper showing of the important map data throughout the entire area surveyed and resurveyed. There will also be shown an appropriate reference to the former approved plat or plats, and a citation of the authorization for the extension survey. The area statement will include 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 (sec. 625). Where such field work is required, the data derived by the retracement will be employed for all purposes along the plan of a dependent resurvey. Thus where there are segregations to be made, the areas of the new lottings will be derived by exact calculation.

There are types of metes and bounds surveys (sec. 472) where it is questionable as to how much of the detail 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 where it may be obviously unnecessary to represent all such data. In these cases it may be noted on the plat, if notation appears to be needed, that the data will be found in the field notes of the survey.

In some cases there are numerous and frequently very irregular lottings to be shown, as on townsite plats, and plats of subdivisions of lake-front property, where surveyors, landowners, and prospective entrymen may refer to the plat for purposes of local survey and identification, and where it appears that it should be unnecessary to first secure a copy of the field notes. If that is likely to be the case, the showing of the complete data should be carried to the plat. The scale of the base drawing, or that of the required additional sheets, will be enlarged in these cases to accommodate the proper representation of the data. The data referring to traverse lines may be shown by marginal tabulation, if that method appears to clarify the subject.

**644.** 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

**645.** A somewhat different type of plat is required for representing resurveys as defined in chapter VI. In all cases where valid rights have been acquired based upon a prior subdivision, it is important that the plat of the resurvey clearly identify the lands so involved, and that the plat of the resurvey indicate the descriptions of such lands with reference to the former plat. The subdivision of the remaining public lands may or may not be modified, according to the type of resurvey.

**646.** A resurvey by the United States after the issuance of a patent does not affect the rights of the patentee under the former survey and plat. The United States, so long as it has not conveyed the title, may resurvey or reestablish boundaries. This is done as may appear necessary, but the resurvey can not affect the rights of owners situated outside of the boundaries of the public lands. The authority to make resurveys is subject to the necessary limitation that the courts may protect the private rights based upon the former survey and plat against interference by the corrective survey. The courts may properly take jurisdiction over matters of interference and hear disputes relating to the position of the former lines.

**647.** The requirements for showing the positions of alienated lands on the plats of independent resurveys are given in the memorandum forms which appear in sections 448, 449, and 450, chapter VI. In the following sections it will be shown how the identification is to be accomplished in the cases of both tract segregations and conformed entries.

**648.** The tract segregations will be laid out on the plats of resurveys as any private land claim would be shown upon an original plat, but in order to show the detail of complicated situations one or more additional sheets are frequently necessary. If a claim is found to be conformable as defined in section 445, fifth paragraph, chapter VI, its boundaries may be shown by giving greater weight to such parts of the regular subdivision-of-section lines of the resurvey. In every case the outline of all tract segregations is to be shown on the first or principal sheet on the normal plan usually employed to show other types of private land claims.

**649.** On any of the several sheets, as appropriate, an index will be supplied to tabulate the description of each tract in terms of the original plat. The following index form is acceptable:

*Index to segregated tracts*

| Tract | | Original survey | | | |
|---|---|---|---|---|---|
| No. | Entry and status | Tp. | Rg. | Sec. | Subdvn. |
| 39 | Buffalo 2979.<br>H. E.<br>W. J. Williams.<br>Patented. | 58<br>58<br>58 | 75<br>75<br>75 | 29<br>29<br>29 | NW¼NW¼.<br>S½NW¼.<br>NW¼SW¼. |
| 41 | Buffalo 1567.<br>D. L. E.<br>W. J. Williams.<br>Pending. | 58<br>58<br>58 | 75<br>75<br>75 | 20<br>20<br>29 | SE¼SW¼.<br>W½SE¼.<br>NE¼NW¼. |
| 77 | Designated school section. | 58 | 75 | 36 | All. |
| 95 | Sundance 03186.<br>D. L. E.<br>C. R. Massey.<br>Final certificate. | 58<br>58 | 74<br>74 | 30<br>30 | Lot 1.<br>Lot 2. |
| 101 | Vacant. | 58 | 75 | 24 | Lot 4. |
| 102 | Vacant. | 58 | 75 | 23 | NE¼SE¼. |

**650.** In some cases there is a demand for the description of a tract in terms of its component parts as determined by the original survey; in these exceptional cases, and only as deemed to be appropriate, the several parts may be indicated by letters A, B, C, etc., with the index modified as follows:

*Index to segregated tracts*

| Tract | | Original survey | | | | Component parts | |
|---|---|---|---|---|---|---|---|
| No. | Entry and status | Tp. | Rg. | Sec. | Subdvn. | Sub-tract | Area |
| 42 | Buffalo 0833.<br>H. E.<br>Thomas R. Williams.<br>Pending. | 58<br>58<br>58<br>58 | 75<br>75<br>75<br>75 | 20<br>21<br>21<br>21 | NE¼SE¼.<br>Lot 4.<br>NW¼SW¼.<br>SW¼SW¼. | B<br>A<br>C<br>D | 40.00<br>32.00<br>40.00<br>40.00 |
| 46 | Buffalo 08642.<br>H. E.<br>Emmet Cain.<br>Pending. | 58<br>58<br>58<br>58 | 75<br>75<br>75<br>75 | 24<br>24<br>24<br>24 | Lot 3.<br>NW¼SW¼.<br>NE¼SW¼.<br>SE¼SW¼. | A<br>B<br>C<br>D | 28.12<br>40.00<br>40.00<br>40.00 |

**651.** The above method is well adapted to the identification and subdivision of isolated tracts of public lands where said tracts have been surveyed by metes and bounds. In these cases the arrangement of the data carried by the index will be the same, and the status of the tract will be shown as vacant.

**652.** If there are one or more conformable claims to be identified by amended description in terms of the resurvey, without segregation by metes and bounds, another form of index will be required, as follows:

*Index to conformed entries under modified description*

| Tract | Original survey | | | | Resurvey | | | |
|---|---|---|---|---|---|---|---|---|
| Entry and status | Tp. | Rg. | Sec. | Subdvn. | Tp. | Rg. | Sec. | Subdvn. |
| Buffalo 984.<br>T. & S.<br>Fred A. Jones.<br>Pending. | 45<br>45<br>45 | 79<br>79<br>79 | 12<br>12<br>12 | NE¼SE¼.<br>NW¼SE¼.<br>NE¼SW¼. | 45<br>45<br>45 | 79<br>79<br>79 | 12<br>12<br>12 | SW¼SE¼.<br>SE¼SW¼.<br>SW¼SW¼. |
| Buffalo.<br>S. S. List 6.<br>Approved. | 45 | 79 | 12 | SE¼SE¼. | 45 | 79 | 13 | NW¼NE¼. |

**653.** The several forms of index may be combined readily into one tabulation, if desirable, in which case it should be given a general title as *Index to Segregated Tracts and Appropriated Subdivisions;* the bracket for "component parts" may be filled in only as needed. Tract segregations will be required where modified descriptions embrace subdivisions that are smaller than the regular 40-acre unit.

**654.** The special requirements for lotting fractional parts of sections that are invaded by tract segregations are set out in sections 455 and 456, chapter VI, and are illustrated by the diagrams which accompany the text.

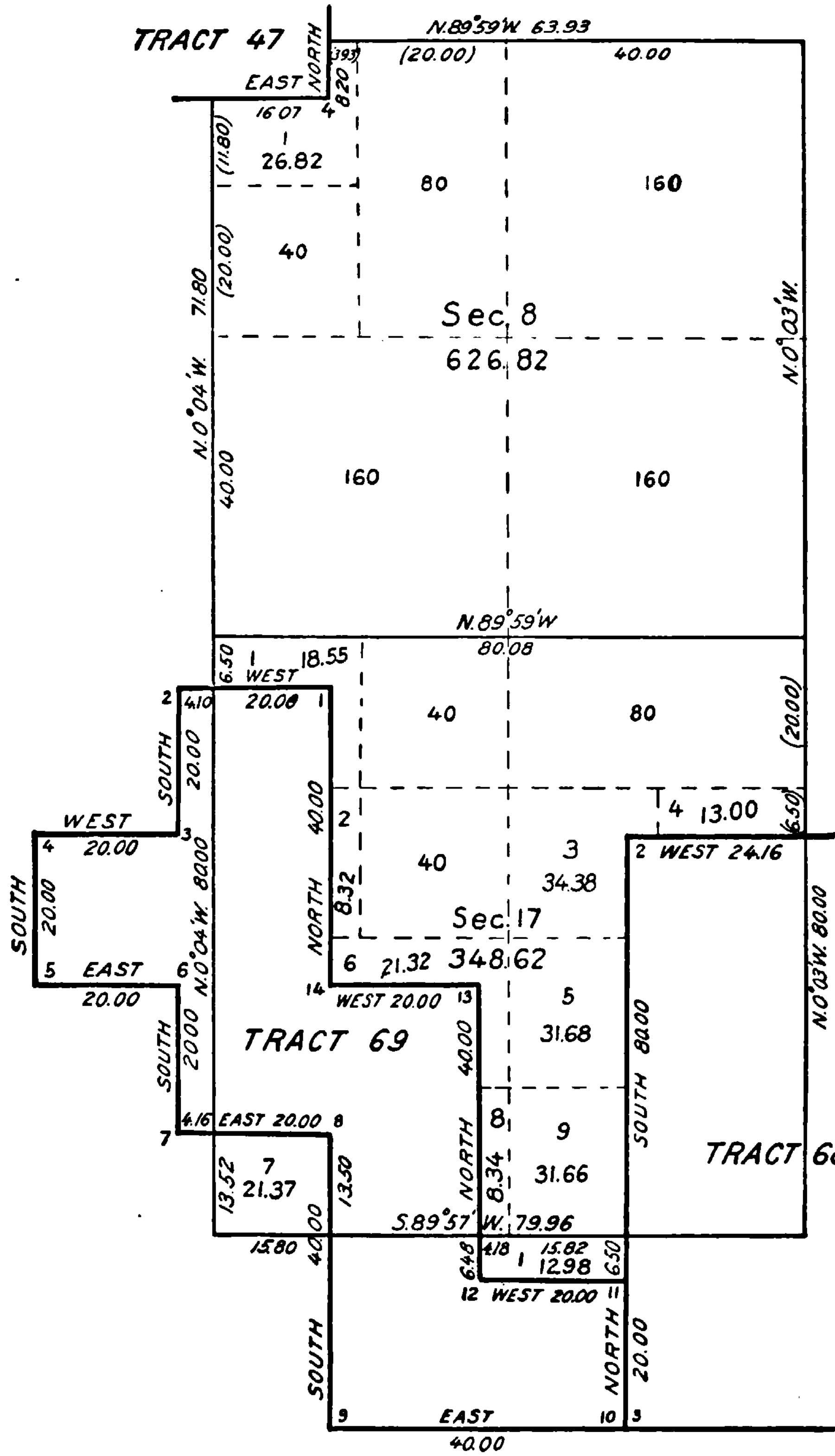



FIGURE 89.—Normal tract segregations, with fractional lotting of the adjoining public land. The tract segregations will be laid out on the plats of resurveys as any private land claim would be shown upon an original plat.

**655.** Occasionally there is a need for denoting the several parts of a tract in terms of quarter-quarter sections and fractional lots of the *resurvey*. This may be accomplished by protraction, showing lot numbers and areas as determined by the resurvey. The lottings within the tract should be made to complete the adjoining fractional quarter-quarter sections of the resurvey. This type of lotting requires no change in the index.

**656.** Where a tract is to be subdivided, preference will be given to the method best suited to the situation: (1) If it is deemed essential to perpetuate the units of the original survey then the lines of the original quarter-quarter sections will be shown; but (2) in those cases of relinquishment or cancellation where it appears probable that any new entry will be coupled with adjoining lottings by the resurvey then a lotting within the segregated tract as determined by the section boundaries of the resurvey should be adopted. It may well be noted that in the great majority of cases the patent eventually issues in accordance with the original entry, and the necessity for the subdivision of segregated tracts is exceptional. If the circumstances indicate the necessity for the subdivision of a tract at the time of the preparation of the resurvey plat, the regional or public survey office will exercise judgment based upon the type of disposal and the purpose to be served, but where such necessity is not clearly apparent no subdivision of this nature will be made. A supplemental plat may be prepared at a later date to meet specific requirements.

**657.** If there are overlapping claims as defined in section 445, sixth paragraph, chapter VI, the conflict will be indicated on the plat of the resurvey; but no new lot numbers will be assigned nor quantities shown within the segregated tracts that are involved in the conflict. (See fig. 90.)

The showing of the component parts will await the construction of a supplemental plat.

A memorandum will be 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 will be lotted regularly as heretofore provided, except that the description of any subdivision of the original survey embraced in a tract or conformed entry under modified description will not be repeated on the resurvey plat; instead it will be assigned an appropriate lot number.

**658.** No memorandum or other declaration will be inserted or shown upon a plat of a resurvey that can be construed as an adjudication of a settlement right, entry, or State selection or right under any grant *as to status* nor as an adjudication of a conflict, excepting as appropriate action on the case may have been taken prior to the date of the approval of the resurvey plat.

**659.** The usual technical data in reference to the direction and lengths of lines will be shown upon the plats of resurveys arranged on the several sheets as may be appropriate. The fractional distances along the section lines, the record intersections of the lines of the resurvey with the lines of claims, and the connections to the angle points of the tract surveys essential in the computation of the areas of the public land subdivisions will be shown in such a manner as to indicate the values employed. The complete topographical representation will always be carried by the first or principal sheet. The section numbers will be carried on all of the sheets. The first or principal sheet will carry a memorandum of the total number of sheets in the series, usually under the subtitle, and will be numbered one in the upper right corner with the additional sheets numbered consecutively.

**660.** On plats of independent resurveys the lot numbers and areas within the sections that are invaded by nonconformable tract segregations will usually be shown on the additional sheets, where such sheets are required, otherwise the lot numbers and areas will be shown on the first or principal sheet.

**661.** On plats of dependent resurveys the areas of the subdivisions are shown only in those exceptional cases where the differences between the actual quantity of the vacant subdivisions as found by resurvey and the former area as returned on the original approved plat are so great as to warrant revision. In that case the question of a revision should rest upon the element of *quantity* rather than upon that of *distortion*, and for practical purposes a variation of approximately 2.00 acres to the quarter-quarter section has been found advisable before making a change. If revision is made new lot numbers will be assigned to each vacant subdivision, but no total area within the section will be shown.

**662.** The total area shown within each independently resurveyed section will indicate the sum of the several parts which are to be identified by exclusive reference to the resurvey plat. In the area statement to be supplied on the plat of a dependent resurvey, giving the area resurveyed, the number of acres will be the same as the total shown on the original plat, except as revised lottings have been required under the rule stated in section 661, in which case the total should reflect the proper amount of the increase or decrease. In the total area statement to be supplied on the plat of an independent resurvey and on the plat of a dependent resurvey where mineral or other claims are segregated, the number of acres will be shown in three parts: (1) Total area of segregations; (2) total area exclusive of segregations; and (3) total area resurveyed. If a tract overlaps a township boundary, only the part within the township will be

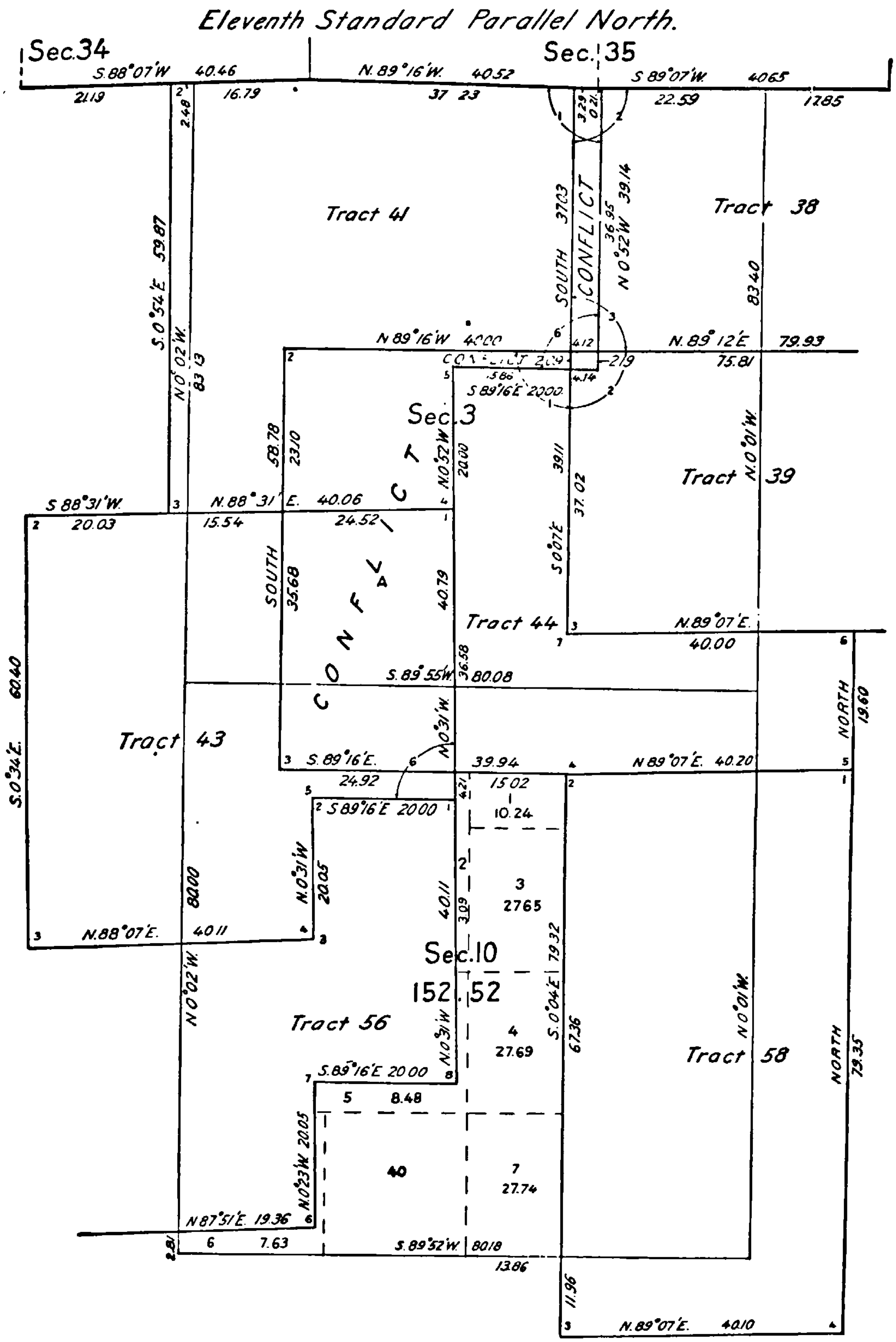



**Figure 90.**—Tract segregations in conflict, but not an adequate basis for amendment of descriptions. If there are overlapping claims the conflict will be indicated on the plat of the resurvey.

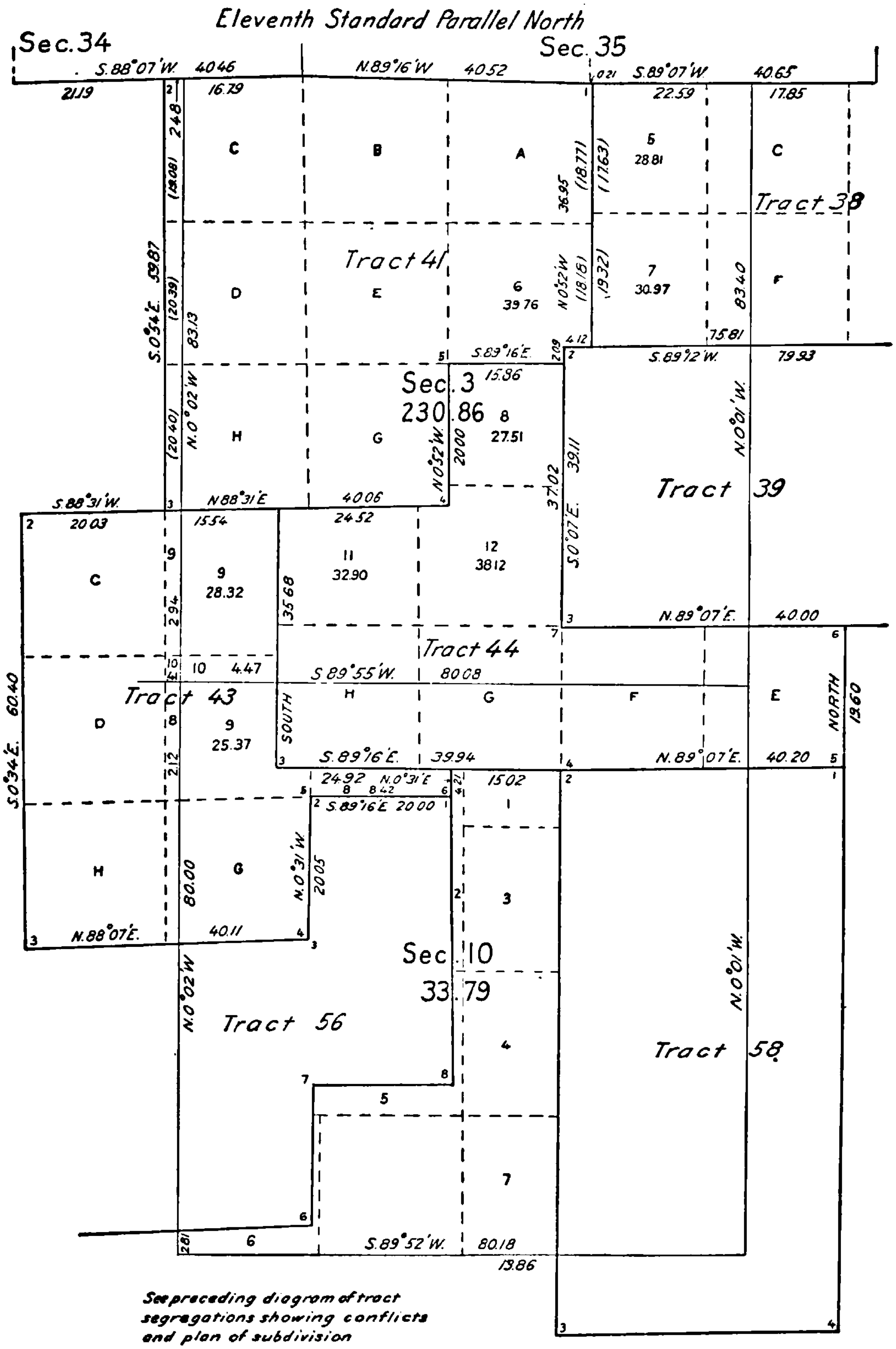



FIGURE 91.—Tract segregations, with revised form of conflict-free lottings; applicable after the adjudication of the rights. A supplemental plat will be issued subsequent to the adjudication of the rights involved within a conflict.



700004°—47——29

counted in this total; and if there are conflicts the area in conflict will be counted once only.

**663.** The first or principal sheet of the plat of a resurvey will carry an appropriate memorandum of the authority upon which the resurvey was made; all of the sheets will show the usual form of certificate of acceptance.

**664.** Office instructions for the preparation of a supplemental plat will be issued subsequent to the adjudication of the rights involved within a conflict when required to facilitate an amendment of entry or patent. On the supplemental plat, component parts that are free of conflict will be protracted and designated as shown on figure 91, and lot numbers will be assigned to the revised component parts of each adjudicated tract, serially within the sections of the resurvey, and areas shown, to afford descriptions that are conflict free. In these cases the supplemental plat will carry a revised index to the segregated tracts shown and a reference to the preceding plat. In the index all subdivisions in terms of the original survey will be listed but no sub-tracts will be assigned to any of them that are reduced by the elimination of previous conflicts. In the columns of resurvey descriptions and areas of component parts there will be listed the appropriate section numbers, lot numbers, and areas of the reduced tract subdivisions which are conflict free and a footnote will follow the index referring to each new lot indicating the lot is a portion of the original subdivision free of conflict.

**665.** The usual rules of field procedure will be observed in the protraction of the tract subdivisions—i. e., if by dependent resurvey, or where adequate control is shown in the record, the original sections will be subdivided regularly—but if by independent resurvey and limited control for the tract segregations, the points for all intermediate sixteenth-section, quarter-section, and section corners on the original tract boundaries will be determined by proportionate intervals between the established angle points, and the interior lines will be drawn to connect corresponding points on the opposite sides of the tract boundaries, fixing the corners of each component part by intersections. The areas to be computed will be based upon the data derived in the resurvey. If additional field work is required in order to supply data needed in the computations or otherwise, the regional administrator will request authority to proceed.

**666.** The following table is a revised index conforming to fig. 91:

662

*Index to segregated tracts*

| Tract | | Original survey | | | | Component parts[1] | | 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 | SW¼NE¼. | D | 40.00 | ------ | ------ | ------ | ---------- |
| | | 44 | 80 | 2 | SE¼NE¼. | E | 40.00 | ------ | ------ | ------ | ---------- |
| | | 44 | 80 | 1 | SW¼NW¼. | F | 40.00 | ------ | ------ | ------ | ---------- |
| | | 44 | 80 | 2 | Lot 3. | -------- | 28.81 | 44 | 80 | 3 | Lot 5.* |
| | | 44 | 80 | 2 | SE¼NW¼. | -------- | 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. Brunning. | 44 | 80 | 3 | Lot 3. | C | 37.00 | ------ | ------ | ------ | ---------- |
| | Pending. | 44 | 80 | 3 | SE¼NW¼. | D | 40.00 | ------ | ------ | ------ | ---------- |
| | | 44 | 80 | 3 | SW¼NE¼. | E | 40.00 | ------ | ------ | ------ | ---------- |
| | | 44 | 80 | 3 | NW¼SE¼. | F | 40.00 | ------ | ------ | ------ | ---------- |
| | | 44 | 80 | 3 | NE¼SW¼. | G | 40.00 | ------ | ------ | ------ | ---------- |
| | | 44 | 80 | 3 | SE¼NE¼. | -------- | 39.76 | 44 | 80 | 3 | Lot 6.* |
| 43 | Buffalo 011734. | 44 | 80 | 3 | SW¼SW¼. | A | 40.00 | ------ | ------ | ------ | ---------- |
| | H. E. | 44 | 80 | 10 | NW¼NW¼. | B | 40.00 | ------ | ------ | ------ | ---------- |
| | Perry Barnes. | 44 | 80 | 10 | SE¼NW¼. | C | 40.00 | ------ | ------ | ------ | ---------- |
| | Pending. | 44 | 80 | 10 | SW¼NW¼. | D | 40.00 | ------ | ------ | ------ | ---------- |
| | | 44 | 80 | 3 | SE¼SW¼. | -------- | 28.32 | 44 | 80 | 3 | Lot 9.* |
| | | | | | | | 2.94 | 44 | 80 | 4 | Lot 9.* |
| | | 44 | 80 | 10 | NE¼NW¼. | -------- | 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.* |
| | | 44 | 80 | 10 | NW¼NE¼ | -------- | 8.42 | 44 | 80 | 10 | Lot 8.* |
| | | 44 | 80 | 3 | SW¼SE¼. | -------- | *0.00 | ------ | ------ | ------ | ---------- |
| 44 | Buffalo 07532. | 44 | 80 | 11 | NW¼NE¼. | A | 40.00 | ------ | ------ | ------ | ---------- |
| | H. E. | 44 | 80 | 11 | NE¼NW¼. | B | 40.00 | ------ | ------ | ------ | ---------- |
| | Antoine Faure. | 44 | 80 | 11 | NW¼NW¼. | C | 40.00 | ------ | ------ | ------ | ---------- |
| | Pending. | 44 | 80 | 10 | NE¼NE¼. | D | 40.00 | ------ | ------ | ------ | ---------- |
| | | 44 | 80 | 2 | NW¼SW¼. | -------- | 27.51 | 44 | 80 | 3 | Lot 8.* |
| | | 44 | 80 | 3 | SE¼SE¼. | -------- | 32.90 | 44 | 80 | 3 | Lot 11.* |
| | | 44 | 80 | 2 | SW¼SW¼. | -------- | 38.12 | 44 | 80 | 3 | Lot 12.* |
| | | 44 | 80 | 3 | NE¼SE¼. | -------- | *0.00 | ------ | ------ | ------ | ---------- |

[1] See sec. 650.
*Portion of original subdivision that is free of conflict.

**667.** A word of caution to the engineers and draftsmen who are engaged upon the platting of *resurveys* is needed in order to guard against a possible misinterpretation of the rules on that subject, to the effect that it is not expected that the different cases can all be brought into a similar treatment. The contributing factors to be dealt with appear in considerable variety, and the methods suited to those situations which may not be involved in a particular case should be promptly set aside, so as to avoid the introduction of unnecessary complications. The normal resurvey may be brought within a fairly definite, standardized drafting practice, but each unusual case needs a special analysis with the purpose that the field office may exercise discretion as to how the detail may be most suitably platted.

## SUBTITLES

**668.** Plats will generally be given the usual title by township, range, meridian, and State, and if appropriate a subtitle 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) Segregation Survey
(9) Subdivision of Sections
(10) Metes and Bounds Survey
(11) Survey of the Moore Coal Mine
(12) Protraction Survey

Only the main purpose of the plat will be included in the subtitle. The detail will be carried in the memorandum.

# Chapter X

# MINERAL SURVEYS



## DISTINGUISHING FEATURES OF THE MINERAL SURVEY

**669.** There is set out in this chapter matters relating to the field and office procedure to be observed 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 to be determined by lines other than the normal subdivision of the public lands. The right of the mineral claimant to appropriate and develop the mineral values, and to proceed to patent varies. Appropriate citations will be found in the next section.

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, develop the same to his exclusive use, and, if desired in the protection of his right, may apply for a mineral survey and obtain a patent.

All other forms of mineral deposits are known as placers and usually do not require a mineral survey as they are conformed to the public survey unless they are located on unsurveyed land or the configuration of the mineral deposit is such as to make conformation impracticable. Consequently, the survey procedures hereinafter outlined apply especially to lode claims although they will be followed generally in executing appropriate surveys of placer claims.

Millsites embracing land occupied for milling purposes or used in any manner 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. sec. 910; 28 U. S. C. sec. 690), but also providing for their disposition. (R. S. secs. 2319–2344; 30 U. S. C. secs. 22–24, 26–30, 33–47, 51, 52). Present procedures are derived from this basic legislation.

**670.** The Act of March 3, 1925 (43 Stat. 1144; 43 U. S. C. sec. 51; Manual, Appendix I), necessitated a detailed revision of the regulations governing the administration of mineral surveys, but the field surveying operations remained fixed. A full statement of the administrative control of the general public land surveys, with citations of the authorities, is contained in chapter I, and in sections 9 and 10 there is reference to the several regional and public survey offices. Citations which refer specifically to the making of mineral surveys will be found in section 669 and in the following sections, where closely related to the subject matter.

Administrative details such as those relating to 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 procedures, and accordingly are governed by current office regulations. Certain rules for these administrative procedures are the subject of instructions, contained in the Code of Federal Regulations, Title 43, Chapter I, Subchapter L, Mineral Lands, Part 185.

The procedures for locating, maintaining and obtaining patent to mining claims for minerals that are subject to such appropriation, which are found on the public domain, and information regarding the acquisition of mineral deposits of the classes which are subject to disposal under the mineral leasing acts, are likewise the subject of specific instructions, contained in the Code of Federal Regulations, Title 43, Chapter I, Subchapter L, Mineral Lands.

**669**

## REQUIREMENTS OF FIELD WORK

**671.** The term "survey" as here employed includes the usual technical procedure, and also all examinations required for the preparation of the affidavits of the value of expenditures for development purposes, descriptive reports on placer claims, and any other reports to be made by the mineral surveyor.

**672.** In every case the survey made and reported is to be an actual survey on the ground in full detail, made by the mineral surveyor in person after the receipt of the order, and without reference to any knowledge he may have previously acquired by reason of having made the location survey or otherwise, and the record will show the actual facts existing at the time. This precludes a calculation of the connections to corners of the public survey and to 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).

**673.** The survey of a mining claim may include several contiguous locations owned in common, but in conformity with statutory requirements such survey record will distinguish the several locations and exhibit the boundaries of each. *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).

**674.** All lengths of lines are to be returned as their true horizontal equivalents in the *foot unit*, as determined by the general methods of measurement prescribed in sections 16, 17, 35, 36, and 37, chapter II. The high degree of accuracy required in the making of mineral surveys calls for careful steel-tape measurements; and if needed in order to secure acceptable results, a spring balance should be used and temperature corrections applied.

**675.** All mineral surveys are to be made with an instrument by which the meridian may be determined independently of the magnetic needle, and the directions of all lines are to be referred to the true meridian. An engineer's transit with or without a solar attachment may be employed and any method described in chapter II may be used. The true course of at least one line of each survey is to be ascertained at the time of the survey by observation either upon the sun or Polaris or any bright star in the equatorial belt by one of the methods given in sections 84 to 123, inclusive, chapter II, with proper verification of the time and latitude; the methods so employed and the results will be recorded in the field notes of the survey. Specimen field notes: Manual Appendix X.

**676.** The magnetic declination is to be noted at each corner of the survey; if it is the same at the several corners one statement to this effect, and the value of the declination will be given in the field notes. The declination will be noted and recorded at each corner of the survey where differences are found.

**677.** The survey will be made in strict conformity with, or be embraced within, the lines of the location upon which the order is based. If the survey and location are identical that fact will be clearly stated in the field notes. If not identical, a bearing and distance will be given 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 will 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).

**678.** The survey will be given but one number. A location under the mining laws can legally be made only of a tract or piece of land embraced within one set of boundary lines; and two or more tracts merely cornering with each other can not legally be embraced in a single location. *Gomeira Placer Claim*, 33 L. D. 560 (1905); *Hidden Treasure Mine*, 35 L. D. 485 (1907). But 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 I. D. 614 (1932).

**679.** In accordance with the principle that courses and distances must give way when in conflict with fixed objects and monuments, the mineral surveyor will not under any circumstances change the corners of the location for the purpose of making them conform to the description in the record. If the difference from the location certificate is slight, it may be explained in the field notes, as indicated in the specimen field notes.

**680.** Revised Statutes, sec. 2324 (30 U. S. C. sec. 28), expressly provides that "the location must be distinctly marked upon the ground so that its boundaries can be readily traced," and "that all records of mining claims 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.

**681.** A single discovery working can not 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.

**682.** These provisions of law must be strictly complied with in each case to entitle the claimant to a survey and patent, and should a claimant under a location made subsequent to May 10, 1872, who has not complied with said requirements in regard to marking the location upon the ground and recording the location certificate, apply for a survey, the mineral surveyor will decline to make it prior to reporting the facts to the regional or public survey office and receiving further instructions. *Philip Dephanger*, 1 L. D. 581 (1882).

**683.** 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.

**684.** Should the survey be applied for under a location made prior to May 10, 1872 (see R. S. secs. 2319–2328, 2331), the mineral surveyor will be governed by the special instructions accompanying the order for survey.

## LODE LINES AND END LINES

**685.** No lode claim located subsequent to May 10, 1872, should 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 will be 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 will be shown on the plat.

**686.** 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

**687.** The fixation of the position of the official survey upon the ground will be ascertained by connecting it by course and distance either to a corner of the public survey, preferably the nearest, or to a location monument, but in any event the connecting line will not exceed a length of two 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 will be so connected.

**688.** 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 should be established as corner No. 1.

**689.** The two 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.

**690.** 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 will be connected with an established public survey corner.

**691.** From corner No. 1 the successive boundaries of each location will be run in regular manner, numbering the remaining corners in consecutive order.

**692.** A lode and a mill site embraced in one survey will be distinguished by the letters A and B, respectively, following the number of the survey. The corners of the mill site will be numbered independently of those of the lode. A corner of the mill site, preferably corner No. 1, will be connected with a corner of the public survey or location monument, and a corner of the mill site with a corner of the lode claim.

**693.** When a placer claim includes lodes, or when several contiguous placer or lode locations are included as one claim in one survey, the corners of each location will be given a separate consecutive numerical designation, beginning with corner No. 1 in each case. In the former case, describe the placer claim first in the field notes.

## CONFLICTS

**694.** When the exterior lines of a claim conflict with the survey of another claim, the distances to the points of intersection and the courses and distances along the line intersected from an established corner of such conflicting claim to such points of intersection should be reported in the field notes: *Provided,* That where a corner of the conflicting survey falls within the claim being surveyed, this corner should be selected from which to give the tie. When the same line of a conflict is intersected by two lines of the survey, the tie will be given from the same corner of the conflicting survey at both intersections.

**695.** When the lines of two locations of the survey intersect, only the point of intersection will be given on the line being described.

**696.** Conflicts with unsurveyed locations will not be reported unless excluded from the area claimed.

**697.** Surveyed claims owned by the applicant, in conflict with or contiguous to the survey, will be reported in the field notes.

**698.** 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.

**699.** Connection will also be given to any survey, the record position of which is within 100 feet of the lines of the survey being executed; also to any other neighboring survey, the location of which is not definitely fixed by the record. Such connections will be made and conflicts shown according to the boundaries of the neighboring or conflicting claims as each is marked, defined, and actually established upon the ground. The field notes will fully and specifically state how and by what visible evidence the several conflicting surveys were identified on the ground, as well as those which appear to conflict, according to their returned tie or boundary lines, and report all material errors or discrepancies found in such surveys. In the survey of a group of contiguous claims where any corners are common to two or more claims of the group, bearings should be mentioned but once and the corner described as a common corner in the claim first mentioned in the field notes.

## LOCATION MONUMENTS

**700.** 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 will be established. The site, when practicable, should be some prominent point, giving good visibility from every direction, and the site should be so chosen that the permanency of the monument will not be endangered by snow, rock, or land movements or other natural causes. Its position with reference to latitude and longitude should be recorded as accurately as the known data and the instruments used will afford.

**701.** The monument should consist of a stone not less than 30 inches long, 20 inches wide, and 6 inches thick, set two-thirds in the ground with a conical mound of stone 4 feet high and 6 feet base alongside. The letters "U S L M" followed by the number of the survey in connection with which it is established will be plainly chiseled upon the stone. The exact reference point will be indicated on the monument by a cross (×) chiseled on the top. Any necessary departure from the prescribed material and size of monument is to be explained.

**702.** From the monument the precise course and distance will be taken to two or more bearing trees or rocks, and to any well-known and permanent objects in the vicinity, such as buildings, shafts, mouths of adits, prominent rocks, or the confluence of streams. Bearing trees will be properly scribed "B T" and the bearing rocks chiseled "B O" together with the number of the location monument; the exact point on the tree or stone to which connection is made to be indicated by a cross or other unmistakable mark. Bearings should also be taken to prominent mountain peaks or other land marks, 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, will be furnished.

## CORNER MONUMENTS

**703.** Corner monuments may consist of the following material, given in the order of preference:

(A) Tubular iron posts with flaring base, cement core, and brass cap for marking with steel dies, of the type adopted for public land surveys;

(B) A stone at least 24 inches long, 6 inches wide, and 4 inches thick, set 16 inches in the ground, with a conical mound of stone, 1½ feet high, 2 feet base, alongside; or,

(C) A rock in place.

If none of the foregoing material is available, a concrete post, 24 inches long, 6 inches square, set 16 inches in the ground, or durable wooden post at least 3 feet long by 4 inches square, set 24 inches in the ground, and surrounded by a substantial mound of stone or earth, may be used. Should it become necessary to vary from these instructions, the returns will contain a full statement of the reason therefor.

**704.** All corners will be established in a permanent and workmanlike manner, and the distinguishing initial letter or letters, corner, and survey numbers will be neatly chiseled or scribed on the side facing the claim. The precise corner point will be permanently indicated on the monument. When a rock in place is used, its dimensions above ground will be stated, and a cross chiseled at the exact corner point. Corners common to two or more locations will bear the initial letter and corner number of each location.

**705.** In case the point for the corner is inaccessible or unsuitable, a witness corner will be established, which will bear the letters "W C" in addition to the regular markings. When practicable the witness corner should be located upon a line of the survey and as near as possible to the true corner point, with which it must be connected by course and distance. The reason for the establishment of a witness corner will be stated in the field notes.

**706.** The position of all corners should be recorded by course and distance to bearing trees, rocks, and other permanent objects, as prescribed in the establishment of 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 with the corner and described in the field notes.

## TOPOGRAPHY

**707.** Note carefully all topographic features of the claim, taking distances on the lines to intersections with all streams, gulches, ditches, ravines, mountain ridges, roads, trails, etc., with their widths, courses, and other data that may be required for mapping purposes. If the claim is situated within a town site, all important municipal improvements, and the street and block system, within the claim, will be located for mapping purposes.

## FIELD NOTES

**708.** Field notes and other reports must be typewritten in black-record ink, and upon the proper blanks, which will be 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 550, chapter VII, and as employed in the specimen field notes, appendix, page 575.

**709.** The mineral surveyor will prepare and file a preliminary plat on tracing cloth, drawn on a scale of 200 feet to an inch, if practicable, in conformity with the specimen plat (insert No. 2), the lines of the claim surveyed being shown heavier in contrast with conflicting claims. A copy of such calculations of areas as are made by double meridian distances and of all triangulations or traverse lines will also be furnished.

**710.** In order that the results of the survey may be reported in a uniform manner, the field notes and preliminary plat will be prepared in strict conformity with the specimen field notes and plat, which are made part of these instructions. They are designed to furnish all needed information concerning the manner of describing the boundaries, corners, lode lines, connections, intersections, conflicts, and improvements, and of stating the magnetic 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.

**711.** Throughout the description of the survey, after each reference to the lines or corners of a location, give the name thereof, and if unsurveyed state the fact. If reference is made to a location included in a prior official survey, the survey number will be given, followed by the name of the location.

**712.** 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.

**713.** 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.

**714.** 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.

**715.** The title-page should contain the post-office address of the claimant or his authorized agent.

## IMPROVEMENTS

**716.** In R. S. sec. 2325 (30 U. S. C. sec. 29), it is directed that at least $500 shall be expended upon a mineral claim as a prerequisite to patent.

**717.** In preparing the certificate of the value of the improvements, the form shown in the specimen field notes will be followed.

**718.** Only actual expenditures and mining improvements made by the claimant or his grantors, having a direct relation to the development of the claim, are to be included in the estimate. Labor or improvements, within the meaning of the statute, are deemed to have been had on a mining claim, whether it consists of one location or several, when the labor is performed or the improvements are made for its development—that is, to facilitate the extraction of the metals it may contain. *Emily Lode*, 6 L. D. 220 (1887).

**719.** The expenditures required may be made on the surface or in running a tunnel, drifts, or crosscuts for the development of the claim. Improvements of any other character, such as buildings, machinery, or roadways, will be excluded from the estimate unless it is clearly shown that they are associated with actual excavations, such as cuts, tunnels, and shafts, and are essential to the practical development and to actually facilitate the extraction of mineral. Mills for ore treatment, or roadways, tramways, or trails built for transporting the extracted ore from the mine, are not to be included.

**720.** All mining and other improvements on the claim will be located by course and distance from corners of the survey, or from points on the indicated lode line, specifying with particularity the dimensions and character of each. The improvements upon each location should be numbered consecutively, the point of discovery always being No. 1. Improvements made by a former locator who has abandoned his claim are not to be included in the estimate, but should be described by separate statement in the field notes and shown on the plat.

**721.** The field notes will show in detail the value of each mining improvement included in the estimate of expenditures, and when a tunnel or other improvement has been made for the development of other claims in connection with the one for which survey is made, the name, ownership, and survey number, if any, of each claim to be credited, and the value of the interest credited to each will be stated.

**722.** When a lode and mill site are included in the same survey, an expenditure of $500 at the time of application for patent is required upon the lode claim only.

**723.** 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 will be required.

**724.** 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 judgment of credits as the exigencies of the case may seem to require being utterly at variance with the essential idea inherent in the term "a common improvement."

In any patent proceedings where a part of a group of mining claims is applied for and reliance is had upon a common improvement, the land department should be fully advised as to the total number of claims embraced in the group, as to their ownership, and as to their relative situations, properly delineated upon an authenticated map or diagram. Such information should always be furnished in connection with the first proceeding involving an application of credit from the common improvement, and should be referred to and properly supplemented in each subsequent patent application in which a like credit is sought to be applied.

**725.** 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.

**726.** 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.

**727.** If the value of the labor and improvements upon a mineral claim is less than $500 at the time of survey, authority is given to file thereafter supplemental proof showing $500 expenditure made prior to the expiration of the period of publication. The information on which to base this proof must be derived by the mineral surveyor, who makes the actual survey, from a careful examination upon the premises.

**728.** 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 regional or public 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.

## DESCRIPTIVE REPORTS ON PLACER CLAIMS

**729.** Revised Statutes, sec. 2331 (30 U. S. C., sec. 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 (43 CFR 185.24, 185.28).

The mineral surveyor is required to make a full examination of all placer claims at the time of survey (43 CFR 185.73) and to file with his field notes a descriptive report, under oath, duly corroborated by one or more disinterested persons and covering the following items:

(*a*) The quality and composition of the soil, and the kind and amount of timber and other vegetation;

(*b*) The location and size of streams, and such other matter as may appear upon the surface of the claims;

(*c*) The character, extent, and position of all surface and underground workings for mining purposes;

(*d*) The proximity of centers of trade or residence;

(*e*) The proximity of well-known systems of lode deposits or of individual lodes;

(*f*) The use or adaptability of the claim for placer mining, including the availability of water in sufficient quantity for practical operations;

(*g*) Works or expenditures made by the claimant or his grantors for the development of the claim; and,

(*h*) The true position of all known mines, salt licks, salt springs, and mill sites. When none is known to exist on the claim, the fact will be so stated.

## AMENDED SURVEYS

**730.** Amended surveys are ordered only by the Director, Bureau of Land Management. The conditions and circumstances peculiar to each separate case and the object sought by the required amendment are set forth in the authorization from that office, and alone govern all special matters relative to the manner of making such surveys and the form and subject matter to be embraced in the field notes.

**731.** The amended surveys are to 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

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fact will be distinctly stated in the field notes. If not identical, the bearing and distance are to be given from each established corner of the amended survey to the corresponding corner of the original survey. The lines of the original survey, as found upon the ground, are to be laid down upon the preliminary plat in such manner as to contrast and show their relation to the lines of the amended survey.

**732.** The field notes of the amended survey are to be prepared on the same size and form of blanks as are required for the field notes of the original survey, and the abbreviation "Am." will be used after the survey number wherever it occurs.

## PLATS

**733.** Chapter IX is devoted to the subject of plat making and in so far as applicable will be followed. In addition, the following instructions relating especially to mineral plats will be observed. The returns of the survey when filed in the regional or public survey office will be carefully examined and compared with the records to determine that all conflicts with prior approved surveys are correctly shown, that all connecting lines given are in harmony with the record, that all material errors found in prior surveys are fully reported, and that the calculations of intersections and of conflicting areas are correct. The final plat will be 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 field notes, showing the improvements, conflicts, and physical features described therein, together with all courses and distances of intersecting lines and connecting lines, where space will permit. Any topographic features described in the field notes tending to confuse or obscure the plat may be omitted, but as the copy of the plat posted on the claim is a notice to the public of the ground applied for, all wagon roads, streams, and other objects that may aid in locating the surveyed ground should be shown.

In case the entire survey 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. ——." The last sheet will carry the certificate of approval, with the extra sheets of the same width and not longer than the last sheet. Although a form plat showing protractor and marginal lines is available, its use is optional with the public survey office.

**734.** The approval of a mineral survey is final, no acceptance being required as in the case of the public land subdivisional surveys. When approved, the plat will be reproduced and the returns of the survey will be distributed in accordance with existing regulations.

# APPENDIX

The Manual Appendix contains continuations or elaborations of the subject matter where editorially desirable to make the separations from the principal textual material. It is arranged by the identical chapter and section numbers.

# Appendix I

# EARLY LAWS AND CITATION OF AUTHORITIES

**6.** The rectangular system of survey of the public lands was inaugurated by a committee appointed by the Continental Congress. On the 7th of May 1784, this committee reported "An ordinance for ascertaining the mode of locating and disposing of lands in the western territory, and for other purposes therein mentioned." The ordinance as finally passed on the 20th of May 1785, provided for townships 6 miles square, containing 36 sections of 1 mile square. The first public surveys were made under this ordinance. The townships 6 miles square, were laid out in ranges extending northward from the Ohio River, the townships being numbered from south to north, and the ranges from east to west. The region embraced by the surveys under this law forms a part of the State of Ohio. In these initial surveys only the exterior lines of the townships were surveyed, but the plats were marked by subdivisions into sections of 1 mile square, and mile corners were established on the township lines. The sections were numbered from 1 to 36, and the surveys were made under the direction of the geographer of the United States.

The Act of May 18, 1796 (1 Stat. 464), provided for the appointment of a surveyor general and directed the survey of the lands northwest of the Ohio River and above the mouth of the Kentucky River, "in which the titles of the Indian tribes have been extinguished." Under this law it was provided that "the sections shall be numbered, respectively, beginning with the number one in the northeast section and proceeding west and east alternately through the township, with progressive numbers till the thirty-sixth be completed." This method of numbering sections is still in use.

The Act of May 10, 1800 (2 Stat. 73), required the "townships west of the Muskingum, which * * * are directed to be sold in quarter townships, to be subdivided into half sections of three hundred and twenty acres each, as nearly as may be, by running parallel lines through the same from east to west and from south to north at the distance of one mile from each other, and marking corners at the distance of each half mile on the lines running from east to west and at the distance of each mile on those running from south to north. * * * And the interior lines of townships intersected by the Muskingum, and of all the townships lying east of that river, which have not been heretofore actually subdivided into sections shall also be run and marked. * * * And in all cases where the exterior lines of the townships thus to be subdivided into sections or half sections shall exceed, or shall not extend, six miles, the excess or deficiency shall be specially noted and added to or deducted from the western and northern ranges of sections or half sections in such townships, according as the error may be in running the lines from east to west or from south to north."

The Act of February 11, 1805 (2 Stat. 313), directed the subdivision of the public lands into quarter sections and provided that all the corners marked in the public surveys shall be established as the proper corners of sections, or subdivisions of sections, which they were intended to designate, and that corners of half and quarter sections not marked shall be placed as nearly as possible "equidistant from those two corners which stand on the same line." This act further provides that "The boundary lines actually run and marked * * * shall be established as the proper boundary lines of the sections or subdivisions for which they were intended; and the length of such lines as returned by * * * the surveyors * * * shall be held and considered as the true length thereof and the boundary lines which shall not have been actually run and marked as aforesaid shall be ascertained by running straight lines from the established corners to the opposite corresponding corners; but in those portions of the fractional townships where no such opposite or corresponding corners have been or can be fixed, the said boundary lines shall be ascertained by running from the established corners due north and south or east and west lines, as the case may be, to the * * * external boundary of such fractional township."

The Act of April 25, 1812 (2 Stat. 716), provided "That there shall be established in the Department of the Treasury an office to be denominated the General Land Office, the chief officer of which shall be called the Commissioner of the General Land Office, whose duty it shall be, under the direction of the head of the department, to superintend, execute, and perform all such acts and things touching or respecting the public lands of the United States, and other lands patented or granted by the United States, as have heretofore been directed by law to be done or performed in the office of the Secretary of State, of the Secretary and Register of the Treasury, and of the Secretary of War, or which shall hereafter by law be assigned to the said office."

The Act of April 24, 1820 (3 Stat. 566), provided for the sale of public lands in half-quarter sections, and requires that "in every case of the division of a quarter section the line for the division thereof shall run north and south * * * and fractional sections, containing one hundred and sixty acres and upward, shall, in like manner, as nearly as practicable, be subdivided into half-quarter sections, under such rules and regulations as may be prescribed by the Secretary of the Treasury; but fractional sections containing less than one hundred and sixty acres shall not be divided."

The Act of May 29, 1830 (4 Stat. 417; R. S. secs. 2412, 2413), provided for the fine and imprisonment of any person obstructing the survey of the public lands, and for the protection of surveyors, in the discharge of their official duties, by the United States marshal, with sufficient force, whenever necessary.

The Act of April 5, 1832 (4 Stat. 503), directed the subdivision of the public lands into quarter quarters; that in every case of the division of a half-quarter section the dividing line should run east and west; and that fractional sections should be subdivided under rules and regulations prescribed by the Secretary of the Treasury. Under the latter provision the Secretary directed that fractional sections containing less than 160 acres, or the residuary portion of a fractional section, after the subdivision into as many quarter-quarter sections as it is susceptible of, may be subdivided into lots, each containing the quantity of a quarter-quarter section as nearly as practicable, by so laying down the line of subdivision that they shall be 20 chains wide, which distances are to be marked on the plat of subdivision, as are also the areas of the quarter quarters and residuary fractions.

Both the Act of April 24, 1820, *supra*, and the Act of April 5, 1832, *supra*, provided that the corners and contents of half-quarter and quarter-quarter sections should be ascertained, as nearly as possible, in the manner and on the principles directed and prescribed in the Act approved February 11, 1805, *supra*.

The Act of July 4, 1836 (5 Stat. 107), provided for the reorganization of the General Land Office, and that the executive duties of said office "shall be subject to the supervision and control of the Commissioner of the General Land Office under the direction of the President of the United States." The repealing clause is, "That such provisions of the act of the twenty-fifth of April, in the year one thousand eight hundred and twelve, entitled 'An act for the establishment of a General Land Office in the Department of the Treasury,' and of all acts amendatory thereof, as are inconsistent with the provisions of this act, be, and the same are hereby, repealed."

From the wording of this act it would appear that the control of the General Land Office was removed from the Treasury Department, and that the Commissioner reported directly to the President; but, as a matter of fact, the Secretary of the Treasury still had supervisory control, for the Act of March 3, 1849 (9 Stat. 395), by which the Department of the Interior was established, provided, "That the Secretary of the Interior shall perform all the duties in relation to the General Land Office, of supervision and appeal, now discharged by the Secretary of the Treasury * * *." By this act the General Land Office was transferred to the Department of the Interior.

The Act of March 3, 1925 (43 Stat. 1144), provided for the reorganization of the public survey offices as follows: The office of surveyor general is hereby abolished, effective July 1, 1925, and the administration of all activities theretofore in charge of the surveyors general, including the necessary personnel, all records, furniture, and other equipment, and all supplies in their respective offices, are hereby transferred to and consolidated with the field surveying service, under the jurisdiction of the United States Supervisor of Surveys, who shall hereafter administer same in association with the surveying operations in his charge and under such regulations as the Secretary of the Interior may provide.

The administrative plan that was set up through the Act of March 3, 1925, continued in operation until displaced by the reorganization of July 16, 1946, wherein the General Land Office was abolished and its functions transferred to the Bureau of Land Management. Manual, Chapter I, section 7.

The laws (1) in reference to the reorganization of the public survey offices (March 3, 1925, 43 Stat. 1144; 43 U. S. C. sec. 51), effective July 1, 1925, and (2) in reference to the transfer to the States of the field notes and plats on the completion of the surveys (May 28, 1926, 44 Stat. 672; 43 U. S. C. secs. 25, 25a, 25b), superseded certain long established and important provisions of the Public Land Laws, of which the following sections of the Revised Statutes are given here for the information bearing upon former practices:

Surveyor general, how and where appointed.

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

Transfer of papers and discontinuance of office in case of completed surveys.

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

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

Devolution of powers upon commissioner in case of discontinuance.

R. S. secs. 2220, 2221. Under the authority and direction of the Commissioner of the General Land Office any deputy surveyor or other agent of the United States shall have free access to any such field notes, maps, records, and other papers for the purpose of taking extracts therefrom or making copies thereof without charge of any kind; but no transfer of such public records shall be made to the authorities of any State until such State has provided by law for the reception and safekeeping of such public records, and for the allowance of free access thereto by the authorities of the United States.

Free access to public records delivered to States, and condition of such delivery.

## Appendix II

# THE CHAIN UNIT

15. The chain unit is known as the invention of Edmund Gunter, an English astronomer of the seventeenth century; the chain unit of measurement is especially convenient in computing areas in the unit of acres, one acre being equal to 10 square chains. In the colonial area of the United States, the boundaries of the land grants that were made to the English speaking people were usually measured in the same unit, but the lengths of lines were frequently expressed in terms of "poles," 4 poles being equal to 1 chain.

The public land fractions of even 20.00 and 40.00 chains for the quarter and half-mile distances greatly simplify the subdivision of the section into the aliquot parts, termed the quarter-quarter and quarter sections, or units of area as 40 acres and 160 acres. The fraction of 10 chains along the section boundary gives the side of a 10-acre subdivision, or quarter-quarter-quarter unit.

Again, where the law requires a proportional distribution of differences in measurement as in making retracements for the restoration of lost corners, and in the subdivision of a section into its aliquot parts, this is accomplished in terms of a few links added to or subtracted from the 20.00 and 40.00 chain measurement that is shown in the official record. No other linear unit can be so well suited to these practices.

In the beginning (sixth rule; Manual sec. 6) all lines were to be measured with chains, containing 2 perches of 16½ feet each, subdivided into 25 equal links; the chain was to be adjusted to a standard kept for that purpose. This short unit was frequently called the "2-pole" chain. The more common term now for the perch, or pole, is the rod, which equals 16½ feet in length; however, that term is more ordinarily applied to the dimensions of small tracts, length of fence lines, widths of land cultivation in strips, etc. In the larger scale surveys, and especially in the public land surveying practice, the unit is the chain of 66 feet in length, divided or graduated into 100 links.

The ordinary foot unit, while used almost exclusively in city, town, and village subdivisions, and in railroad, highway, and topographic surveys, is not well suited to the *acre unit of area*. This should be noted in sections 584 to 595, inclusive, on the computation of *areas*. All public land surveying records are in the chain unit, though the term "pole" will be found in some of the early field notes.

In its earliest construction the chain was made from iron, later heavy steel wire, in short pieces which were bent at the ends to form rings; three extra rings were placed in between the pieces, each assembly to make up one whole link, or 7.92 inches. Adjustable handles, with swivels, were placed at the extreme ends; this gave flexibility to the whole, and means for making corrections to a standard length. There were many wearing surfaces, and other ready causes for errors in length. Almost daily testing was required, and the errors could be large if this was neglected. The link chain was not superseded by the steel ribbon tape, in general practice, until after 1900.

The 2-pole (or 4-pole) chain could be used in level or gently rolling country, but the chain itself required "leveling," and frequently a plummet at one end. On steep slopes there was the practice of "breaking chain," i. e.—using only 10, 20, or more links at a time, whatever could be held horizontally. In consequence of the difficulties, and the many chances for error, and later the need for much greater accuracy in all respects, the long steel-ribbon tape finally supplanted the link chain.

The boundaries of the grants of land that were made to private individuals or companies by the British crown both in the area of the Colonial States and in the territory that was turned over to the Federal Government by those States were usually described in terms of natural objects and metes-and-bounds traverse, the latter by direction of lines and lengths in terms of poles or chains. There were few, if any, exceptions to the latter unit.

## THE ARPENT AND VARA UNITS

The land grants by the French crown were usually described in terms of the *arpent*. Where the Spanish settled first, the land survey distances were expressed in the *vara* unit. The conversions that are most frequently needed are given in table 26, Standard Field Tables.

Grants by the French crown were usually expressed as so many *arpents in area* and/or as a tract of so many *arpents frontage* upon a certain body of water, and so many arpents back, on either side; sometimes as a tract of so many arpents in the two or more directions along the sides. The arpent is a unit of area, approximately 0.85 acres, and when used as a linear term is intended to refer to the length of the side of one square arpent.

The grants by the Spanish crown and by the Mexican Government, prior to the cessions to the United States, were more often described as by the British plan, but with lengths of lines expressed in the *vara* unit.

In the State of Texas where the titles and land survey descriptions were brought down from the Spanish sovereignty, the vara unit of linear measurement is employed; 36 varas are recognized as being equal to 100.000 feet.

In the survey of private land grants, therefore, and in making retracements and resurveys, it has been necessary to interpret the language of each grant, and to convert the dimensions to the equivalent in the chain unit.

The public domain is made up largely of areas acquired from France, Mexico, and Spain, by cession and purchase. Prior to the acquisition of the areas by the United States, those foreign governments had made many grants of land to private individuals as reward for services rendered, to promote trade, and encourage settlement in their colonies. Such private land grants, when duly authenticated and confirmed, were recognized by our government and the areas thereof were segregated from the lands subject to disposal under the general public land laws.

These land grants were surveyed under authority, and described in terms of the units of measurement customarily used by, the granting sovereignty. Thus, the arpent (*arpen*) was in general use in the French settlements in North America, and the vara was generally employed throughout the Spanish and Mexican settlements. The present day use of those units on surveys within the public domain is limited to those instances where it may be necessary to retrace the boundaries of private land grants.

Slightly different values were employed for the arpent and vara in the French, Spanish, and Mexican private land grants in the several surveying districts, due to the lack of exact standards, the continuation of local practice and usage, and the use of approximate conversion factors. Where necessary to ascertain the definite equivalents for conversion of the units, an examination should be made of the early surveying records and court opinions of that particular district for the authority.

The values stated in table 26, Standard Field Tables, are provided as an aid in the interpretation of the descriptions which may be found in the early land grants.

## The Arpent

The arpent (*arpen*) is a French unit of *area* whose value varied depending on origin and local custom, as the *arpent de Paris*, the *arpent commun*, and the *arpent d'ordonnance*. *Troll* v. *City of St. Louis*, 168 SW., 167 (1914).

The arpent is not primarily a unit of linear measure, but tracts of land were frequently described in terms of arpent frontage and depth, the unit being the side of a square arpent; in this manner, by custom and usage, the arpent came to be considered also in terms of linear value.

The Surveyor General's office at St. Louis, Mo., adopted a definite value for the arpent which was used consistently in the surveys in Arkansas and Missouri, as follows:

1 arpent = 0.8507 acres
The side of the square arpent = 2.91667 chains (192.500 feet).

(Report of the Commissioner, General Land Office, 1869, p. 406).

A slightly different value for the arpent appears to have been adopted in Louisiana, Mississippi, Alabama, and northwestern Florida. While no authoritative definition for the value of the arpent in this region is known, the following values have been derived from the records of early surveys:

1 arpent = 0.84625 acres (nearly).
The side of the square arpent = 2.909 chains (191.994 feet)

## The Vara

The vara is a Spanish and Mexican unit of linear measure which was employed generally in description of lands granted by those sovereignties. The vara also is found to have different values, depending on locality and custom.

The *Castilian vara* was the Spanish unit of linear measurement generally adopted in the land grants of that sovereignty in Florida, with the following value:

1 vara = 33.372 inches (4.2136 links)
100 varas = 4.2136 chains (278.100 feet)

*Mitchel* v. *United States*, 15 Peters 51, 57 (1841).

The *Mexican vara* was the unit of linear measurement generally adopted in the early land descriptions in the area of the public domain of the southwest, where early settlement was of Spanish and Mexican origin.

The standard vara of Mexico which was brought to the United States at the close of the Mexican War was found to be 32.9682 inches in length. *United States* v. *Perot*, 98 U. S., 428 (1878). However, by agreement of September 15, 1837, between the Mexican republic and the holders of her bonds, it is stated that the Mexican vara is equal to 837 French millimetres; with this value

1 vara = 32.95269 inches

elsewhere in that agreement, the value of the vara is given

1 vara = 32.99312 inches

(Report of the Commissioner, General Land Office, 1854, p. 27).

In California, the value of the Mexican vara has been recognized by common consent, as:

$$1 \text{ vara} = 33.00000 \text{ inches}$$

(Report of the Commissioner, General Land Office, 1854, p. 22; *United States* v. *Perot*, *supra*). This value also has been used universally in the survey of the private claims in New Mexico, having been officially recognized by the Court of Private Land Claims, and generally in Arizona.

In Texas, by legislative enactment, the value of the Spanish vara has been established as:

$$1 \text{ vara} = 33.33333 \text{ inches}$$

(Acts of Texas Legislature, 1919, p. 232). Ordinarily, in Texas, it is recognized that 36 varas = 100.000 ft.

It will be seen that the value of the vara is not the same for all localities, and that local authorities should be consulted for a definite determination of the value in the particular locality of a survey.

## STADIA TEST

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

| Field record | | | | |
|---|---|---|---|---|
| Measurement of base by steel tape and clinometer | | | Vertical rod reading | Transcribed field notes |
| Mean vertical angle | Distance on slope | True horizontal distance | | |
| | *Chains* | *Chains* | *Feet* | |
| $-3\frac{3}{4}°$ | 6.40 | 6.386 chs. | 9.515 | July 7, 1945, I made the following test of the stadia wire interval: |
| $-4\frac{1}{2}°$ | 2.70 | 2.692 | 9.518 | Horizontal length of base = 14.160 chs |
| $+12\frac{1}{4}°$ | 5.20 | 5.082 | 9.522 | Mean of ten rod readings = 9.5200 ft. |
| | | | 9.519 | Vertical angle of test = +1°54′ |
| Total base | | = 14.160 | 9.527 | $K$ = 98.193 |
| | | | 9.513 | |
| $(c+f)$ | | = .012 | 9.521 | $\log \frac{K}{66}$, rod in feet and horizontal distance in chains = 0.172537 |
| | | | 9.524 | |
| Stadia base | | = 14.148 chs. | 9.521 | |
| " " | | = 933.768 ft. | 9.520 | |
| Mean rod reading = | | | 9.5200 | |
| Coefficient for 1°54′ = 0.9989; 0.0011×9.5200 = | | | .0105 | |
| $r \cos^2 v$ = | | | 9.5095 | |
| $K = \frac{933.768}{9.5095} = 98.193$ | | | | |
| $\log K = 1.992081$ | | | | |
| " $66 = 1.819544$ | | | | |
| " $\frac{K}{66} = 0.172537$ | | | | |

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

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

## THE USE AND TEST OF THE MAGNETIC COMPASS

**40.** There are many legitimate uses of the compass, provided that frequent and complete tests have been made in that same locality, by solar or other acceptable method, by which to determine the magnetic declination and its diurnal variation. In all cases this is dependent upon the needle being in good order, and where there is known freedom from local attraction. Among the common uses, there are: (1) as an aid in the retracement of the early surveys that were made by needle compass (this is frequently very helpful in following an old line); (2) when making surveys for topographic detail (of secondary accuracy) at times of cloudy weather, or in the early or late hours of short winter days when the sun is low, and during the noon period; (3) for blazing the true lines when the sun can not be used (but the exact location of all corners must be determined by the approved methods); and, (4) similarly, for noting bearing trees, when the sun is not available. Where the needle is employed as in blazing or noting bearing trees, the field-tablet record should show that a test has been made on that date on a line of known azimuth as a check against the possibility of magnetic storm.[1]

Another general use, frequently very helpful, is to use the needle for the setting of a trial mark for beginning the meridian observations, when there has not been a chance to set a reference mark by a better method. Sometimes a beginning point on a survey, or a turning point, is badly "pocketed" where there is little or

[1] Magnetic Declination in the United States: Definition of terms, compass surveys, and tables. U. S. Coast and Geodetic Survey: Superintendent of Documents, Government Printing Office, Washington, D. C.

no chance for a solar observation, and in situations where there can not be a satisfactory back sight. In these cases the use of the needle may give a satisfactory direction to a forward point that may be occupied for a meridian observation, and for correction of that point to desired position.

The detail of the use of the needle in the above manner is not ordinarily carried to the transcribed field notes, other than the normal recording of the magnetic declination, and the local attraction if found to exist. A record of the magnetic declination is doubly important if the needle has proven to be helpful in the retracement or identification of a prior survey. Section 236, item 19.

The larger General Land Office solar transits have a variation plate and vernier that will permit a good reading to the nearest 5′; the smaller instruments do not have a variation plate, the readings being estimated to the nearest 10′. To be dependable, no readings should be made where there are nearby electric or steel wires, rails, or similar disturbing influences.

The observations should include certain minimum requirements, as follows:

1. At the camp meridian, through the whole day at intervals of not to exceed 1 hour, on 2 or more days, well separated; this will ordinarily be done when making the tests for the orientation of the solar unit. The data will give the amount and time of the daily variation.

2. On 1 mile of each township exterior, where these lines are a part of the survey, taken at two or more well separated points, in connection with the line work; date and time of day recorded.

3. Same, on 1 mile of the subdivisional survey, observed within each quarter township.

4. At the township or section corner at the southeasterly point of the survey, this reading to be corrected to the mean magnetic declination.

## THE TRANSIT ADJUSTMENTS

**41.** Presuming that the transit is in good order and adjustment at the beginning of the survey, and that the chief of field party is supplied with his favorite college text books on surveying, which give the detail of how to make the transit adjustments, and having in hand the maker's bulletin or Manual on the transit, its care, use, test and adjustment, its performance then depends largely on the attention that is given to its care, the "touch up" adjustments that may be required from time to time, and the methods of operation by which small residual errors of adjustment may be compensated or eliminated. It is equally important to understand the things that should be avoided. These very practical considerations are stressed in the explanations that follow, all with regard to the conditions of the survey most likely to be encountered, as these fit into the Manual methods.

The instrument should be cleaned daily to avoid accumulations of dust, just a brushing off; a small flat-brush for the general cleaning; a pointed brush for the tangent and clamp screws; a camels-hair brush and/or a piece of soft-worn linen (free from lint) for the lenses, exposed arcs, verniers, and the reflector. Avoid all noticeable accumulations of dust or oil. Be prepared daily to give the instrument complete protection against dust, rain, or snow.

Avoid an over-adjustment of any kind. Do not continually change the adjustments. Unless it is plainly demonstrated do not make an adjustment at all. In most cases do not make an adjustment until the performance from day to day gives a consistent indication that a certain "touch up" will be an improvement. Then be certain of the direction of the movement that is required, and in small amount to improve the adjustment without passing the point of perfect adjustment.

If the instrument has suffered the misfortune of a fall or other accident, be extremely careful not to make matters worse by forcing any movement that binds in the least. If binding is noticed in the slightest particular, tighten every clamp to snug and let it be sent to the maker or to an instrument shop for attention.

There is no field adjustment for worn centers, nor to correct centers that have been sprung by an accident. The daily performance will indicate the condition of the centers. Many observations require a careful levelling with the telescope level. When so levelled on one center, it should hold for the other center; if not, the centers are worn, or sprung in relation one to the other. There is no field adjustment, or compensation for this. If small, it may be neglected in work that is not too exacting; if bad, it requires shop correction.

An instrument that is in good adjustment when shaded, or in moderate temperatures, may show quite a change in the plate levels and/or in collimation, when exposed to a hot sun.[2] Do not change the adjustments under these conditions; instead, employ the methods that will compensate the differences.

The eyepiece should be on correct focus for the user of the instrument. Insist that others do not change that focus when taking just an occasional sight. Always check this focus if others have used the instrument. Precision observations cannot be secured if there is appreciable "parallax" in this focus. Check the eyepiece focus against a perfectly flat field in the sky, sighting away from bright light, and where there are no objects such as a moving cloud that would influence the muscles of the eye.[3]

The term "direct" sighting as used in reference to making the instrumental adjustments, stellar observations, etc., means the position of the telescope when the telescope level is underneath; "reversed" sighting is the opposite position.

Before starting to make any adjustments, make certain that the parts are thoroughly clean, and that the related movements are working smoothly, freely, and without play such as weaving in any noticeable amount.

Also, give daily attention to the tripod to see that the wing nuts are snug, but not so tight as to cause a straining on the tripod head.[4] Notice that all screw adjustments, and plate screws, are snug, and that the metal shoes are tightly fitted.

The problem in making the instrumental adjustments is to bring all geometrical elements into proper inter-relation. All engineer's transits of American design, the one-minute transit ordinarily employed in land surveying, are substantially the same in basic principles of construction. They differ only slightly in the detail of accomplishing the desired adjustment. The vertical axis is the line through the vertical centers; it intercepts the horizontal circle at the center of the plate

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[2] The change indicated comes from unequal temperatures within the instrumental parts, therefore inequalities in expansion. If an adjustment must be made in the sun, the instrument should be protected by shading, and turned frequently to equalize its expansion or contraction changes.

[3] To verify this focus of the eyepiece, first hold a piece of white paper a few feet in front of the objective lens, checking the appearance of the cross wires which should be sharp and black; then turn the telescope to a well-defined distant object, focusing by movement of the objective slide for sharp appearance of the image. If no parallax can be detected when moving the eye position from side to side or up and down, the eyepiece focus is good, but if the image becomes displaced with respect to the cross wires the eyepiece focus is not perfect. In the latter case, first change the objective focus to remove the parallax (disregarding sharpness of image until that has been accomplished); this will bring the image into the plane of the cross wires. The sharpness of the image may now be improved by a slight re-focus movement of the eyepiece. That position should be final for the user of the instrument, unless it becomes disturbed.

[4] When making a transit set-up for a precision observation, such as a repetition of angles or a series of direct and reversed sightings, where the final value in horizontal angle is sought much inside of a single vernier reading, and when making instrumental adjustments, it is necessary to remove the possibility of torque or straining. After getting a firm tripod setting, simply loosen the three wing nuts from snug, give the tripod head and legs a firm twist to the right and left to a perfectly free position, then tighten the wing nuts to snug.

graduations; it intercepts the horizontal plane of the telescope, or instrumental "H. I.", at the line of sight of the telescope, and at the horizontal axis of the latter.

There are five transit adjustments that may occasionally require a slight "touch up" in the field, but this should be seldom, and should be undertaken only with caution, and after ample demonstration, by performance, that the error is consistent under all normal conditions.

## Plate Levels

1. To bring the plate levels into a plane that is normal to the vertical axis. An error is ordinarily first noticed in daily use, especially in solar transit orientation, where the practice is to level with the solar unit on the west, reverse to solar unit on the east, or normal position, then, just prior to orientation, correct for level by just half the displacement of each bubble. If either bubble shows that it is consistently displaced slightly to one side on the reversals, especially when well shaded and in moderate temperatures, the error may be regarded as having been demonstrated, and may be corrected, if needed. A quarter-division displacement, when compensated in the manner described, represents not over 15″ in adjustment.

Carefully level the instrument using the telescope level, which is more sensitive than the plate levels. Then bring the plate levels into agreement.[5]

## Collimation

2. To make the line of sight normal to the horizontal axis. A small error may scarcely be noticeable where the sights are short, as when running through heavy forest cover or undergrowth, but it will be appreciable when reversing on long sights in the open. The difference in the two forward pointings is *four times* the error. As in the adjustment of the plate levels, an error in collimation may change appreciably in a hot sun, unless the instrument is well shaded, due to unequal temperatures within the instrumental parts that may cause disturbance in expansion. When fully demonstrated under normal conditions, an error in collimation may be corrected if needed, but it had better be left alone than to overadjust. Make a record of what is done, including the direction of the adjustment, and approximate amount in the turn of the capstan.

The sighting points should be at a considerable distance, the longer the line the better, but balanced for distance back and forward so as not to require appreciable change in focus[6] when turning from one to the other; both should be on low vertical angle from the instrument.

Ascertain the exact forward point at the mean of the reversals from the rear pointing. On any reversal then, the forward sighting shows double the actual error of collimation, counting from the mean. The General Land Office solar transits have the erecting eyepiece (image erect). Therefore the direction for the correction of the cross-wire assembly should be *apparently to increase* the error, but only in *half amount.*

For example, telescope direct, if the forward sighting is to the right of the true

[5] Models A, B, and C: Description of models, Manual Appendix II, section 78. Face the instrument, level vial on the near side. Mounting screw at left; capstan adjustment at right. Models B and C: two top slotted screws for mounting; capstan adjustment below, fitted with opposing spring inserted. It is helpful to use the reading glass when approaching good adjustment, to magnify the position of the bubble ends with relation to the vial division lines; avoid overadjustment.

[6] The collimation may be checked for change from long to short focus, but this is strictly a maker's adjustment.

mean, the reticle is to be moved to the right. The capstan screws are normal right-handed screws, but are purposely slight and should not be strained under any circumstance. First loosen the capstan that must be freed a partial turn (usually not over 1/16) to permit the tightening of the companion screw.[7] Check carefully, and make certain not to overadjust.

## Horizontal Axis

3. To make the horizontal axis normal to the vertical axis, or to correct any inequality in the height of the standards. A slight error may not be noticeable in taking ordinary sights, but will be manifest on reversals when sighting at extreme vertical angles. In most cases there is little opportunity to make the customary test under field conditions, probably the best check is to make the reversals on Polaris when at elongation.[8]

The usual plan of reversals in the observing programs is designed to compensate for small errors in this adjustment. It is well, occasionally, to reduce separately each of any two azimuth observations of a pair. If there is an appreciable error in this adjustment, the difference will be noted when making the separate reductions. In the event that an error in the adjustment of the horizontal axis seems probable, a direct check should be made by the reversals on Polaris.

A discrepancy in the reductions in pairs, if consistent along with several such tests, indicates an error in this adjustment. If the reductions of pairs of observations come out differently, it is a strong indication though not necessarily a proof that an error is present in the horizontal axis, as other inaccuracies may enter into the results. However, if the separate reductions compare well, it is usually safe to conclude that the adjustment of the horizontal axis is in good order.

If the difference in the reversals of the horizontal axis is appreciable, it may be corrected as follows:

If the adjustment is to go up, loosen the screws in the pivot cap and turn the adjusting screw right handed until the horizontal axis is in the required position. If it is already too high at point of adjustment, back the screw off a little and again raise by a right hand turn to the correct position.[9] When the adjustment is satisfactory, the screws in the pivot cap should be turned down just enough to prevent looseness in the bearings.

The later transits model A are equipped with what the makers call "automatic bearings" on the axle of the telescope. These include four small spiral springs, completely enclosed, which supply slight friction to the bearing cap. The friction provides a balance for the telescope in any position. The caps should be screwed down to a snug fit, as the springs will prevent any binding of the axle. Any slight rocking movement of the blocks need cause no concern as this will not affect the accuracy of the adjustments.

The models B and C transits have the upper bearing blocks separate from the

[7] Note the additional caution that the prior adjustment here may have placed a strain on these capstans, or on the vertical capstans, and/or the possibility that the collets through which the capstans play may not move freely. If the adjustment does not respond as it should, the vertical capstans may be freed slightly, but equally, then tap the vertical collets very gently. After the adjustment for the direction of the sighting has been accomplished, carefully reseat the vertical capstans. If all four capstans have been loosened at the same time, or if there has been any tapping on the collets, carefully verify the position of the vertical wire in true vertical alinement. Check on a plumb line, or sight on a sharp point and test by movement of the telescope in vertical angle.

[8] The reversals on Polaris may be made at any point in hour angle, provided that proper allowance is made for the small differential in azimuth. A check at twilight is the best time for this test.

[9] Sometimes in making a downward adjustment it is necessary first to force the pivot block beyond the point of perfect adjustment (by tightening the screws in the pivot cap, then loosen these screws before making the upward turn at the point of adjustment).

standard cap. The standard cap is screwed solidly to the standards, and carries in its center a capstan screw which presses against the upper bearing block. The proper friction or brake action on the telescope axle is adjusted by tightening or loosening these two capstan screws, one on top of each standard.

Identification and description of the instrument models: Manual Appendix II, section 78.

**4. Horizontal sighting: to be combined with:**
**5. Vernier of the vertical circle:**

In (4) it is to adjust the transit for levelling; and in (5) it is to secure correct vertical angle readings from true horizontal. On (4) alone the adjustment may be secured either by movement of the vertical capstans of the reticle, or by adjustment of the telescope level. Ordinarily, in the field, there is no good way to ascertain which of the two movements should have preference; however, when combined with (5) it is readily seen whether the vernier is in good position when the transit is levelled with the telescope level (disregarding the sighting), or if the vernier is in better position when the telescope is sighting in the true horizontal plane (disregarding the telescope bubble). If (4) is in good position (disregarding vertical angle readings) the adjustments should of course be left in that position, but if a "touch up" is required, make it at the point to favor the vernier setting as it is.

If the transit is to be used for careful levelling, it will have to be tested for that purpose. The first thing is to secure a true horizontal plane by any one of several methods. If the telescope level is of the "reversion" type, simply take the mean of the two horizontal sightings, telescope "direct" and telescope "reversed."

If the telescope level is not of the reversion type, the usual field practice is to secure the exact difference of elevation of two points A and B, well separated on nearly horizontal ground. This is done by placing the transit on the line between the points and equally distant from them; level carefully by the telescope bubble, and then take rod readings on both A and B; the difference in the rod readings will be the true difference in elevation of the points. Next, make a transit set-up on the line A—B extended, near A but far enough away so that sharp focus may be secured. Take the rod reading on A; then, set the target for the reading when in true horizontal sighting on B, which will be the same as on A plus or minus the differential.

The adjustment (4) may then be made, proceeding on the analysis previously described as to which one of the two points of adjustment should be moved. If this is to be done with the vertical capstans, note that with the erecting eye-piece the movement of the reticle is to be in the direction *apparently to increase the error*, and in *full amount* to sight in the true horizontal plane. Observe the same precautions as in making the adjustment for collimation.

If the adjustment (4) is to be made by movement of the telescope level, do the sighting in the true horizontal plane and bring the bubble to center when the sighting is in that position.

## Vernier of the Vertical Circle

5. After the transit has been adjusted for levelling, note the readings of the vernier of the vertical circle *when sighting in the true horizontal plane*, both in the direct and reversed positions. If these are appreciably different than zero, opposite in sign, and similar in amount, or nearly so, and if the vernier seems to be well "fitted" to the circle, it is much safer to use the readings as index errors as so much to be $\left\{\begin{matrix}\text{added to}\\ \text{or subtracted from}\end{matrix}\right\}$ plus vertical angles, and as so much to be

700004°—47——31

$\left\{\begin{matrix}\text{subtracted from}\\ \text{or added to}\end{matrix}\right\}$ minus vertical angles, direct position of the telescope. A similar record for the reversed position.

The difficulties liable to be encountered in moving the vernier are the loss of the proper space between the circle and vernier, thus changing the length of the vernier in relation to the arc, and the danger of not setting the vernier concentric with the circle. If the vernier is set too close there is grave danger of burring the graduated edges of both circle and vernier.

Note also, in the event that it is necessary to reset the vernier, that frequently the vernier does not seem to remain exactly where it is intended to place it; careful watching is required for some time after making a change in the setting.

If the vernier readings in the direct and reversed positions are appreciably different, it means there is an element of "*eccentricity*" in the relation of the center of the graduations to the setting of the vertical circle on its horizontal axis, which, if large, may be very troublesome. It can not be corrected in the field, but it may be partly compensated if the circle can be thoroughly tested on known vertical angles at intervals up to $+60°$.

Errors in vertical angle readings may be undetected unless a test is made for that purpose. If there is freedom from eccentricity, then the test (4) and the mean of direct and reversed readings, after applying the index error as noted above, should be in close agreement, and reasonably accurate for altitude observations. However, if the index corrections as determined by the tests (4) and (5) have not been correctly applied, and/or the compensation for eccentricity allowed for, if present, taking the mean of the reversals does not eliminate these errors.[10]

One other point. In the tests (4) and (5), the direct and reversed readings *may be* in close agreement, seemingly good but at the same time fail to show an eccentric mounting when the points of zero correction are in a vertical line, telescope horizontal. If that should be the case, an error of eccentricity does not become manifest in the tests until taken in the positions such as $\pm 40°$ vertical angle.

There are two methods of ordinary field practice that will demonstrate an error in vertical angle reading, i. e.—that the readings are not counted strictly from the true horizontal plane. The first is by latitude observation on Polaris as checked against a meridian altitude observation on the sun, for latitude, or a latitude observation on a star within the equatorial belt, or either as checked against a known true latitude. The second is to check an altitude observation for azimuth on the sun or a star southeasterly against an observation southwesterly. Taking the mean by either method will accomplish a compensation. If successive comparisons show consistent differences then it may be regarded as demonstrated that even though the adjustments (4) and (5) have been made, and the index corrections properly applied, there is still present an uncompensated factor in eccentricity.

The equal altitude observation accomplishes a complete elimination of error in both (4) and (5); also, an error due to eccentricity. The more nearly the azimuth observation southeasterly, as above, can be brought into balance with the southwesterly, the more nearly complete will be the compensation for such errors.

[10] It can be accomplished if the vertical circle has *two double opposite verniers*, but the General Land Office solar transit is equipped with just one double vernier.

### The Magnetic Needle

The Manual comments on the legitimate uses of the compass, sections 40, 41, 236 item 19, and Appendix II, section 40, presume that the needle is in good order, and that all needed tests have been made.

A sluggish needle indicates weak magnetism or a dull pivot, or both. If the needle is properly active and oscillates freely, the next tests are for balance and straightness. The correction for balance is to move the weight toward the high end. Note carefully whether the cover glass is a simple cover, held by a bezel ring, or if it is a screw cover. The needle should be tested also for straightness and for the centering of the pivot. To test for straightness, read the angle between the two ends, first with the needle in normal position, then when turned end for end. This difference will be twice the error, and indicates the needle is bent one half that amount. If corrected the two ends of the needle should be 180° apart, providing the pin is in the center of the circle. To test the center pin read both ends of the needle at 0° and 180°, then turn instrument and test at 90°. Both ends of the needle should read exactly opposite in all instances; if not the pivot is bent.

## THE STAR MAGNITUDES, AND THE PLANETS

**61.** 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 2.2 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", i. e.—very changeable in position, so that the interpolations between the dates will be rough, close enough however for identification; their travel in the sky, from week to week, will be readily noted on acquaintance with them. The proximities of the planets to the selected stars, up to about 40 minutes in time of transit and 10° difference in declination are shown, in the tabulations, by footnote-reference.

The planets will appear differently in the telescope, Venus, very bright and slightly crescent when farthest from the sun, though not so bright, but decidedly crescent when near the sun. Mars is always an infrared, or dull red, in color, bright when the transit is near the midnight hour, but Mars is scarcely noticeable when its transit is within two or three hours of noon. Jupiter is very bright when passing the meridian any time from 9 p. m. to 3 a. m., and then in that position some of its several moons will always be in evidence, easily noticed 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 during the periods when their meridian passage occurs between 9 a. m. and 3 p. m., as their positions are then 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.

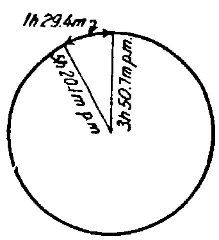
## REDUCTION FROM RIGHT ASCENSION TO GREENWICH MEAN TIME

**62.** Example of computation (for the tabulation in the Ephemeris) of the Greenwich mean time of the meridian transit of the star "No. 25/49, α Aquilæ (Altair), Mag. 0.9, on Sept. 16, 1945:

| | |
|---|---|
| Right ascension, or sidereal time of meridian transit, Sept. 16, 1945, from the American Ephemeris and Nautical Almanac, p. 316 | $\begin{cases}24^h\\19^h48^m07.7^s\end{cases}$ |
| Sidereal time of $0^h$ civil time, at Greenwich, same date, same reference, p. 12 (also, tabulated in the American Nautical Almanac, p. 3) | $23^h38^m18.3^s$ |
| Sidereal time interval | $20^h09^m49.4^s$ |
| Reduction to mean time interval (from the American Ephemeris, table II, pp. 535 to 537, or the Nautical Almanac, table V, pp. 287 and 288; condensed on p. 27 of the Ephemeris, and table 19, Standard Field Tables, p. 207) | $-3^m18.2^s$ |
| Mean time interval | $20^h06^m31.2^s$ |
| Subtract for p. m. | $-12^h$ |
| Star's Greenwich meridian transit, civil date, and mean time, Sept. 16, 1945 | $8^h06^m31.2^s$ p. m. |
| Tabulated in the Ephemeris as | $8^h06.5^m$ p. m. |

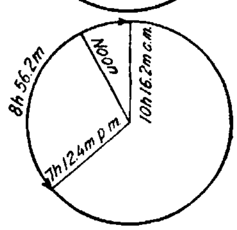
## EXAMPLES OF COMPUTING HOUR ANGLES OF POLARIS, BOTH WEST AND EAST OF MERIDIAN, WITH DIAGRAMS

**66.** Examples of computing hour angles of Polaris; all taken out for longitude 117°15′ W.:



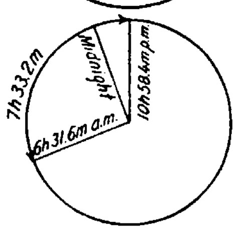

West of the meridian, p. m. obsn., U. C. in p. m.

| | | |
|---|---|---|
| Feb. 18, 1945, l. m. t. of obsn. | | $=5^h20.1^m$ p. m. |
| Gr. U. C., same date | $=3^h\ 52.0^m$ p. m. | |
| Red. for long. | $= -1.3$ | $=3\ 50.7$ p. m. |
| Hour angle, west | | $=1^h29.4^m$ |



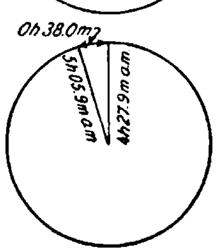

West of the meridian, p. m. obsn., U. C. in a. m.

| | | |
|---|---|---|
| May 14, 1945, l. m. t. of obsn. | | $=\begin{cases}+12\\7^h12.4^m\end{cases}$ p. m. |
| Gr. U. C., same date | $=10^h17.5^m$ a. m. | |
| Red. for long. | $= -1.3$ | $=$ 10 16.2 a. m. |
| Hour angle, west | | $=$ $8^h56.2^m$ |



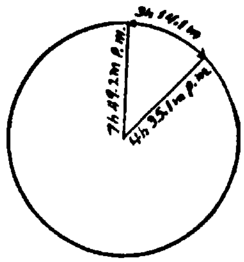

West of the meridian, a. m. obsn., U. C. in p. m.

| | | |
|---|---|---|
| Nov. 3, 1945, l. m. t. of obsn. | | $=\begin{cases}+12\\6^h31.6^m\end{cases}$ a. m. |
| Gr. U. C., Nov. 2 | $=10^h59.7^m$ p. m. | |
| Red. for long. | $-1.3$ | $=$ 10 58.4 p. m. |
| Hour angle, west | | $=7^h33.2^m$ |



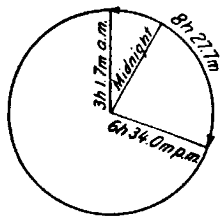

West of the meridian, a. m. obsn., U. C. in a. m.

| | | |
|---|---|---|
| Aug. 11, 1945, l. m. t. of obsn. | | $=5^h05.9^m$ a. m |
| Gr. U. C., same date | $=4^h29.2^m$ a. m. | |
| Red. for long. | $-1.3$ | $=4\ 27.9$ a. m. |
| Hour angle, west | | $=0^h38.0^m$ |



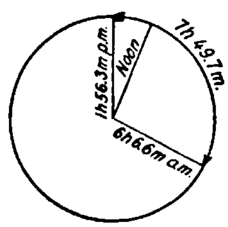

East of the meridian, p. m. obsn., U. C. in p. m.

| | |
|---|---|
| Gr. U. C., Dec. 20, 1945 | = 7$^h$ 50.5$^m$ p. m. |
| Red. for long. | = −1.3 |
| L. M. T. of U. C., Dec. 20 | = 7 49.2 p. m. |
| L. M. T. of obsn., same date | = 4 35.1 p. m. |
| Hour angle, east | = 3$^h$ 14.1$^m$ |



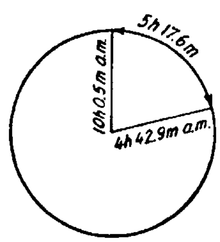

East of the meridian, p. m. obsn., U. C. in a. m.

| | |
|---|---|
| Gr. U. C., Sept. 2, 1945 | = 3$^h$ 3.0$^m$ a. m. |
| Red. for long. | = −1.3 |
| L. M. T. of U. C., Sept. 2 | = { 3 1.7. a. m. +12 |
| L. M. T. of obsn., Sept. 1 | = 6 34.0 p. m. |
| Hour angle, east | = 8$^h$27.7$^m$ |




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

| | |
|---|---|
| Gr. U. C., Mar. 19, 1945 | = 1$^h$57.6$^m$ p. m. |
| Red. for long. | = −1.3 |
| L. M. T. of U. C., Mar. 19 | { = 1 56.3 p. m. +12 |
| L. M. T. of obsn., same date | = 6 6.6 a. m. |
| Hour angle, east | = 7$^h$49.7$^m$ |




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

| | |
|---|---|
| Gr. U. C., May 18, 1945 | = 10$^h$ 1.8$^m$ a. m. |
| Red. for long. | −1.3 |
| L. M. T. of U. C., May 18 | = 10 0.5 a. m. |
| L. M. T. of obsn. | = 4 42.9 a. m. |
| Hour angle, east | = 5$^h$17.6$^m$ |

## DEVELOPMENTS OF THE SOLAR UNIT

**78.** The several models of instruments that have been used extensively in the subdivision of the public lands of the United States, as designed for instrumental orientation in parallel position with the pole-zenith-sun celestial triangle.

The Burt solar compass, 1836 to 1914: an outstanding improvement over the needle compass; an excellent instrument on the prairies and in the woods, fully capable of performing within the accuracy that was required during the period of its use. It was not equipped for making stellar observations, and was not suited to rough mountain country.

The engineer's transit, 1885 to 1900: equipped with the Burt solar attachment mounted on the transit telescope. This adapted the theory of instrumental orientation to the transit, but did not add to the accuracy. The solar compass performed with much greater speed, and with more stability of adjustment.

The engineer's transit, 1886 to 1910: equipped with the Smith solar attachment mounted on one standard; four-point base; declination tangent motion by long screw, ball and socket construction; latitude clamp operating on the frame of the solar unit. This combined the speed of the solar compass with the facilities of the transit for running lines. It was well suited to rough mountain country. It lacked certain details of construction required in making stellar observations, and for the exact field adjustment of the solar unit.

An engineer's transit, 1900 to 1914: fully equipped for making stellar observations for time, latitude, and azimuth; the Smith solar unit. This provided the means for making altitude observations on the sun, aiding greatly in checking and verifying the performance of the solar unit. This model, as heretofore, lacked esssential detail for the exact field adjustment of the solar unit; the need for the re-design of the solar unit became apparent.

A. The General Land Office Solar Transit, 1914 to 1945. Transit fully equipped for making stellar observations for time, latitude, and azimuth, including altitude observations on the sun. Essentially the Smith solar unit, but with a three-point base; striding level adjustment; re-design of the clamp and tangent motion for the declination arc. This instrument has been thoroughly well-adapted to the public-land surveying practice, adding very considerably to the accuracy of the solar orientation. The long-continued and widespread use of this instrument provided the experience that was required in order to trace and demonstrate residual errors of construction and adjustment, if present in individual instruments of this series.

B. The General Land Office Solar Transit, 1937 to 1945. Transit specifications as in model A. A telescopic solar unit, combining the principles of the Smith solar, but with a three-point base; declination clamp as in model A; *latitude clamp operating on the latitude axis;* complete field adjustment by the prime vertical method; striding levels eliminated.

C. The General Land Office Solar Transit, 1946. Transit specifications as in model A, *and for the first time in any surveying instrument, a solar circle in the reticle of the transit telescope.* The solar unit as in model B, excepting that *the declination clamp operates on the reflector axis;* improved mechanical construction including *means for setting the declination vernier* without disturbing the radius and the concentric mounting with relation to the arc; *greatly improved optical construction* in the solar telescope.

## ADJUSTMENT OF THE SOLAR UNIT

**79.** Before starting in with the adjustments it should be determined that the solar telescope revolves smoothly in its collar bearings, neither too tight nor too loose; that there is free and smooth motion to the latitude and declination arcs; that the clamps are positive, and the tangent motions smooth; that the eyepiece is carefully focused upon the cross wires; and, that the objective is carefully focused upon a distant object, then secured in this position.[11]

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.

[11] Models A and C: the eyepiece turns freely, and has a pin which travels in a guide slot; this pin is not a clamp. The objective may be moved by first loosening, then pushing the screw, which will be found to travel in a guide slot near the lower (or left hand) collar bearing. Model B: the focus is secured by the movement of the whole eyepiece assembly; grasp the upper portion of the telescope tube which slides within the lower portion. There is no set screw for this focus adjustment.

Select a suitable sighting point, then in order to find its reflected image, determine the vertical angle counting from the H. I. of reflector; compute the setting for a north declination on the value: $\sin \delta = \sin \varphi \sin v$.

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°, and turn the solar telescope in hour angle to pick up the image of the sighting point.[12] 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° 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°, 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 $90° \pm \delta$; 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° for north declination; less than 90° 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

[12] 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.

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 declination, 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 (Manual sec. 83; table 22, Standard Field Tables).

If the field tests (1), (2), and (3) have been carried through successfully, the solar 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 levelling, 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 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 tests (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 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 relation 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. Figure 100.

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

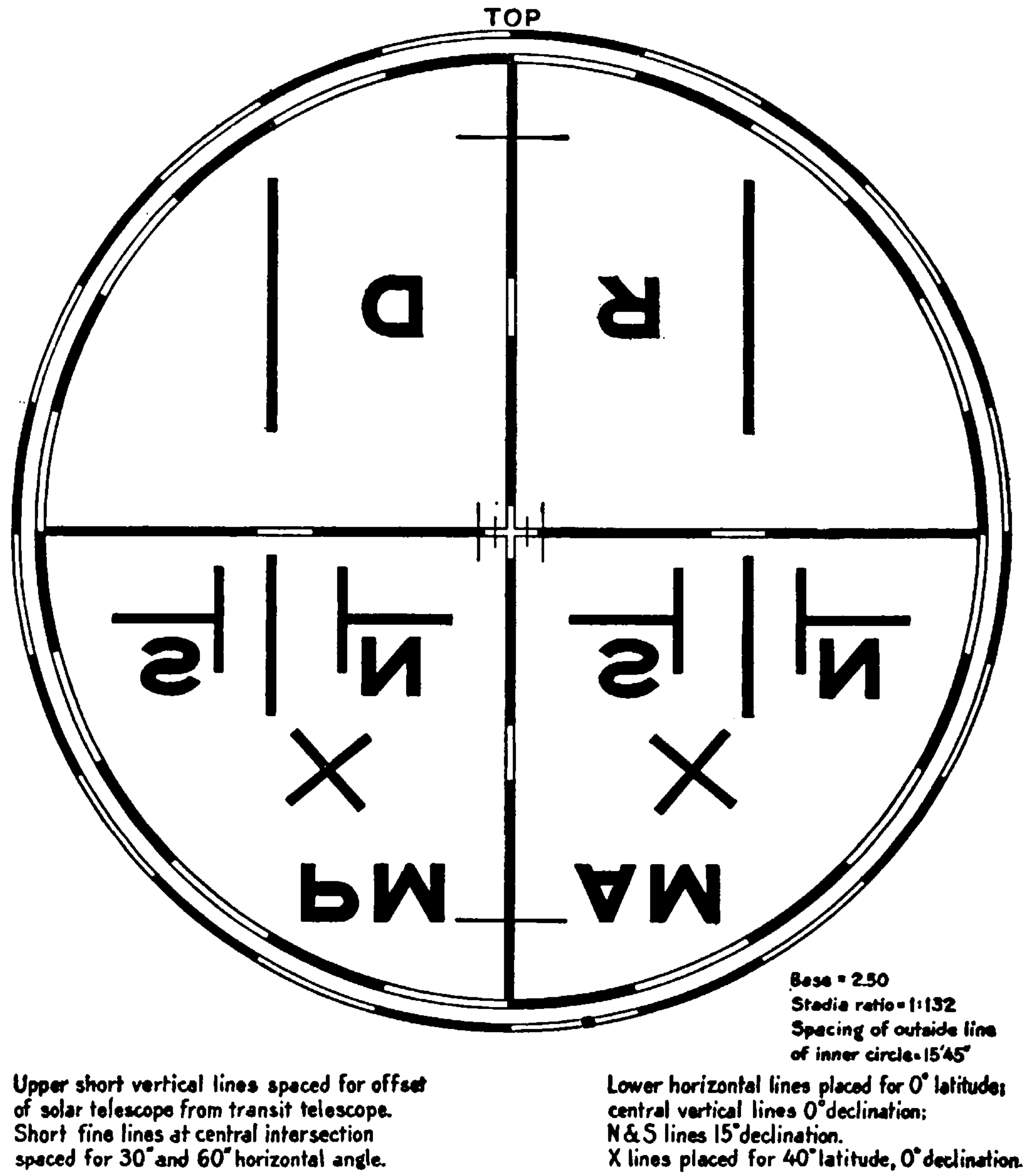



FIGURE 100. The solar diagram.

vertical lines are for testing the declination arc at 0° and at 15° 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°.

(1) *The equatorial wires, for parallel to axis of reflector.*—With the solar telescope clamped at 0° latitude, 0° in declination, and the transit oriented 90° 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.[13]

(2) *Collimation.*—With the solar telescope clamped at 0° latitude, make a direct sighting[14] 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. Manual Appendix II, section 41.

(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 semidiameter 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 displacement 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;

[13] A very light tapping on the capstans may be necessary to move the reticle in rotation. Model A has the regular capstans. Models B and C have a cover ring over the adjusting screws; the cover ring screws back over the telescope tube.

[14] Model C: The reflector is constructed of *clear optical glass*, the planes truly parallel, and duly tested. The direct sighting will be through the reflector glass.

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 101.

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 pointings should be symmetrical with respect to the D and R lines.

Adjust second at one end of the frame that supports the solar telescope.[15] 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.

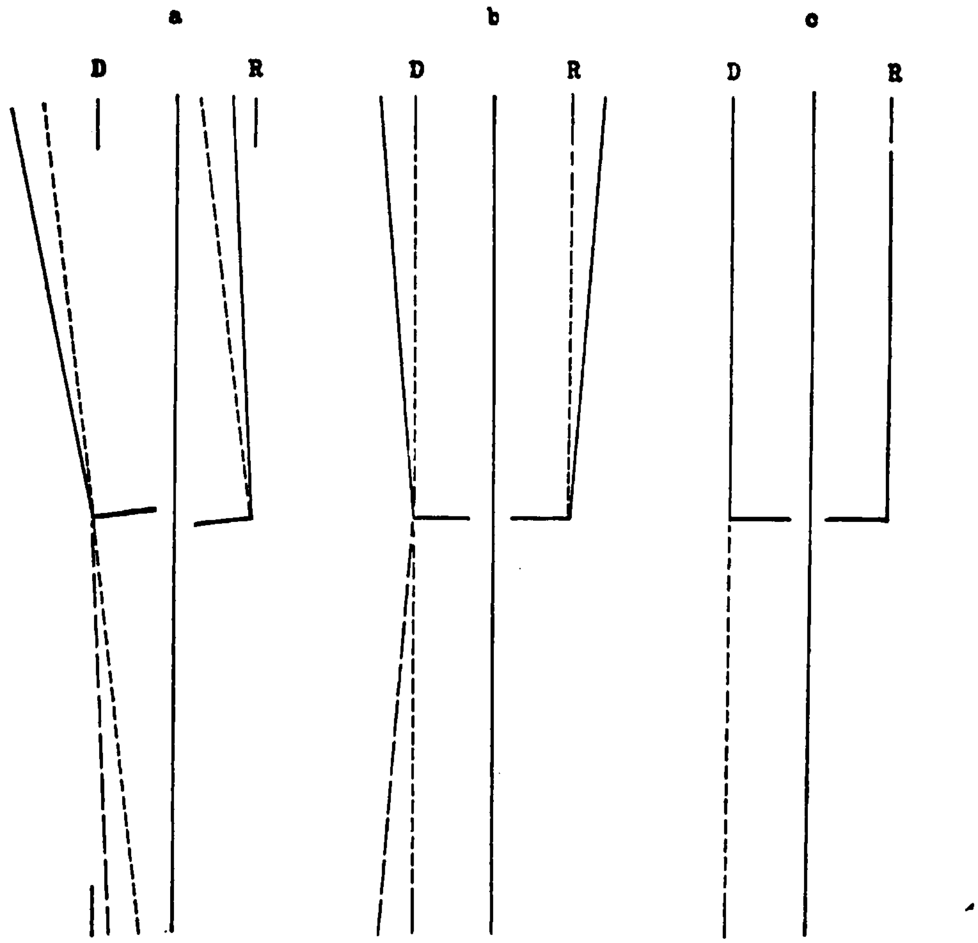
[15] Model A has heavy capstan nuts that control this adjustment.

Model B has three capstan screws; the center screw pulls the eye-piece end closer to the base; the outside are opposing screws.

Model C has two capstan screws; the neat adjustment is secured through the slight movement of a metal wedge, which itself is controlled by a slow-motion screw. In this model, first loosen the opposing capstan screws slightly; after the adjustment has been made, tighten again against the wedge.

In both models B and C care should be exercised to apply the same tension on the opposing screws. Note that an unequal tension may cause a strain at the cradle bar which supports the solar telescope which would tend to pass a strain to the collar bearings.

FIGURE 101. Adjustment of the Polar Axis.




ADJUSTMENT OF THE POLAR AXIS.

(*a*) The discrepancies in the diagram are exaggerated.

(*b*) First. Make the vertical plane of the latitude axis normal to the vertical plane of the transit telescope. Bring the sightings into symmetry, direct and reversed positions. Adjust at the foot post that controls the sighting at horizontal.

(*c*) Second. Make the line of sight of the solar telescope normal to the latitude axis. Bring the sightings into parallel, direct and reversed positions. Adjust on the frame that supports the solar telescope.

Third. The last step is to bring the latitude axis into horizontal. Adjust at the foot post that controls that position.

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 excepting only 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 the 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 test. 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. Figure 10. The striding level should be reversed to see if there is any error in the level itself, and if so take the mean position for the true indication of the level.

If the latitude axis is not horizontal it may be made so by adjusting the 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. After doing that, turn the transit 180° in azimuth and reverse both telescopes so as to sight again to the same distant object, setting the main tele-

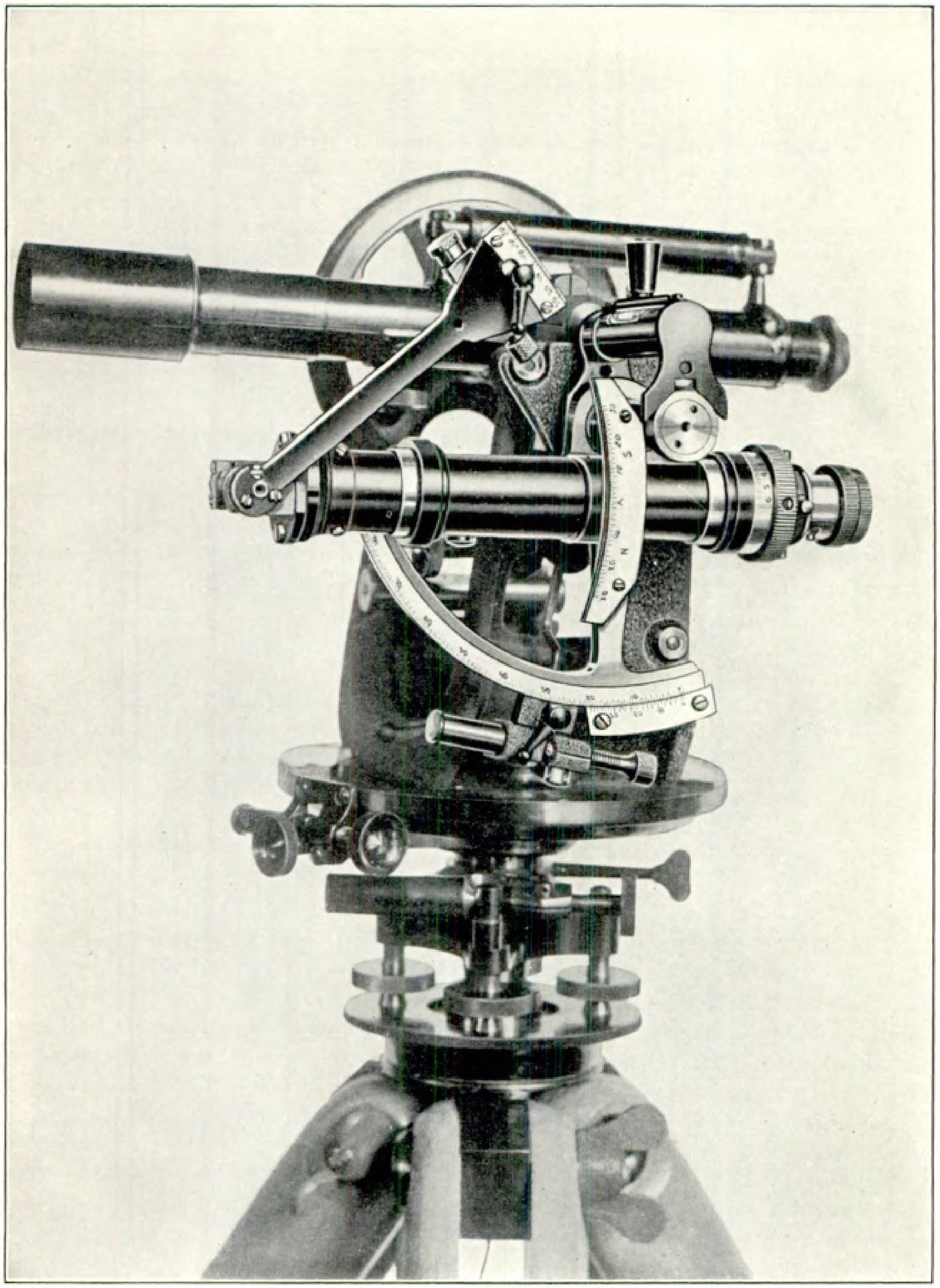


FIGURE 10.—Direct sighting through the solar telescope, with the reflector swung to a central position, and showing the striding level on the latitude axis.

scope upon the object. Figure 11. If the solar telescope does not again sight upon the distant object, one half the error is due to its line of sight not being at right angles to the axis of the latitude arc. Take up half of the amount of the error by means of the 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 accompished, 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. 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° and the part of the arc as from 30° to 50°.

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. Figure 12. The striding level should be reversed to see if there is any error in the level itself, and if so take the mean position for the true indication of the level. If the 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° latitude, and the declination at or near 0°. Set the main telescope on the long vertical line, then turn the transit 90° 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° 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.[16]

The next step is to check the reading at 15° north declination. Proceed in the same manner as above, except to make the turns 105° 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° north declination.

Check again on 15° south declination. The turns are 75° 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 the 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.

[16] 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.

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.

Model C: The declination arc is permanently seated at proper radius, and proper spacing; it is not intended nor expected that this relationship will be disturbed by field adjustment or use. 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 time of construction: it should rarely require attention excepting at the time of a maker's repair job.

When setting the vernier in zero position, a test is made to bring the reflector into an exact 45° 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 the adjustment, and that the reflector position was not disturbed from any cause.

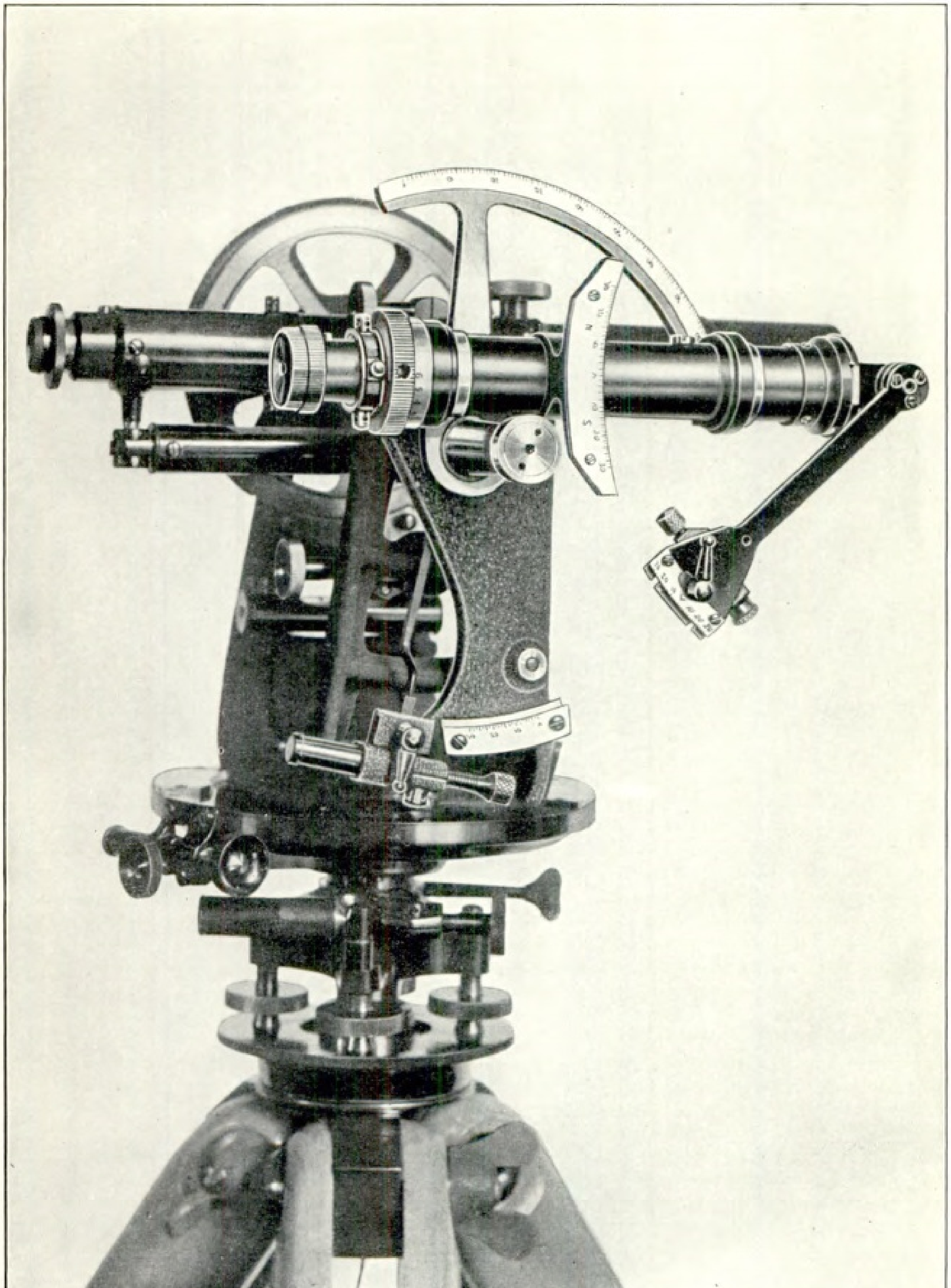


FIGURE 11.—The solar telescope in reversed position.

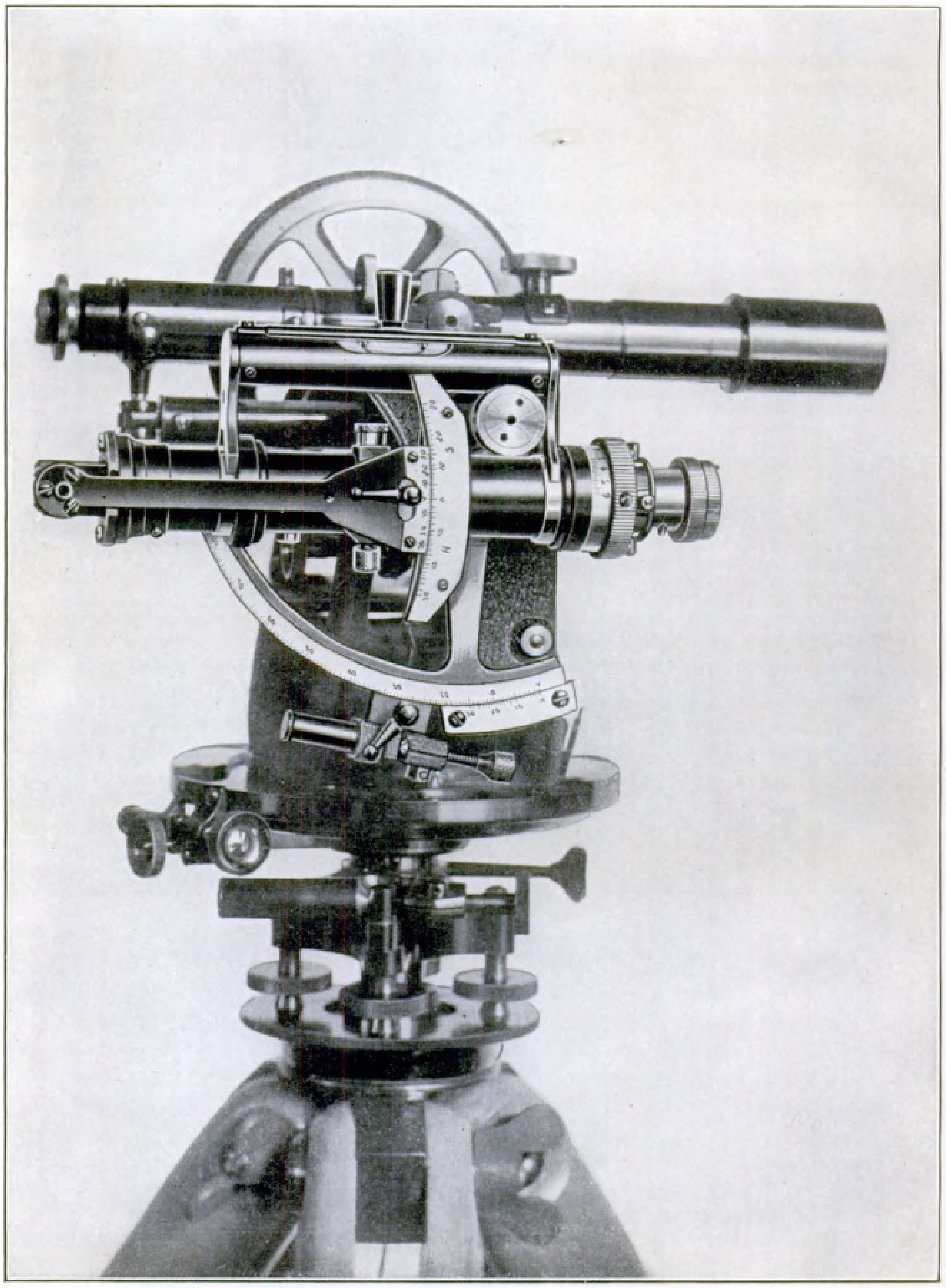


FIGURE 12.—The striding level on the solar telescope.

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. Level the transit and clamp with the main telescope in the meridian, elevated to the sun's altitude. Set your watch to read 12 o'clock as the sun's center crosses the vertical wire of the main telescope. At any convenient time thereafter set off the proper readings on the latitude and declination arcs, and with the instrument in the meridian, bring the sun's image to the center of the field of the 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° 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° for north declination, less than 90° 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°, reflector in the direction of the sighting point; and a north declination set to the value: $\sin \delta = \sin \varphi \sin v$; then turn the transit 90° 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° 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° position.

Set and clamp at 0° latitude, and declination arc at or near 0°. Set the horizontal plate to read 0°, the main telescope on the sighting point, the reflector toward the sighting point. Then turn the transit 90° 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° 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° 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°, reflector in the direction of the sighting point, and declination arc set to the value: $\sin \delta = \sin \varphi \sin v$. Then turn the transit 90° 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° 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° 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 *instrvmental 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, "$\delta$" is the calculated noon declination; $A$ will exceed 90° for north declinations; less than 90° for south declinations.

Start the test with the main telescope on the sighting point, plate reading at 0°, reflector in the direction of the sighting point. On the solar unit, set and clamped in 0° 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 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.

## 82. EXAMINATION, ADJUSTMENT, AND TEST OF THE GENERAL LAND OFFICE SOLAR TRANSIT

| *Principal Adjustments and Tests* | *Tests for Repairs and Reconditioning* |
|---|---|
| TRANSIT | |
| Plate levels | Centers |
| Cross wires, horizontal and vertical | Focusing movements |
| Collimation | Collimation, both long and short focus |
| Horizontal axis | Pivots and bearings |
| Horizontal sighting {single bubble / reversion bubble | Readings, A and B verniers, at intervals of 30° |
| Fitting of vernier, vertical circle | Repetition of angles, at 30°, 60°, and 90° |
| Zero of vernier at two positions of vertical circle | Reading of graduations, both circles and verniers (condition) |
| Vert. ang. readings at +40° and −40° | Horizontal and vertical clamps and tangent motions (condition) |
| Stadia ratio | |
| Needle: pivot, magnetism, and balance | Leveling screws (condition) |
| | Clean and lubricate (condition) |
| SOLAR UNIT | |
| Equatorial wires, parallel to axis of mirror | Fitting of telescope in collar bearings |
| | Focusing movements |
| Collimation | True image, direct sighting |
| Spacing of equatorial wires | True image, reflected |
| Line of sight, right angle to latitude axis | Fitting of axis of mirror |
| Latitude axis horizontal | Fitting of latitude arc, vernier, clamp, and tangent motion |
| Parallel sighting at horizontal | |
| Parallel sighting at 40° N. | Fitting of declination arc, vernier, clamp, and tangent motion |
| Zero, latitude vernier | |
| Reading of latitude arc at 40° N. | Reading of graduations, both arcs and verniers (condition) |
| Zero, declination vernier | |
| Reading of declination arc, noon test, latitude known | Reading of decl. arc at 15° N. and 15° S. |
| | Reading of decl. arc on 30° true hor. ang. |
| Azimuth tests: a. m. and p. m. | Reading of hour circle |

ACCESSORIES

| | |
|---|---|
| Transit case and fitting | Tripod, parts and fitting |
| Adjusting tools and sundries | Tripod case |
| Striding levels | Shipping box |

MEMORANDUM

√: Good  X : Requires correction  X√: Good after correction

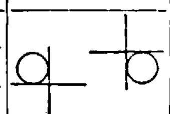
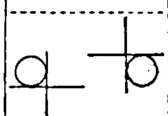
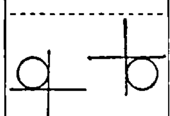
## THE SUN, SOUTH DECLINATION

**108.** Example of direct altitude observation of the sun for azimuth and time, sun south declination:
Date: November 9, 1944. Instrument: Buff No. 14187.
Observer: George W. Johnson. Recorder: Ray W. Garrett.
Collimator test of vertical circle,[17] September 5, 1944:

| | | |
|---|---|---|
| Telescope direct, sights good at zero | | 0°00′00″ |
| Telescope reversed, sights high at zero | | 0 01 00 |
| Mean index correction at zero | | 0′30″ |
| At true vertical angle | +40°00′00″ | −40°00′00″ |
| Mean corrected value | +40 00 30 | −40 00 00 |
| Mean index correction | −0′30″ | 0′00″ |

### *Transcribed field notes*

Nov. 9, 1944, at my station on the random line between secs. 13 and 14, T. 1 S., R. 27 W., 5th Prin. Mer., Arkansas, in latitude 34°39′37″ N., and longitude 93°50′ W., elevation above sea level approximately 1,000 ft., and temperature approximately 40° F., at 8ʰ56ᵐ a. m., app. time, in order to verify the adjustments of the solar unit, I make a series of three altitude observations of the sun for azimuth, each with the telescope in direct and reversed positions, observing opposite limbs of the sun, and reading the horizontal angle from a flag on my retracement line set by solar transit orientation S. 0°40′ W., SE. to the sun. My watch carries approximate apparent time.

| Observation | Telescope | Sun | Watch time | Observed vertical angle[17] | Horizontal angle, flag to sun |
|---|---|---|---|---|---|
| 1st | Direct<br>Reversed |  | $8^h\ 56^m\ 00^s$<br>8 57 00 | 22° 43′ 00″<br>22 18 00 | 49° 03′ 00″<br>48 15 00 |
| | Mean | | $8^h\ 56^m\ 30^s$ | 22° 30′ 30″ | 48° 39′ 00″ |
| 2d | Reversed<br>Direct |  | $8^h\ 57^m\ 30^s$<br>8 58 30 | 22° 57′ 00″<br>22 34 00 | 48° 42′ 00″<br>47 57 00 |
| | Mean | | $8^h\ 58^m\ 00^s$ | 22° 45′ 30″ | 48° 19′ 30″ |
| 3d | Direct<br>Reversed |  | $8^h\ 59^m\ 00^s$<br>9 01 00 | 23° 15′ 00″<br>22 50 00 | 48° 21′ 00″<br>47 33 00 |
| | Mean | | $9^h\ 00^m\ 00^s$ | 23° 02′ 30″ | 47° 57′ 00″ |

[17] In sec. 46 it is required that index corrections be cleared in the field tablet record. A test by collimator method for index error of the vertical circle used in this observation is given here. The correction for vertical angle readings follows in the example.

| | |
|---|---|
| By 1st obsn. flag bears | S. 0°39′41″ W. |
| " 2d " " " | S. 0 39 53 W. |
| " 3d " " " | S. 0 39 57 W. |
| Mean, true bearing of flag | S. 0°39′50″ W. |
| Watch fast of l. m. t., by 2d obsn. $15^m57^s$ | |

*Field record*

The declination of the sun for the mean period of the three observations= 16°56′38″ S.

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

| | | *1st obsn.* | *2d obsn.* | *3d obsn.* |
|---|---|---|---|---|
| | v= | 22°30′30″ | 22°45′30″ | 23°02′30″ |
| Transit index correction | = | −0 30 | −0 30 | −0 30 |
| Refraction (Coef.: .98 x 1.02=1.00) | = | −2 19 | −2 17 | −2 15 |
| Sun's parallax | | + 8 | + 8 | + 8 |
| | $h$= | 22°27′49″ | 22°42′51″ | 22°59′53′, |

The above observations are reduced for azimuth by the equation:

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

The function "sin δ" becomes negative for south declinations.

1st obsn.:

$\phi=34°39′37″$  $h=22°27′49″$  $\delta=16°56′38″$ S.

| | | |
|---|---|---|
| $\cos \phi=.822539$ | $\sin \delta=-.291435$ | $\tan \phi=$ .691408 |
| $\cos h=.924122$ | | $\tan h=$ .413470 |
| .760126 | .760126 | −.285876 |
| | −.383404 | −.383404 |

Cos $A$=−.669280
$A$=S. 47°59′19″ E.
Hor. ang.= 48 39 00

Bearing of flag=S. 0°39′41″ W.

2d obsn.:

$h$=22°42′51″

| | | |
|---|---|---|
| $\cos \phi=.822539$ | $\sin \delta=-.291435$ | $\tan \phi=$ .691408 |
| $\cos h=.922443$ | | $\tan h=$ .418600 |
| .758745 | .758745 | −.289423 |
| | −.384101 | −.384101 |

Cos $A$=−.673524
$A$=S. 47°39′37″ E.
Hor. ang.= 48 19 30

Bearing of flag=S. 0°39′53″ W.

3d obsn.:

$h=22°59'53''$

| | | |
|---|---|---|
| $\cos\phi=.822539$ | $\sin\delta=-.291435$ | $\tan\phi=\ .691408$ |
| $\cos h=.920518$ | | $\tan h=\ .424435$ |
| $.757162$ | $.757162$ | $-.293458$ |
| | $-.384904$ | $-.384904$ |

Cos $A=-.678362$

$A=$S. $47°17'03''$ E.

Hor. ang.$=$ 47 57 00

Bearing of flag$=$S. $0°39'57''$ W.

The second observation is reduced for time by the equation:

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

The product "tan $\phi$ tan $\delta$" is additive for south declinations.

| | | |
|---|---|---|
| $\cos\phi=.822539$ | $\sin h=.386134$ | $\tan\phi=.691408$ |
| $\cos\delta=.956591$ | | $\tan\delta=.304660$ |
| $.786833$ | $.786833$ | $.201644$ |
| | $.490745$ | $.490745$ |

Cos $t=.701381$

$t=45°27'41''$

$=3^h1^m51^s$

App. time$=8^h58^m09^s$ a. m.

Equation of time$=-16\ 06$

L. m. t. of obsn. $=8^h42^m03^s$ a. m.

Watch time of obsn.$=8\ 58\ 00$ a. m.

Watch fast of l. m. t.$=\ 15^m57^s$

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

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

$90°-\phi=90°-\ 34°39'37''\ =\ 55°20'23''=$colat.

$90°-\delta=90°-(-16\ 56\ 38\ )=106\ 56\ 38\ =$codec.

$90°-h=90°-\ 22\ 27\ 49\ =\ 56\ 32\ 11\ =$coalt.

$2S=229°49'12''$

$S=114\ 54\ 36$

Codec.$=106\ 56\ 38$

$S-$codec.$=\ 7°57'58''$

log sin $S$ 9. 957593

log sin ($S-$codec.) 9. 141724

log 9. 099317

| | | | |
|---|---|---|---|
| | log | 9.099317 | |
| log sin colat. | 9.915156 | | |
| log sin coalt. | 9.965729 | | |
| log | 9.880885 | 9.880885 | |
| log cos² ½ $A$ | = | 9.218432 | |
| log cos ½ $A$ | = | 9.609216 | |
| ½ $A$ | = | | 66°00′21″ |
| $A$ | = | | N. 132 00 42 E. |
| | = | | S. 47°59′18″ E. |
| Hor. ang. | = | | 48 39 00 |
| Bearing of flag | = | | S. 0°39′42″ W. |

**110.** The second of the above series is selected for an example of reduction for azimuth by the equation:

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

| | | | |
|---|---|---|---|
| | 90°00′00″ | | |
| h = | 22 42 51 | | |
| $\zeta$ = | 67°17′09″ | $\zeta$ = | 67°17′09″ |
| $\phi$ = | 34 39 37 | $\phi$ = | 34 39 37 |
| $\zeta+\phi$ = | 101°56′46″ | $\zeta-\phi$ = | 32°37′32″ |
| $\delta$ = | 16 56 38 (−) | $\delta$ = | 16 56 38 (−) |
| $\zeta+\phi+\delta$ = | 85°00′08″ | $\zeta-\phi+\delta$ = | 15°40′54″ |
| ½ $(\zeta+\phi+\delta)$ = | 42°30′04″ | ½ $(\zeta-\phi+\delta)$ = | 7°50′27″ |
| $\zeta+\phi$ = | 101°56′46″ | $\zeta-\phi$ = | 32°37′32″ |
| $\delta$ = | 16 56 38 (−) | $\delta$ = | 16 56 38 (−) |
| $\zeta+\phi-\delta$ = | 118°53′24″ | $\zeta-\phi-\delta$ = | 49°34′10″ |
| ½ $(\zeta+\phi-\delta)$ = | 59°26′42″ | ½ $(\zeta-\phi-\delta)$ = | 24°47′05″ |

| | | |
|---|---|---|
| log cos ½ $(\zeta+\phi+\delta)$ | | 9.867623 |
| log sin ½ $(\zeta+\phi-\delta)$ | | 9.935075 |
| | | 9.802698 |
| log cos ½ $(\zeta-\phi-)$ | 9.958033 | |
| log sin ½ $(\zeta-\phi+)$ | 9.134873 | |
| | 9.092906 | 9.092906 |

| | | |
|---|---|---|
| log tan² ½ $A$ | = | 0.709792 |
| log tan ½ $A$ | = | 0.354896 |
| ½ $A$ | = | 66°10′12″ |
| $A$ | N. | 132°20′24″ E. |
| | S. | 47°39′36″ E. |
| Hor. angle | = | 48 19 30 |
| Bearing of flag | S. | 0°39′54″ W. |

**111.** The second of the above series is likewise selected for an example of reduction for time by the equation:

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

| | | |
|---|---|---|
| log sin $\frac{1}{2} (\zeta + \phi - \delta)$ | | 9. 935075 |
| log sin $\frac{1}{2} (\zeta - \phi + \delta)$ | | 9. 134873 |
| | | 9. 069948 |
| log cos $\frac{1}{2} (\zeta + \phi + \delta)$ | 9. 867623 | |
| log cos $\frac{1}{2} (\zeta - \phi - \delta)$ | 9. 958033 | |
| | 9. 825656 | 9. 825656 |
| | log $\tan^2 \frac{1}{2} t$ | = 9. 244292 |
| | log tan $\frac{1}{2} t$ | = 9. 622146 |
| | $\frac{1}{2} t$ | = 22°43′50″ |
| | $t$ | = 45°27′40″ |
| | | = $3^h 01^m 51^s$ |
| App. time of observation | | = $8^h 58^m 09^s$ a. m. |
| Equation of time | | = −16 06 |
| L. m. t. of observation | | = $8^h 42^m 03^s$ a. m. |
| Watch time of observation | | = 8 58 00 a. m. |
| Watch fast of l. m. t. | | = $15^m 57^s$ |

## COMPUTATION OF GEOGRAPHIC POSITION

*Table of "M" and "P" Factors, and Explanation for the Conversion of Ordinary Latitudes and Departures in Chains Measurement to Seconds of Latitude and Longitude, With Examples.*

**133.** The "M" factors may be applied directly to measurements along a *meridian;* "P" factors to measurements along a *parallel.* A traverse that extends in the same general direction may be reduced to the equivalent latitude and departure, then convert the totals. Where there are abrupt changes in the direction (especially of long traverses), a conversion should be made to each of the principal turning points.

The latitudes should be converted first.

When taking out the "P" factor, use the latitude of the township or section line from which the measurement is taken. On a traverse, use the mean latitude. Where a traverse is converted in intervals, use the mean latitudes between the successive principal turning points.

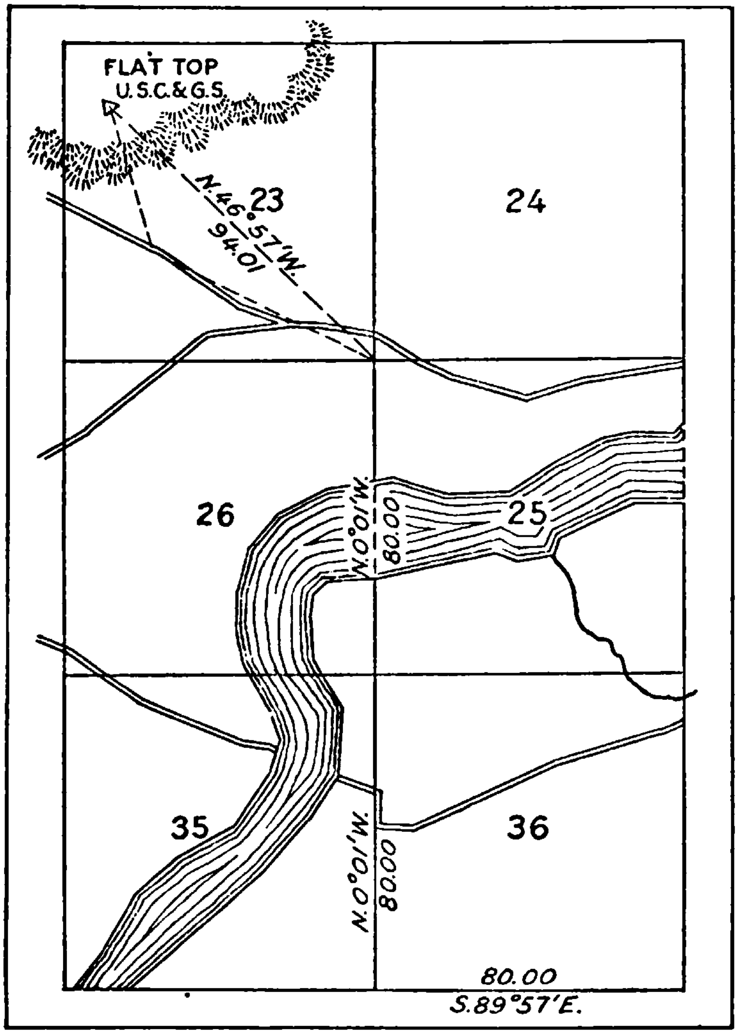
The following example prepared for 45° latitude is a condensed form derived from a table of "M" and "P" factors published by the U. S. Geological Survey.

| Lat. | nat M | nat P | Diff. nat P | | | | $d\phi$ 5″ | log M | log P | Diff. log P | | | | $d\phi$ 5″ | Lat. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1′ | 2′ | 3′ | 4′ | | | | 1′ | 2′ | 3′ | 4′ | | |
| ° ′ | | | | | | | | | | | | | | | ° ′ |
| 45 0 | .65167 | .91847 | | | | | | 9.814027 | 9.963065 | | | | | | 45 0 |
| | | | 27 | 53 | 80 | 106 | | | | 126 | 252 | 379 | 505 | | |
| 5 | 66 | .91980 | | | | | 2 | 21 | 3696 | | | | | 11 | 5 |
| | | | 27 | 54 | 80 | 107 | | | | 126 | 253 | 379 | 506 | | |
| 10 | 65 | .92114 | | | | | 4 | 14 | 4328 | | | | | 21 | 10 |
| | | | 27 | 54 | 81 | 108 | | | | 127 | 254 | 380 | 507 | | |
| 15 | 64 | 249 | | | | | 7 | 08 | 4962 | | | | | 32 | 15 |
| | | | 27 | 54 | 81 | 108 | | | | 127 | 254 | 382 | 509 | | |
| 20 | 63 | 384 | | | | | 9 | 4002 | 5598 | | | | | 43 | 20 |
| | | | 27 | 54 | 82 | 109 | | | | 128 | 255 | 383 | 510 | | |
| 25 | 62 | 520 | | | | | 11 | 3995 | 6236 | | | | | 53 | 25 |
| | | | 27 | 55 | 82 | 110 | | | | 128 | 256 | 384 | 512 | | |
| 30 | .65161 | .92657 | | | | | 14 | 9.813989 | 9.966876 | | | | | 64 | 30 |
| | | | 27 | 54 | 82 | 109 | | | | 128 | 256 | 385 | 513 | | |
| 35 | 60 | 793 | | | | | 16 | 82 | 7517 | | | | | 75 | 35 |
| | | | 28 | 55 | 83 | 110 | | | | 129 | 257 | 386 | 514 | | |
| 40 | 59 | .92931 | | | | | 18 | 76 | 8160 | | | | | 85 | 40 |
| | | | 28 | 55 | 83 | 110 | | | | 129 | 258 | 388 | 517 | | |
| 45 | 58 | .93069 | | | | | 20 | 70 | 8806 | | | | | 96 | 45 |
| | | | 28 | 56 | 83 | 111 | | | | 129 | 259 | 388 | 518 | | |
| 50 | 57 | 208 | | | | | 22 | 63 | 9.969453 | | | | | 107 | 50 |
| | | | 28 | 56 | 83 | 111 | | | | 130 | 260 | 389 | 519 | | |
| 55 | .65157 | .93347 | | | | | 25 | 9.813957 | 9.970102 | | | | | 117 | 55 |
| | | | 28 | 56 | 85 | 113 | | | | 130 | 260 | 391 | 521 | | |
| 46 0 | .65155 | .93488 | | | | | | 9.813950 | 9.970753 | | | | | | 46 0 |

The column headed $d\phi 5''$ supplies the differences in nat P and log P at intervals of 5″; intervals of 1, 2, 3, and 4″ may be taken on the lines for 10, 20, 30, and 40′, at one tenth.

Example of interpolations: latitude = 45°23′39″.

| | | | | | |
|---|---|---|---|---|---|
| 45°20′ | nat P: .92384 | | log P: 9.965598 | | |
| 3′ | 82 | | 383 | | |
| 35″ | 16 | | 75 | | |
| 4″ | 2 | | 8 | | |
| | | .92484 | | 9.966064 | 45°23′39″ |




Example of reductions.

See Specimen Township Plat.

From the cor. of secs. 23, 24, 25, and 26, triangulation station "Flat Top" bears N. 46°57' W., 94.01 chs. dist.; an official bronze tablet, seated in a concrete base; U. S. C. & G. S., North American Datum, 1927:

Latitude = 45°47'28.571"
Longitude = 107°56'31.003"

| *Traverse:* | *Chs.* | N. | W. |
|---|---|---|---|
| N. 69°11' W., | 24.93 | 8.86 | 23.30 |
| N. 61°18' W., | 39.11 | 18.78 | 34.31 |
| N. 16°53' W., | 38.19 | 36.54 | 11.09 |
| N. 46°57' W., | 94.01 | 64.18 | 68.70 |

| | For mean lat. of traverse: | | For S. bdy. of Tp.: |
|---|---|---|---|
| nat P: 45°45' | .93069 | | .93069 |
| 2' | 56 | | |
| 5" | 2 | | |
| 8" | 1 | 2" | 1 |
| | .93128 | | .93070 |

| To SE. cor. of Tp.: | | S. | E. |
|---|---|---|---|
| S. 0°01' E., | 160.00 | 160.00 | .05 |
| S. 89°57' E., | 80.00 | .07 | 80.00 |

| | |
|---|---|
| Lat. of Sta. "Flat Top" | 45°47'28.571" |
| na. M = .65158 | |
| South: .65158 × 64.18 = | 41.818" |
| .65158 × 160.07 = 104.298" | 1'44.298" |
| Lat. of SE. cor. Tp. | 45°45' 2.455" |

Memo.: Before taking out the "P" factors note (by inspection) that the mean latitude of the traverse is 45°47'08" (subtract, from the latitude of "Flat Top", one-half the latitude interval of the traverse, 20.9"); also, note that to reach the SE. cor. of the Tp. the easting was measured along the township line.

| | |
|---|---|
| Long. of Sta. "Flat Top": | 107°56'31.003" |
| East: .93128 × 68.70 = 63.979" | 1' 3.979" |
| .93070 × 80.05 = 74.503" | 1'14.503" |
| Long. of SE. cor. of Tp.: | 107°54'12.521" |

## Appendix III

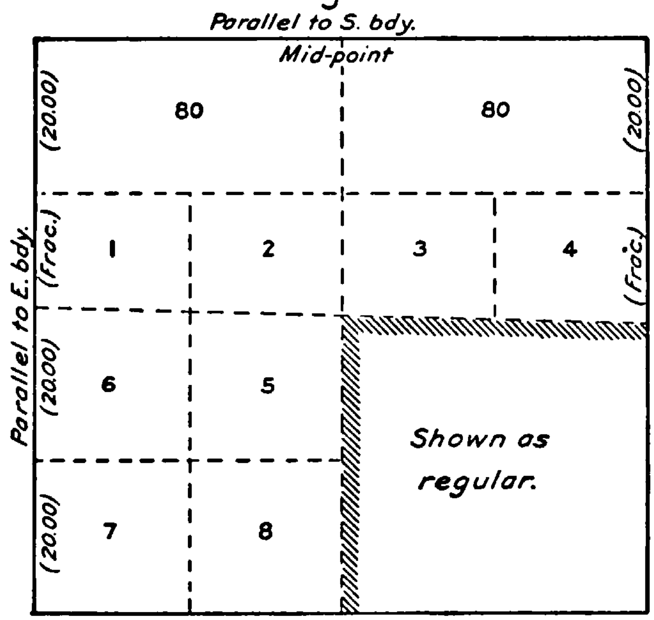
# COMPLETION OF PARTIALLY SURVEYED SECTIONS

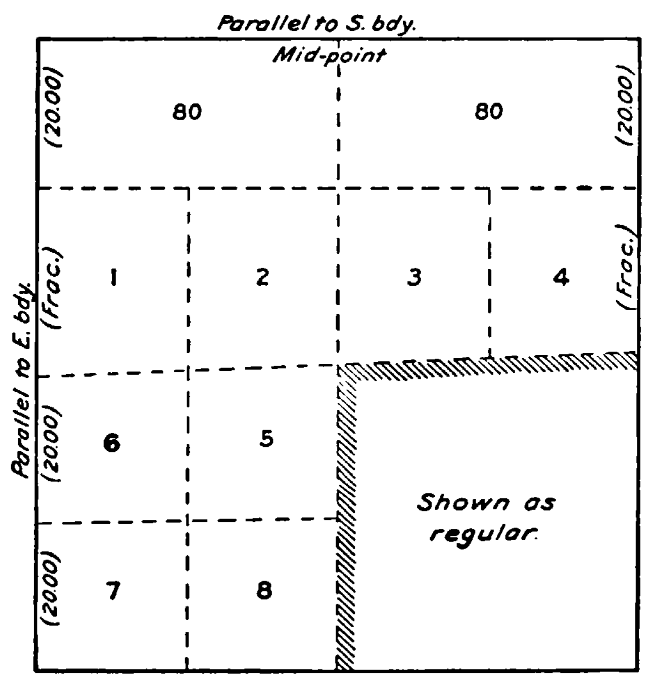
**216.** On the accompanying diagrams, figures Nos. 56 to 64, inclusive, are shown various examples of the procedure for the completion of the survey of irregular sections which contain outlying areas protracted as surveyed, illustrating the rules of survey that are necessary for the protection of such areas.

**217.** Let it be assumed that adjacent to two established section lines, the *meridional* line of which is out of limits in measurement, an outlying regular quarter section has been protracted as surveyed; then to complete the section the new section lines will be extended from the previously established section corners, parallel to the opposite established boundaries, or mean course thereof, to a mutual intersection. The quarter-section corner on the new latitudinal section line would be established regularly at the mean point, and would ordinarily be marked to control the subdivision of two sections. On the new meridional boundary one or two quarter-section corners may be required; one marked to control the subdivision of the section under consideration will be established at 40 chains from the original section corner; the same quarter-section corner would be marked to control the subdivision of the adjoining section if the fractional measurement is to be thrown in the same direction in the two sections, otherwise an additional quarter-section corner marked to control the subdivision of the adjoining section would ordinarily be placed at 40 chains from the new section corner. Again, let the same condition be assumed with the exception that the *latitudinal* section line instead of the meridional line is found to be defective in measurement. Then, to complete the section, the new meridional line would be surveyed as in regular subdivision, parallel to the opposite meridional line, or mean course thereof, ordinarily with quarter-section and section corners of maximum control at 40 and 80 chains, respectively. The new latitudinal section line would then be established on a true line between the section corners, and one or two quarter-section corners will be established as required; one marked to control the subdivision of the section under consideration will be established at 40 chains from the original section corner; the same quarter-section corner would be marked to control the subdivision of the adjoining section if the fractional measurement is to be thrown in the same direction in both sections, otherwise an additional quarter-section corner marked to control the subdivision of the adjoining section would ordinarily be placed at 40 chains from the new section corner.

**218.** Let another assumption be made that adjacent to two established section lines, the *meridional* line of which is out of limits in alinement, an outlying regular quarter section has been protracted as surveyed; then to complete the section, the new meridional line will be projected as a sectional guide meridian, in accordance with the usual rules, ordinarily with quarter-section and section corners of maximum control at 40 and 80 chains, respectively. The new latitudinal section line would then be established on a true line between the section corners, with one or two quarter-section corners as required; one marked to control the subdivision of

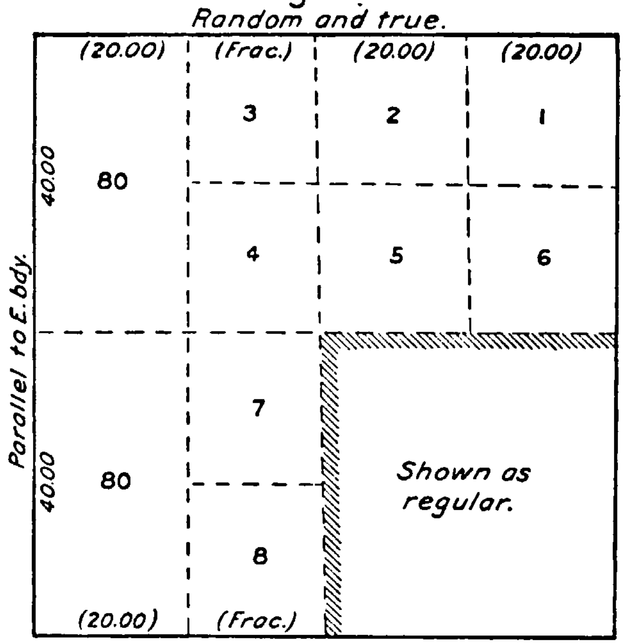
Fig. 56.

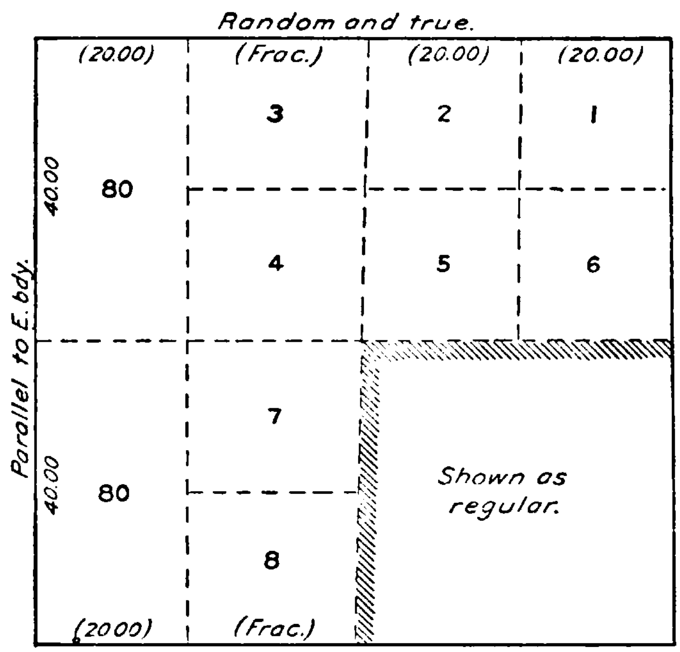



East boundary of section out of limits in measurement; southeast quarter protracted as surveyed; and section to be completed.

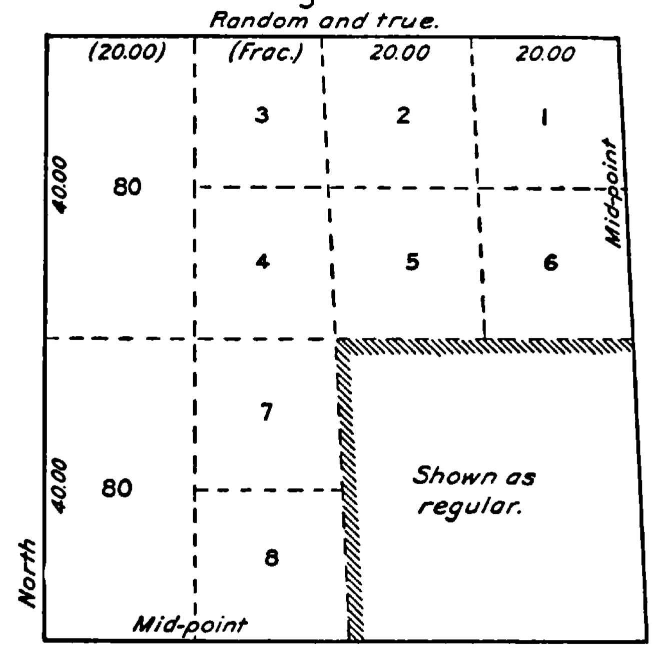
Fig. 57.

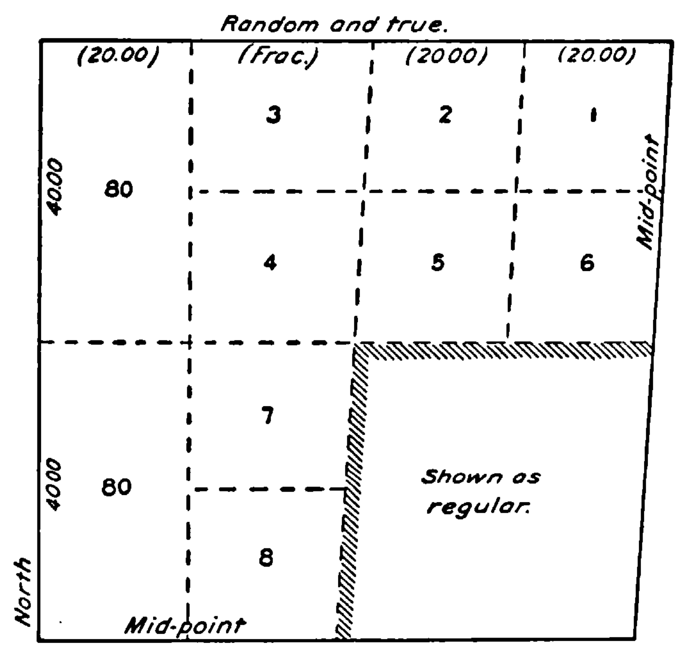



**South boundary of section out of limits in measurement; southeast quarter protracted as surveyed; and section to be completed.**

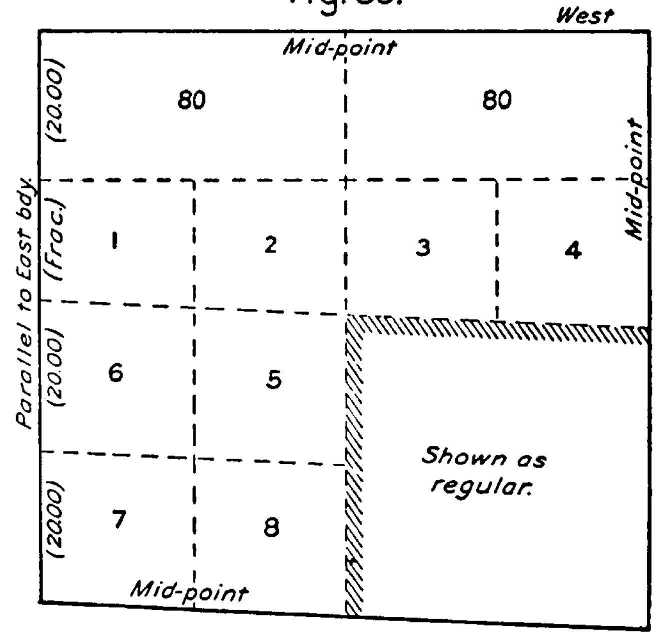
Fig. 58.

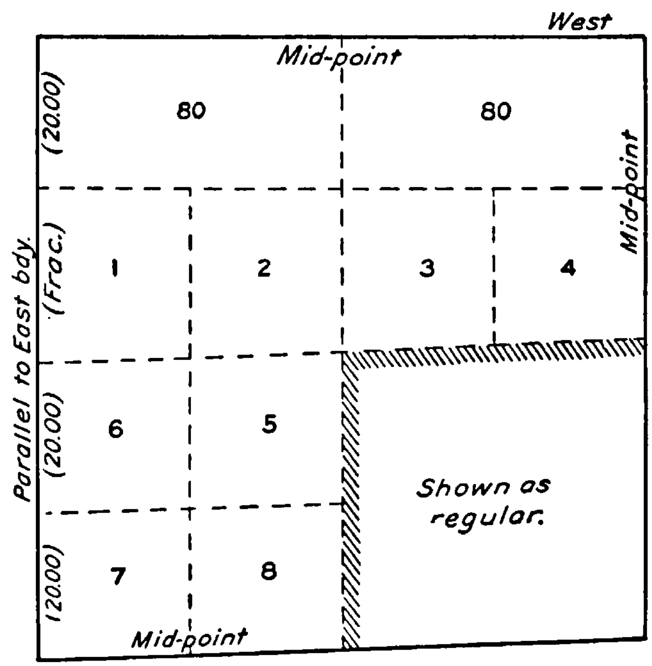



**East boundary of section out of limits in alinement; southeast quarter protracted as surveyed; and section to be completed.**

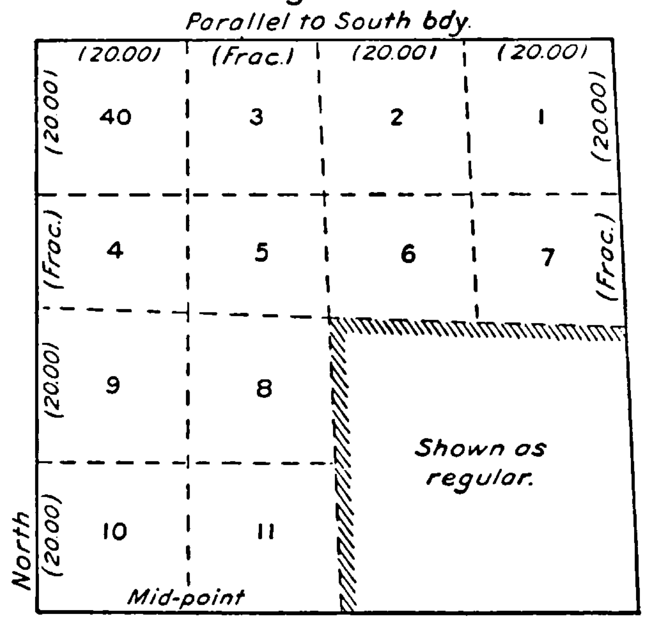
Fig. 59.

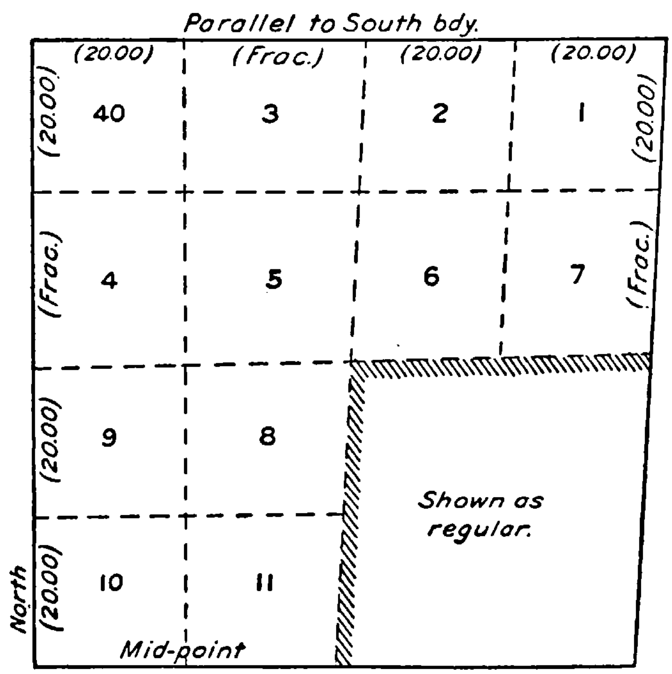



South boundary of section out of limits in alinement; southeast quarter protracted as surveyed; and section to be completed.

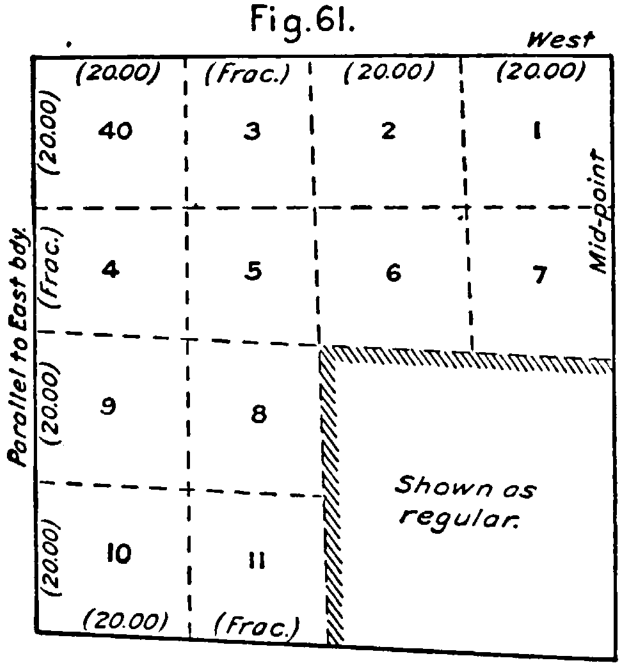
Fig. 60.

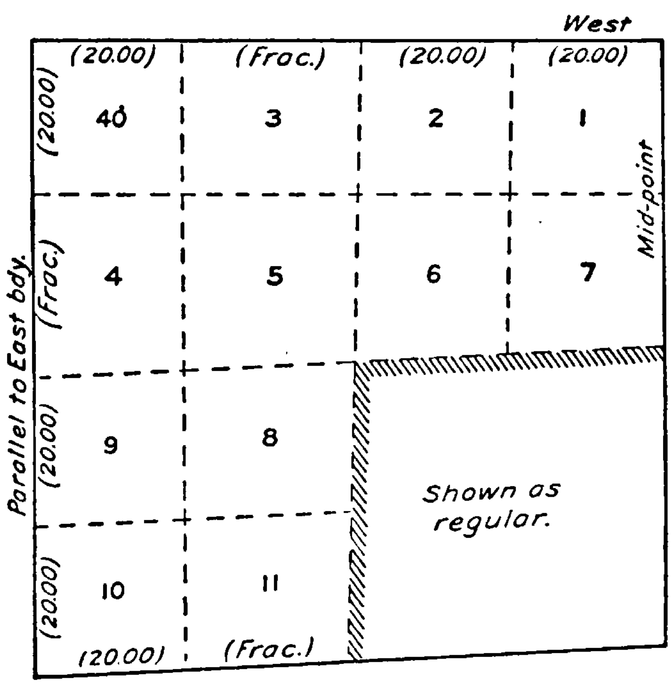



**East boundary of section out of limits in alinement and measurement; southeast quarter protracted as surveyed; and section to be completed.**

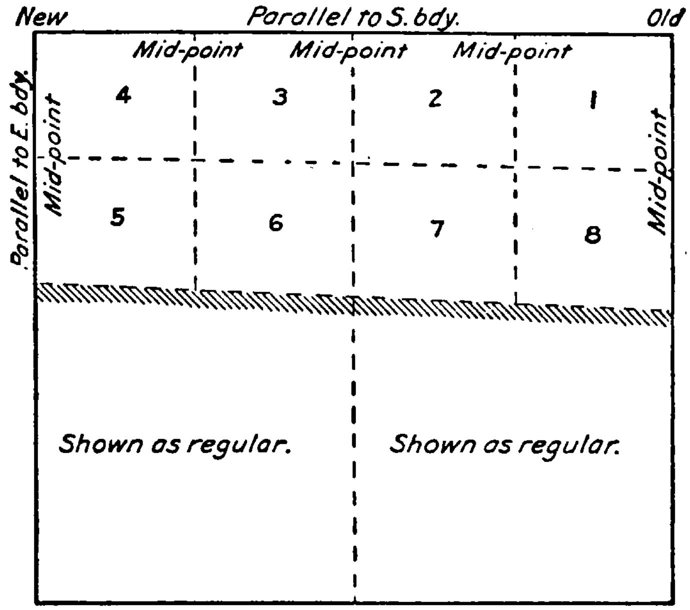
Fig. 61.



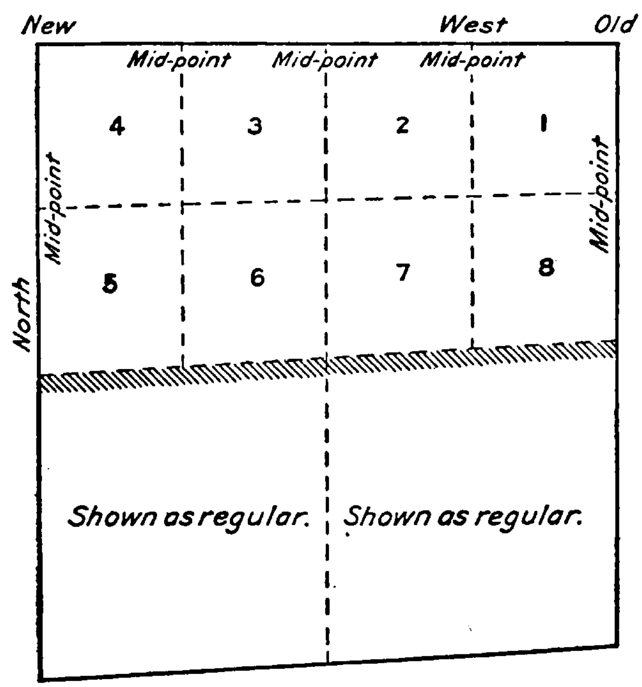




**South boundary of section out of limits in alinement and measurement; southeast quarter protracted as surveyed; and section to be completed.**

Fig. 62.



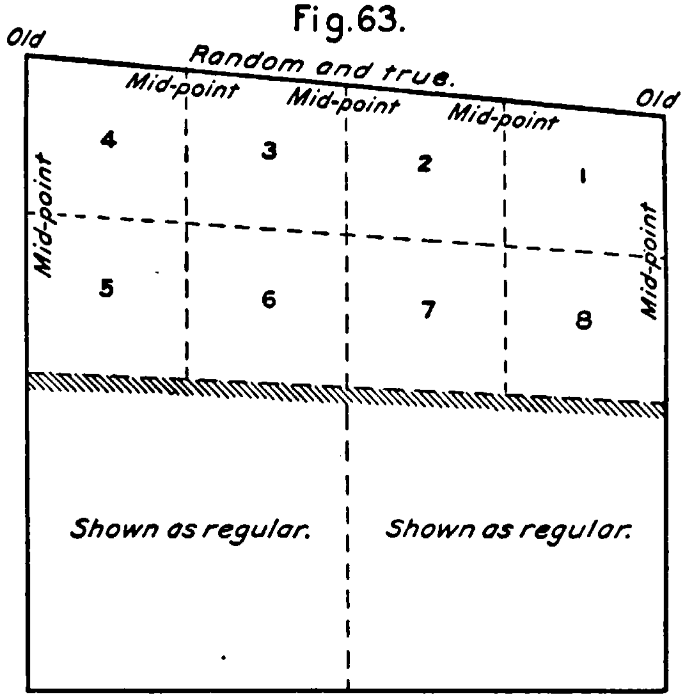

Old bdrs. defective in measurement.



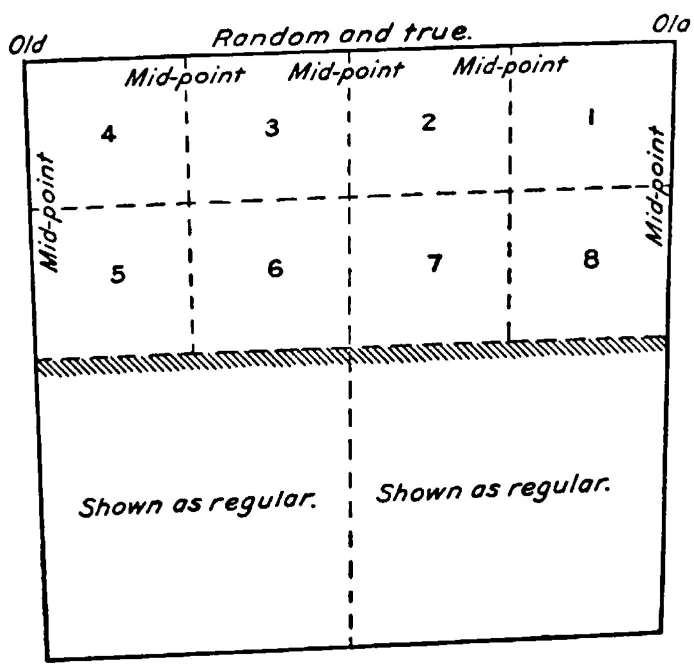

Old bdrs. defective in alinement.

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

Fig. 63.



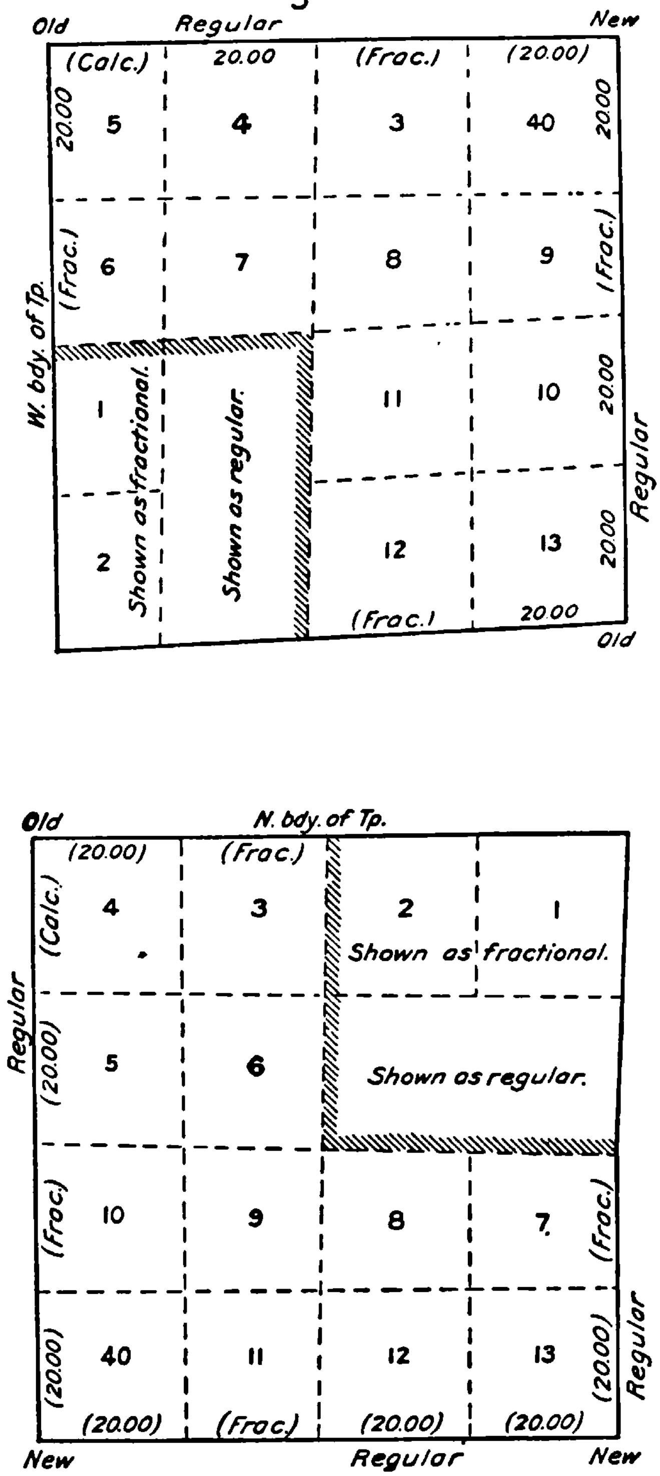

Old bdrs. defective in measurement.




Old bdrs. defective in alinement.

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

Fig. 64.




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

the section under consideration will be required at 40 chains from the original section corner; the same quarter-section corner would be marked to control the subdivision of the adjoining section if the fractional measurement is to be thrown in the same direction in both sections; otherwise an additional quarter-section corner marked to control the subdivision of the adjoining section will ordinarily be established at 40 chains from the new section corner. On the other hand, if the same conditions be assumed with the exception that the original *latitudinal* section line instead of the meridional line is found to be defective in alinement then the new latitudinal section line will have to be established as a sectional correction line, exactly in accordance with the rules already given for running such lines, ordinarily with section corner of maximum control at its intersection with the new meridional section line, and quarter-section corner of maximum control at mid-point. On the new meridional section line one or two quarter-section corners may be required; one marked to control the subdivision of the section under consideration will be established at 40 chains from the original section corner; the same quarter-section corner may be marked to control the subdivision of the adjoining section if the fractional measurement is to be placed in the same direction in the two sections, but if the fractional measurement is to be thrown in the opposite direction in the adjoining section an additional quarter-section corner marked to control the subdivision of that section would ordinarily be required at 40 chains from the new section corner.

**219.** Many cases will arise in the field involving combinations of two or more of the above simple examples, in which instance the engineer is advised to prepare a diagram illustrating the conditions found in the original survey, whereupon the new section lines may be shown with alinement in accordance with the usual rules for subdividing townships, noting that the new section lines are to be initiated at the previously established original section corners, and that the *length* of the meridional boundary will depend both upon the regularity of the length of the opposite original meridional section line and upon the alinement of the previously established latitudinal section line; thereupon the engineer may at once show upon his diagram the position of the necessary quarter-section corners on the new section lines, all in conformity with the simple rules already stated.

**220.** Other instances will be found where half sections are shown upon the original approved plat protracted as surveyed, in some cases where only the opposite section line has not been established and in other cases where parts of the adjacent as well as the opposite section lines have not been established. In case only one section line remains to be established, it will be located upon the true line connecting the original section corners, regardless of bearing; the new opposite quarter-section corner marked to control the subdivision of the stated section will be placed at mid-point, regardless of the length of the new section line; the position of the quarter-section corner marked to control the subdivision of the adjoining section will depend upon the plan of subdividing the remaining public land. Partially surveyed section lines will be completed by extension, the alinement of the same being governed by the usual rules for regular subdivision; the latitudinal or meridional position of the remaining section line (opposite to the half section protracted as surveyed) will usually be controlled by the position of the nearest original section corner, and the alinement of the same will depend upon the usual rules for regular subdivision; the new opposite quarter-section corner marked to control the subdivision of the section containing such half section protracted as surveyed will be placed at mid-point in every case; the position of the quarter-section corner marked to control the subdivision of the adjoining section will depend upon the manner of subdividing the remaining public land.

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

# Appendix V

# HALF-MILE POSTS, ALABAMA AND FLORIDA

**376.** All lost interior quarter-section corners will be restored by single proportionate measurement between the adjoining section corners, *after* the section corners have been identified or relocated.

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 would be run on random only. On the first plan the "half-mile post" would not be at mid-point 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 mid-point.

In both cases, in order to meet the objection that the position of the "half-mile post" did not satisfy the legal requirements for the subdivision of a township, field notes were supplied which gave a true line direction and the mid-point distance for a quarter-section corner, which was called for, but without actually running the true line or constructing a monument at that point. 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 as indicated in section 359. Each set of field notes requires its individual consideration, as the practices were not uniform even in the same surveying district.

The applicable rules for the restoration of the true line mid-point positions for the quarter-section corners in the above practices are derived from the act of February 11, 1805 (R. S. sec. 2396), which requires that "The corner of half and quarter sections not marked shall be placed as nearly as possible equidistant from those two corners which stand on the same line".

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 mid-point 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.

# Appendix VI

# COMPUTATIONS, RETRACEMENT DATA

**427.** There is set out below the principal elements of a *dependent resurvey.* The example is hypothetical, the purpose being to outline the character of the control that must usually be employed, and frequently the very limited extent of any available control that may be regarded as acceptable. To simplify the example, it is shown that a sufficient number of original corner positions can be identified to make a satisfactory restoration of the township exteriors, including the northeast corner of the township by double proportionate measurement. A complete retracement of the township subdivisional lines has been made for the development of the monuments, marks, and other evidence of the original survey, and for the study of the resurvey problem. Reference stakes were set in running the lines of the retracement to mark temporary corner positions where the original monuments could not be identified. All entered or patented subdivisions which were based upon the former official plat were found to be conformable to the control as developed by the retracement, and as finally adopted for the resurvey. The diagram illustrates the situation. The example of the computations shows the conversion from the directions and lengths of lines that were run in the retracement to the true line courses and distances.

KEY TO DIAGRAM, FIG. 69

A. Identified original corner.

B. Intersection of center lines of public crossroads, intended to be located at section corner and generally so recognized; accepted as best available evidence of corner.

C and D. Identified original corners.

E. Corner established by local surveyor; record shows proper application of the method of double proportionate measurement; generally recognized as correct position of corner; accepted on an equality with an identified original corner.

F–M, inclusive. Identified original corners.

N. Same as B.

O. Identified original corner.

P. Intersection of mean position of meridional and latitudinal blazed lines through virgin timber; age count on overgrowth qualifies for date of original survey.

Q. Restored corner based upon control furnished by latitudinal position of blazed line as above and fixed in departure by distance to original line tree.

R. Identified original corner.

S. Same as E.

T. Position determined by location of improvements; point agrees approximately with the theoretical position and it is recognized by adjoining claimants; improvements would be adversely affected by change of point.

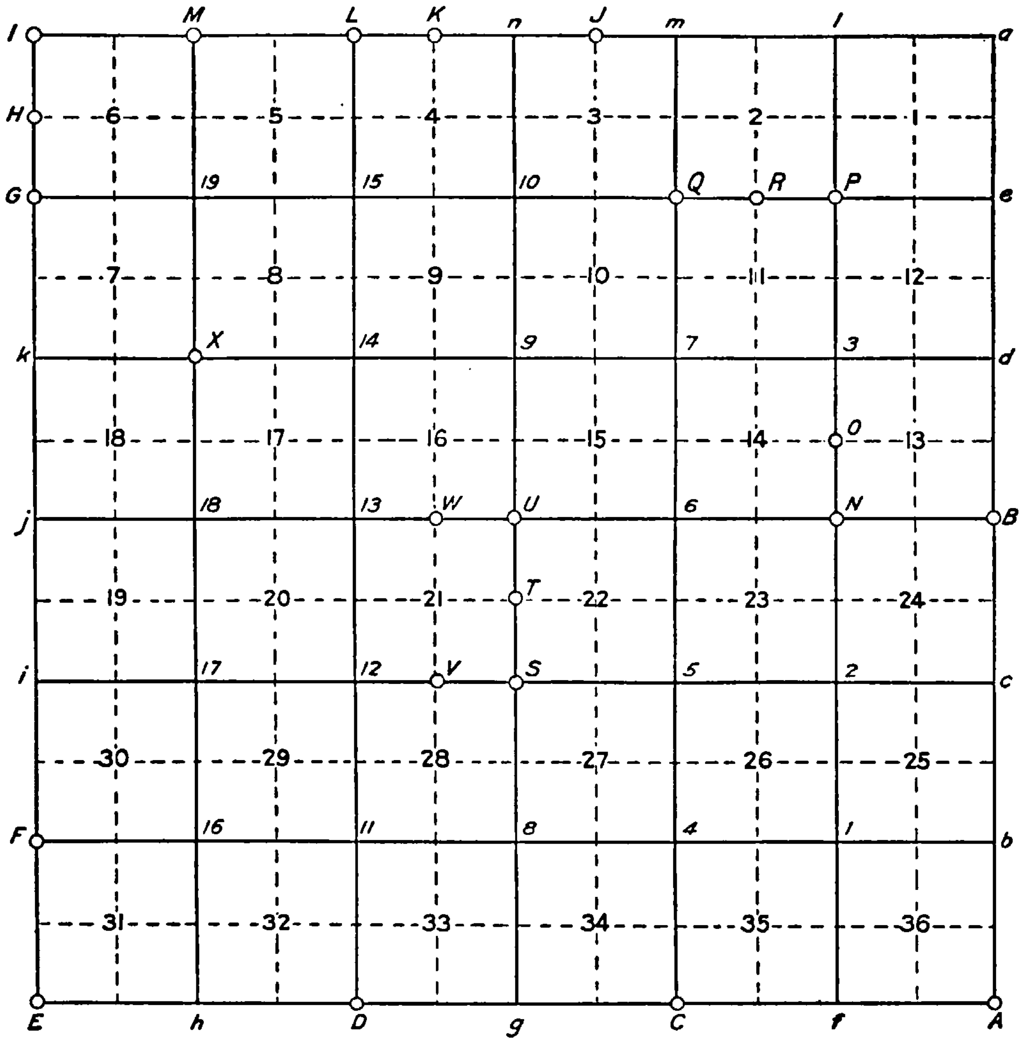
U. Same as E.

V and W. Same as T.

X. Identified original corner.

a. Duly restored by double proportionate measurement and thereafter employed for general control on an equality with an identified original corner.

b–n, inclusive. Theoretical true line position, duly restored by single proportionate measurement.




o *Employed for general control.*
+ *Theoretical position.*

Fig. 69.

## Method

After completing all retracements and having determined upon the general control to be adopted, as indicated in the diagram and accompanying key, the true lines of the dependent resurvey, beginning at the southeast corner of the township, will be reestablished as follows:

## Single Proportionate Measurement

Lines: A–B, B–a, A–C, C–D, D–E, E–F, F–G, G–H, H–I, a–J, J–K, K–L, L–M, and M–I.

## Double Proportionate Measurement

Section corners: 1, f–N and b–F; 2, f–N and c–S; 3, O–P and d–X; 4, C–Q and b–F; 5, C–Q and c–S; 6, C–Q and N–U; 7, C–Q and d–X; 8, g–S and b–F; 9, U–n and d–X; 10, U–n and Q–G; 11, D–L and b–F; 12, D–L and V–i; 13, D–L and W–j; 14, D–L and d–X; 15, D–L and Q–G; 16, h–X and b–F; 17, h–X and V–i; 18, h–X and W–j; 19, X–M and Q–G.

## Interior Quarter-Section Corners

All missing interior quarter-section corners by single proportionate measurement on line between the adjoining section corners as above determined.

## Field Data

The retracements develop the following data in regard to the relative position of certain points of control and the temporary stakes:

Beginning at f, North, 40.00 chains, set temporary stake; 80.00 chains, set temporary stake; 120.00 chains, set temporary stake; 160.00 chains, set temporary stake; 200.00 chains, set temporary stake; 241.20 chains, fall 90 links W. of N; meridional excess f–N = 1.20 chains = 40 links per 80.00 chains.

Beginning at b, West, 40.00 chains, set temporary stake; 80.46 chains, fall 20 links N. of temporary stake previously set; record of original survey shows length of line 80.22 chains; continue west, etc., to F; latitudinal deficiency b–F = 84 links = 14 links per 80.00 chains.

Beginning at 2 (temporary stake), East, 40.00 chains, set temporary stake; 80.82 chains, fall 44 links S. of c; record of original survey shows length of line 79.90 chains; run west from temporary stake at 2 on similar plan; latitudinal excess c–S = 66 links = 22 links per 80.00 chains.

## Calculations

The adjustments of the temporary stakes to true line position, and the determination of the bearings and lengths of the reestablished true lines, are calculated as follows:

BETWEEN SECTIONS 35 AND 36

| Memo | Course | Distance | N. | S. | E. | W. |
|---|---|---|---|---|---|---|
| Retracement f-1 | North | 80.00 | 80.00 | | | |
| Adjustment at 1 for meridional excess | | | .40 | | | |
| Adjustment at 1 for latitudinal deficiency, 80.46—(80.22-0.14). | | | | | 0.38 | |
| True line f-1 | N. 0°16′ E. | 80.40 | 80.40 | | .38 | |
| Adjustment at f | | | .00 | | .00 | |
| Adjustment at 1 | | | .40 | | .38 | |
| Adjustment at ¼ sec. cor. (mean) | | | .20 | | .19 | |

BETWEEN SECTIONS 25 AND 26

| Memo | Course | Distance | N. | S. | E. | W. |
|---|---|---|---|---|---|---|
| Adjustment at 1 from true to temporary | | | | 0.40 | | 0.38 |
| Retracement 1–2 | North | 80.00 | 80.00 | | | |
| Adjustment at 2 for meridional excess | | | .80 | | | |
| Adjustment at 2 for latitudinal excess, 80.82–(79.90+0.22). | | | | | 0.70 | |
| | | | 80.80 | .40 | .70 | .38 |
| | | | .40 | | .38 | |
| True line 1–2 | N. 0°14′ E. | 80.40 | 80.40 | | .32 | |
| Adjustment at 1 | | | .40 | | .38 | |
| Adjustment at 2 | | | .80 | | .70 | |
| | | | 1.20 | | 1.08 | |
| Adjustment at ¼ sec. cor. (mean) | | | .60 | | .54 | |

BETWEEN SECTIONS 23 AND 24

| Memo | Course | Distance | N. | S. | E. | W. |
|---|---|---|---|---|---|---|
| Adjustment at 2 from true to temporary | | | | 0.80 | | 0.70 |
| Retracement 2–N | North | 81.20 | 81.20 | | | |
| Random line to N | East | .90 | | | 0.90 | |
| | | | 81.20 | .80 | .90 | .70 |
| | | | .80 | | .70 | |
| True line 2–N | N. 0°9′ E. | 80.40 | 80.40 | | .20 | |
| Adjustment at 2 | | | .80 | | .70 | |
| Adjustment from 80.00 ch. point on random to N. | | | 1.20 | | .90 | |
| | | | 2.00 | | 1.60 | |
| Adjustment at ¼ sec. cor. (mean) | | | 1.00 | | .80 | |

BETWEEN SECTIONS 25 AND 36

| Memo | Course | Distance | N. | S. | E. | W. |
|---|---|---|---|---|---|---|
| Retracement b–1 | West | 80.46 | | | | 80.46 |
| Random line to temporary stake at 1 | | | | 0.20 | | |
| Adjustment at 1 temporary to true | | | 0.40 | | 0.38 | |
| | | | .40 | .20 | .38 | 80.46 |
| | | | .20 | | | .38 |
| True line b–1 | N. 89°51′ W. | 80.08 | .20 | | | 80.08 |
| Adjustment at b | | | | .00 | | .00 |
| Adjustment from 80.00 ch. point on random to temporary stake at 1. | | | | .20 | | .46 |
| Adjustment at 1 temporary to true | | | .40 | | .38 | |
| | | | .40 | .20 | .38 | .46 |
| | | | .20 | | | .38 |
| | | | .20 | | | .08 |
| Adjustment at ¼ sec. cor. (mean) | | | .10 | | | .04 |

BETWEEN SECTIONS 24 AND 25

| Memo | Course | Distance | N. | S. | E. | W. |
|---|---|---|---|---|---|---|
| c to random line | | | | 0.44 | | |
| Retracement c–2 (reversed) | West | 80.82 | | | | 80.82 |
| Adjustment at 2 temporary to true | | | 0.80 | | 0.70 | |
| | | | .80 | .44 | .70 | 80.82 |
| | | | .44 | | | .70 |
| True line c–2 | N. 89°45′ W. | 80.12 | .36 | | | 80.12 |
| Adjustment from 80.00 ch. point on random to c | | | .44 | | .82 | |
| Adjustment at 2 temporary to true | | | .80 | | .70 | |
| | | | 1.24 | | 1.52 | |
| Adjustment at ¼ sec. cor. (mean) | | | .62 | | .76 | |

## Appendix VII

# SPECIAL SURVEYS, ALASKA

**472.** Congress has enacted many laws pertaining to the disposal of the public lands, applicable only to Alaska, which require special tract surveys. The rules stated in section 472, relating to executing metes-and-bounds surveys and the specific requirements prescribed in the Manual concerning such subjects as the limits of closure; marking corners; corner accessories; meandering streams and other bodies of water; establishing location monuments and the running of connecting lines thereto; connecting a corner of a tract, if located upon surveyed land, to the rectangular system of surveys; marking lines through timber; locating improvements and noting important topographic items; making azimuth determinations; closing against withdrawn areas; segregating bodies of water covering areas of 25 acres or more and located entirely within the boundaries of a tract, etc., govern in surveying tracts in that Territory having irregular boundaries.

Generally no special engineering problems are presented in surveying irregular tracts in Alaska. However, in preparing the special instructions for the survey of any area in that Territory, which is subject to disposal or administration under a specific act of Congress, it is necessary to consider the language of the act and the regulation thereunder in order that the survey will conform to any special requirements relating to the size and configuration of the area; shore space restriction; or other factors.

The Code of Federal Regulations, Title 43, Subchapter A, Part numbers 51 to 100, inclusive, contains the rules and regulations governing the special requirements for the survey of public lands in Alaska.

The establishment of location monuments in Alaska is an important factor in making tract surveys. The rectangular system of surveys has been extended over only a small portion of that Territory and practically all tract surveys are connected to location monuments. In exceptional cases where, because of natural obstacles such as high mountains, bays or inlets from the sea, large lakes or streams, it is impractical to connect the survey with an existing location monument, although it may be within a distance of two miles, the special instructions may provide for the establishment of a location monument in a more accessible place. The site for a location monument should be so chosen that the permanency of the monument will not be endangered by rocks, land movements, erosion, or other causes. Its latitude and longitude should be determined as accurately as known data and the instruments used will permit. When practicable, it is desirable, for obvious reasons, that the monument be connected with other like monuments or surveys in the vicinity. Where the survey is not within 2 miles of an established location monument or a corner of the public land survey and it is within two miles of a well established and recorded Coast and Geodetic Survey Station which is situated above high tide and is accessible by land at all times, it may be connected thereto by course and distance. Additional marks will not be placed on the Coast and Geodetic Survey marker but the field notes will show the name of the station and the latitude and longitude, together with a description of the reference points and other pertinent data.

## FOREST HOMESTEAD SURVEYS

### Exchange Surveys

**472.** Homestead entry surveys within national forests are made by employees of the Forest Service under instructions issued by the regional offices, Bureau of Land Management, without expense to the applicants, to provide designations and areas for lands listed as subject to entry under the Act of June 11, 1906 (34 Stat. 233; 16 U. S. C. secs. 506–509).

Exchange surveys, under the act of March 20, 1922 (42 Stat. 465; 16 U. S. C. sec. 485), are made by employees of the Forest Service under instructions also issued by the regional offices, Bureau of Land Management.

The Bureau of Land Management, upon request of the Forest Service, executes homestead entry and exchange surveys on a reimbursable basis.

Regulations governing the survey of homestead entries in national forests were issued by the General Land Office in 1913, Circular No. 235, dated April 30, 1913 (Survey of National Forest Homesteads, 42 L. D. 124). All technical subjects relating to surveys contained in this circular were superseded by the Manual of 1930. (See letter of approval dated June 14, 1930, page v, 1930 Manual). The cooperative procedure between the Forest Service and the Bureau of Land Management and certain requirements authorized by the Act of June 11, 1906 (34 Stat. 233; 16 U. S. C. secs. 506–509), together with the consideration of special conditions not fully covered by the Manual, should be continued as outlined in Circular No. 235.

Under the provisions of the law the Bureau of Land Management is responsible for the correctness of homestead entry and exchange surveys although these surveys may be executed by employees of the Forest Service. The instructions for such surveys issued must therefore be complete and should refer to the particular sections in the Manual pertaining to technical standards and the details involved in making metes-and-bounds surveys. The regular technical procedure prescribed for executing such surveys should be followed.

The procedure outlined in the Manual for the preparation of field notes and plats for fragmentary and metes-and-bounds surveys will be followed, including the regular certificates of approval and acceptance. The purpose of a homestead entry survey or an exchange survey is to mark the boundaries of a particular area on the ground and to furnish a plat and a set of field notes representing the survey as the basis for patent or other administrative action.

## SOIL STUDIES

**538.** The purpose of the outline here presented is to acquaint the engineer with the more important features of soils to the end that proper determinations may be made in the field as to their occurrence, character and use. Engineers are not expected to be soil scientists but should have a general knowledge of the subject to the extent necessary to avoid making serious errors in the practical job of examining and reporting on soils.

The technical classification of soils is a complex process requiring laboratory analysis. For practical purposes, however, soils may be classified in the field, such classifications being based on a knowledge of the characteristics and properties of soils and their constituents. As soil science has developed, various descriptive terms for the several characteristics and properties of soils have become more or less standardized. These terms will serve the engineer both as a check list by which comparisons may be made, and as a medium for reporting his findings.

The complete description of a soil must include a description of general and special features of the landscape as well as a description of the soil profile.

Among the more important external features which serve as indicators of soil and subsoil are relief, drainage, stoniness, and native vegetation. These features are generally expressed in the following terms:

Relief: Level, undulating, rolling, broken, hilly, mountainous. Here also should be shown elevation above sea level and erosion features, as sheet, gully, etc., modified by such terms as moderate, severe. The degree and direction of slope are important and may be noted with particular reference to the effect on drainage, erosion, and exposure to the sun.

Drainage: Poor, slow, good, free, excessive. Report depth to water table.

Stoniness: Free, few, common, plentiful, vary.

Native Vegetation: The native vegetation can serve as an indicator of the soils on which it is found. Whenever possible the native vegetation should be described. It is important that the general plant associations including forest, brush, shrub, and grasses, be noted. Common plant names may be used.

The internal features of a soil are determined from the soil profile. The soil profile consists of the horizontal layers or horizons, differing from one another in such properties as depth, color, texture, consistence, structure, and reaction, extending from the surface down to and including the parent soil material. The upper or A horizon commonly refers to the cultivable layer. The next lower, or B horizon, is the subsoil. This is essentially of mineral character. Taken together, the A and B horizons represent the true soil. The C horizon, lying below the true soil, may consist of unconsolidated parent material such as hard rock, clay, or sand, but generally refers to weathered material.

Many soils owe their distinctive characteristics to the parent rocks. Thus, soils may have an acid or basic reaction depending on the nature of the parent material. For the same reason they may have a distinctive color. However, normal soils owe their most important characteristics to the effects of climate and biological factors. Thus the parent material is not always a true indicator of the resulting soil.

Parent materials: There are three general classes of parent materials:

- Residual: Materials weathered in place from igneous, sedimentary, and metamorphic rocks.
- Moved and redeposited: Materials may be moved and redeposited by water, wind, glacial action and gravity.
  - By water: Alluvium, lacustrine deposits, marine sediments, beach deposits.
  - By wind: Loess, dune sands, wind drifts.
  - By glacial action: Glacial till, outwash materials.
  - By gravity: Talus.
- Organic: Woody and fibrous peat, moss peat, sedimentary peat, muck, diatomaceous deposits.

The several important internal characteristics of a soil which may be observed in the field and the terms in which these characteristics are commonly expressed are as follows:

Depth: All measurements of the depth of horizons should be made with the top of the A horizon as zero. Accumulations of forest duff or other organic matter should be measured upward. In describing a soil horizon, the distance from the soil surface to the upper and lower limits of the horizons should be stated, viz: 0–4 inches, gray silty loam; 4–16 inches, brown mellow loam grading to yellowish brown; 16–26 inches, yellowish brown sand loam; 26 inches, mixed gravel.

Color: The principal soil colors are black, gray, brown, red, and yellow. These may be modified by the terms grayish, brownish, reddish, yellowish, pinkish, purplish, bluish or olive to make such terms as grayish brown.

While color in itself is of minor importance it is perhaps the most obvious soil characteristic and often serves as an indicator of other important soil characteristics. Dark brown to black soils are regarded as highly productive. These colors are usually due to a high content of humus. Red or reddish-brown soils are less fertile than black or dark brown. Yellow, gray, or white soils usually have low inherent productiveness. In some cases the color of the soil is inherited from parent material and is not due to the soil forming processes. Streaks or tongues of color, the result of imperfect drainage, may produce a more or less distinct mottling.

Texture: Soil texture is determined by the varying proportions of sand, silt and clay which go to make up the soil.

Sand grains feel gritty to the fingers and can be distinguished by the naked eye; silt, barely visible to the naked eye, has the appearance and feel of flour; clay is easily recognized, being composed of very fine particles, sticky, slippery, and plastic.

Loams are essentially mixtures of clay, silt, and sand, together with varying proportions of well decomposed vegetable matter, humus.

The principal soil classes in the increasing order of silt and clay are as follows: sand, loamy sand, sandy loam, loam, silt loam, clay loam, and clay. In addition, there are recognized textures that have been named because of the particular size of the coarser particles, such as fine sand, loamy fine sand, fine sandy loam, coarse sandy loam, and gravelly loam. Variations within the clay and clay loam classes are indicated as sandy clay, silty clay, sandy clay loam, and silty clay loam. Soils containing a sufficient content of stone to influence its use may have the term stony added to its designation.

Consistence: Soil consistence refers to the different grades of compactness. The relative terms commonly used for defining soil consistence are: loose or open; slightly, moderately, or very compact; mellow; friable; crumbly; plastic; sticky; hard; and cemented. Soil consistence varies with the soil moisture. Therefore, consistence must be related to the moisture conditions at the time of observation.

In addition to the foregoing, there are other important characteristics which, since they are not easily determined by simple observation in the field, cannot be expected to fall within the general scope of the engineer's work. These characteristics include:

Structure: Soil structure refers to the arrangement of the individual soil grains. The several types of soil structure are: single grain, crumb, granular, fragmentary, mulch, prismatic, columnar, platy, shot, and angular nut.

Reaction: Soil reaction refers to the acidity or alkalinity of the soil. Soil acidity is generally described in terms of pH values ranging from extremely acid, below pH 4.5, through neutral, pH 6.6—7.3 to very strongly alkaline, pH 9.1 and higher.[1]

[1] The "pH" factor is an arbitrary term in general use to indicate the relative alkalinity or acidity of the soil.

700004°—47——34

## Appendix VIII

SPECIMEN

**FIELD NOTES**

OF THE SURVEY OF THE

**THIRD STANDARD PARALLEL NORTH**

**ALONG THE SOUTH BOUNDARY OF TOWNSHIP 13 NORTH**

**THROUGH RANGES 21, 22, 23, AND 24 EAST**

**THE SIXTH GUIDE MERIDIAN EAST**

**THROUGH TOWNSHIPS 13, 14, 15, and 16 NORTH**

**BETWEEN RANGES 24 AND 25 EAST**

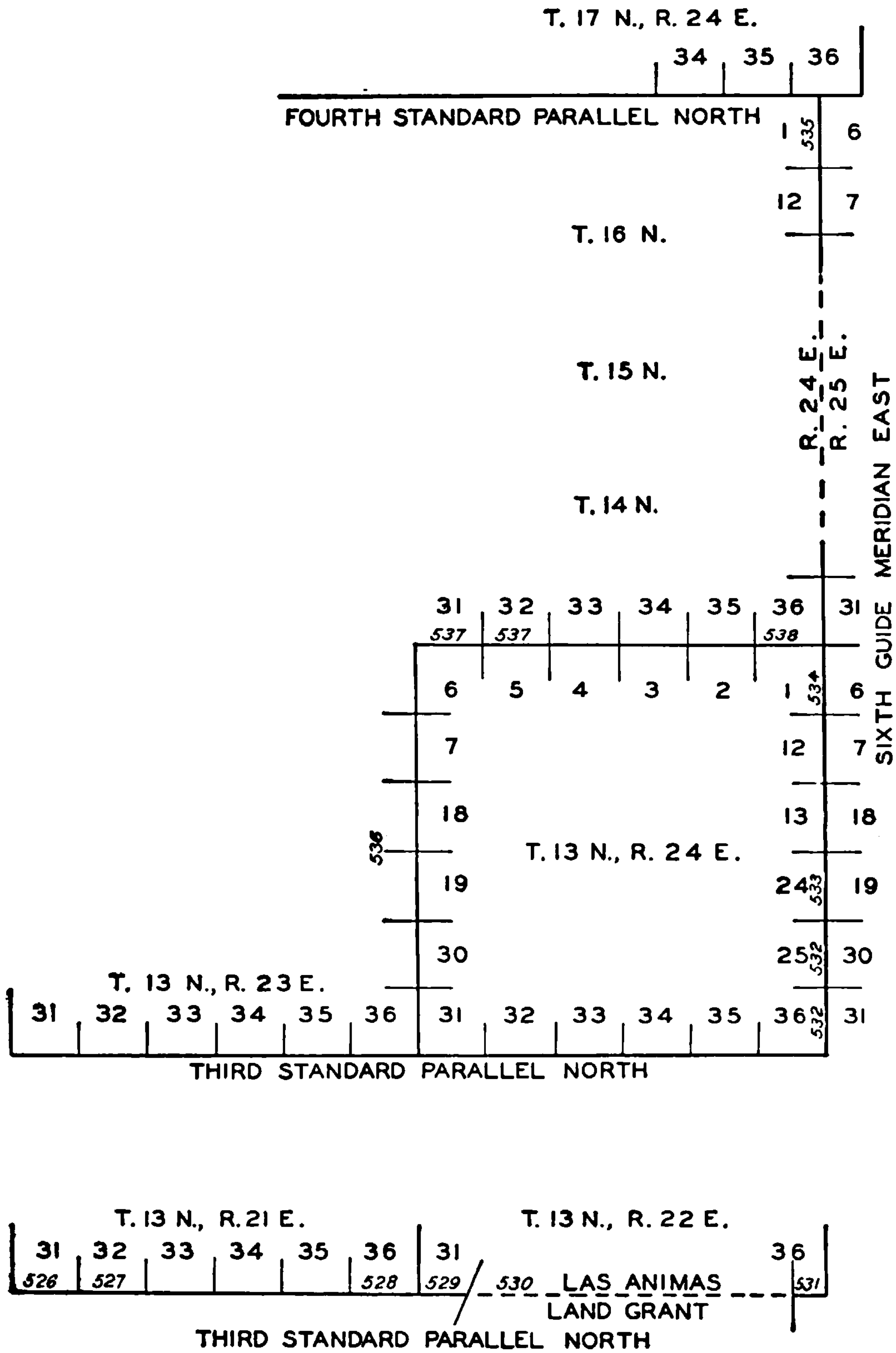
AND THE

**WEST AND NORTH BOUNDARIES OF**

**TOWNSHIP 13 NORTH, RANGE 24 EAST**

[Note: Remainder of title omitted]

## INDEX TO SPECIMEN FIELD NOTES



***Chains***

The survey is executed with a........... engineer's transit, Serial No......, property of the General Land Office. The horizontal circle has a diameter of 5¼ ins. and two double opposite verniers reading to 30″; the diameter of the vertical circle is 5 ins., with one double vernier reading to single minutes. The instrument is in good condition and, having been placed in satisfactory adjustment prior to beginning the survey, is tested and found free from appreciable error.

As the line to be established traverses land that is heavily timbered, but mostly without a dense undergrowth, the secant method is selected; the controlling meridian is established by observation upon Polaris, as shown in the field notes; the bearing of the secant is deflected from the meridian by repetition of angles and is carried forward by transit line, taking the mean of direct and reversed sights at each instrument station.

The measurements are made with narrow steel tapes, 5 chs. and 8 chs. in length; each tape is graduated every link for the first 100 lks. and thereafter at intervals of 10 lks. The tapes are tested by comparison with a 1-chain standard steel tape and found correct. Both sets of measurements are made on the slope and the vertical angles are determined by clinometers in good adjustment; the field notes show the horizontal equivalents. The line is double chained and the mean of the measurements is given in the field notes.

August 16, 1945, at the standard corner of Ts. 13 N., Rs. 20 and 21 E., in latitude 36°59.6′ N., and longitude 105°04.3′ W., as given in the data furnished with the special instructions, I make a series of three observations for the determination, and verification, of time, latitude and azimuth, to be employed in the survey, as follows:

(1) An hour angle observation of Polaris west of the meridian, making four readings, two each with the telescope in direct and reversed positions, marking the mean point in the line thus determined, on a peg driven firmly in the ground, 12.60 chs. N. of station.

| | |
|---|---|
| Mean watch time of observation, a. m. | 5h04m48s |
| Mean altitude of Polaris | 37°59′00″ |

(2) An altitude observation of the sun, first setting on the sun's upper and right limbs, then, after reversal of the instrument, setting on the lower and left limbs; the horizontal angles are measured from the mean point in the line determined by the Polaris observation.

| | |
|---|---|
| Mean watch time of observation | 9h15m20s |
| Mean vertical angle | 40°59′45″ |
| Mean horizontal angle | 105°26′58″ |
| Reduced bearing of point on peg | N. 0°19′30″ W. |
| Reduced watch slow of l. m. t. | 3m30s |

(3) A noon observation of the sun, first setting on the sun's lower limb and noting the transit of the west limb, then, after reversal of the instrument, setting on the upper limb and noting the transit of the east limb.

| | |
|---|---|
| Mean observed altitude | 66°44′15″ |
| Mean watch time of observation | 12h00m43s |
| Reduced latitude | 36°59′44″ N. |
| Reduced watch slow of l. m. t. | 3m28s |

(1) Having verified the watch error and latitude, I complete the reduction of the hour angle observation of Polaris, with the following results:

| | |
|---|---|
| Mean azimuth of Polaris, west | 0°19′36″ |
| Reduced latitude | 36°59′30″ N. |
| Bearing of the secant in lat. of sta. | N. 89°58′00″ E. |
| Bearing of point on peg | N. 0°19′36″ W. |
| Angle to be turned | 90°17′36″ |

Turning from the mean point in the line determined by the Polaris observation, I set a flag on the secant; the multiple angle of four repetitions reads 361°10′30″, which indicates an angle of 90°17′37½″.

The observed magnetic declination is 18° 10′ E.

Beginning at the standard cor. of Ts. 13 N., Rs. 20 and 21 E., which is monumented with a granite stone, 12 x 8 x 10 ins. above ground, firmly set, marked and witnessed as described in the official record.

East, with the establishment of the Third Standard Parallel North, along the S. bdy. of sec. 31, T. 13 N., R. 21 E., on a transit line describing the secant, which starts from a point 4 lks. S. of the Tp. cor., and bears N. 89°58′ E.

Over gently rolling land, through scattering timber.

28.10 Enter heavy timber, edge bears NW. and SE.

40.00 Point for the standard ¼ sec. cor. of sec. 31, N. 2 lks. from the secant.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

SC
¼ S 31
1945

from which

| Chains | |
|---|---|
| | A yellow pine, 10 ins. diam., bears N. 64½° E., 48 lks. dist., mkd. ¼ S31 SC BT. |
| | A blue spruce, 8 ins. diam., bears N. 14¾° W., 127 lks. dist., mkd. ¼ S31 SC BT. |
| 46.50 | Enter clearing, edge bears N. 35° E. and S. 35° W. |
| 47.00 | Road, follows edge of clearing. |
| 58.00 | Cabin bears N., 16 chs. dist. |
| 63.50 | Enter heavy timber, edge bears N. and S. |
| 80.00 | Point for the standard cor. of secs. 31 and 32, on the secant. |
| | Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd. |
| | SC<br>T 13 N \| R 21 E<br>S 31 \| S 32<br><br>1945 |
| | from which |
| | A yellow pine, 9 ins. diam., bearns N. 31¾° E., 22 lks. dist., mkd. T13N R21E S32 SC BT. |
| | A yellow pine, 8 ins. diam., bears N. 67° W., 114 lks. dist., mkd. T13N R21E S31 SC BT. |
| | Land, gently rolling.<br>Soil, loam.<br>Timber, yellow pine and blue sprice, with some juniper. |
| | East, along the S. bdy. of sec. 32, on a transit line describing the secant, which bears N. 89° 58.7′ E. |
| | 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° E.; asc. 175 ft. over broken SW. slope. |
| 40.00 | Point for standard ¼ sec. cor. of sec. 32, S. 1 lk. from the secant, falls on a sandstone boulder, 7 x 5 x 2 ft. above ground. |
| | Seat a brass tablet 3¼ ins. diam., 3½-inch stem, with top mkd. |
| | SC<br>¼ S 32<br><br>1945 |
| | from which |
| | A juniper, 8 ins. diam., bears N. 33¼° E., 22 lks. dist., mkd. ¼ S32 SC BT. |
| | A juniper, 11 ins. diam., bears N. 84½° W., 192 lks, dist., mkd. ¼ S32 SC BT. |
| 46.20 | A sandstone rim rock, 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 record. |
| 80.00 | Point for the standard cor. of secs. 32 and 33, S. 2 lks, from the secant. |
| | Set an iron post, 30 ins. long, 2 ins. diam., 18 ins. in the ground to bedrock, and in a mount of stone to top, with brass cap mkd. |
| | SC<br>T 13 N \| R 21 E<br>S 32 \| S 33<br><br>1945 |
| | from which |

*Chains*

A yellow pine, 9 ins. diam., bears N. 43¾° 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 B O.

Land, rolling, west of creek; level table-land above top of slope east of creek.
Soil, rich loam, sandy loam, and stony.
Timber, mostly juniper, with some yellow pine and blue spruce.

---

NOTE.—The field notes of the survey of the S. bdy. of secs. 33, 34, and 35 continue on the same form, and are omitted here. The field notes of the S. bdy. of sec. 36 have been varied in order to show certain other forms of record.

---

East, along the S. bdy. of sec. 36, on a transit line describing the secant, which bears S. 89° 58.7′ E.

Over level land, through dense undergrowth.

40.00 Point for the standard ¼ sec. cor. of sec. 36, N. 2 lks from the secant.

Set a sandstone, 24 x 10 x 6 ins., 16 ins. in the ground, mkd. SC¼ on N. face; and raise a mound of stone, 4 ft. base, 2 ft. high, N. of cor.

45.00 Begin gradual descent.

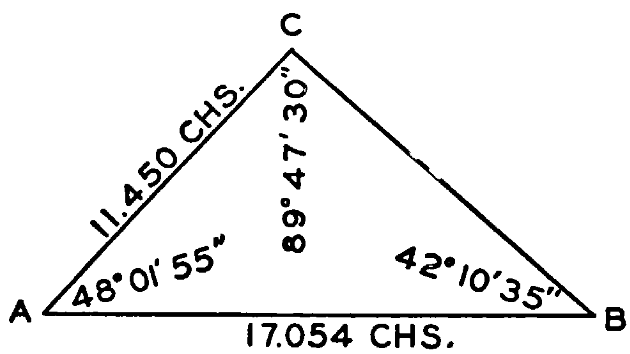
48.92 Bank of Crystal Lake, bears N. 42° E. and S. 37° W.

Point for the meander cor. of sec. 36, N. 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; and raise a mound of stone, 2 ft. base, 1½ ft. high, W. of cor.

In order to determine the distance across the lake by triangulation, I use the above station on the secant as point A, and set a flag B on the secant on the opposite side of the lake; point C is taken northeasterly on the west side; the distance from A to C is 11.450 chs.




All angles by 3 repetitions, with a closing error of 0°0′20″ balanced to 180°, as follows:

At point A=48°01′55″.
At point B=42°10′35″.
At point C=89°47′30″.

Distance across lake=17.054 chs.

65.974 Point B.

66.00 Bank of lake, bears N. 50° E. and S. 45° W.

*Chains*

Point for the meander cor. of sec. 36, N. 3.3 lks. from the secant.

Set an iron post, 30 ins. long, 2 in. diam., 24 ins. in the ground, with brass cap mkd.

T13N
R 21 E
S 36
MC
1945

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. 78¾° E., 312 lks. dist., mkd. T13N R21E S36 MC BT.

Enter heavy timber, edge bears N. 50° E. and S. 45° W.; asc. 215 ft. over stony NW. slope.

80.00 Point for the standard cor. of Ts. 13 N., Rs. 21 and 22 E, N. 4 lks. from the secant.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

SC
T 13 N
R 21 E | R 22 E
S 36 | S 31
1945

from which

A blue spruce, 12 ins. diam., bears N 37¼° E., 114 lks. dist., mkd. T13N R22E S31 SC BT.

A blue spruce, 9 ins. diam., bears N. 64¾° W., 127 lks. dist., mkd. T13N R21E S36 SC BT.

Land, nearly level, west of lake; broken, east of lake.
Soil, sandy loam, and stony.
Timber, blue spruce with some yellow pine and aspen; undergrowth, oak brush.

---

August 21: At this point, in order to verify the alinement of the secant, I make an altitude observation of the sun, first setting on the sun's upper and right limbs, then, after reversal of the instrument, setting on the lower and left limbs; the horizontal angles are measured from a back-sight flag D on the secant.

| | |
|---|---|
| Mean watch time of obsn., a. m. | $9^h18^m47^s$ |
| Mean vertical angle | 44°54′15″ |
| Mean horizontal angle | 157°42′00″ |
| Reduced bearing of flag D | N. 89°57′49″ W. |

As the theoretical bearing of the secant at this point is N. 89° 58.0′ W., the observation indicates that the line has been carried forward acceptably.

---

To lay off a deflection angle of 3′55″, in order to describe a secant through Range 22 East, I set a back-sight flag F, 3.96 lks. (2.61 ft.) to the south of the back-sight flag D previously described, the latter point being located on the secant at 45.00 chs. running E. on the S. bdy. of sec. 36; then, to verify the angle at the station on the secant at the standard Tp. cor., subtended by the two flags, I make 6 repetitions and find that the multiple angle reads 0°23′30″.

East, with the establishment of the Third Standard Parallel North, along the S. bdy. of sec. 31, T. 13 N., R. 22 E., on a transit line describing the secant, which starts from a point 4 lks. S. of the Tp. cor., and bears N. 89°58′ E.

Ascend 65 ft. over stony NW. slope; through heavy timber.

3.50 Ridge, bears N. 60° E. and S. 60° W.; desc. 240 ft. over SE. slope.

22.30 Base of ridge, bears N. 65° E. and S. 65° W.; continue gradual descent.

*Chains*

38.40 Point for the witness standard ¼ sec. cor. of sec. 31, N. 2.1 lks. from the secant.

Set an iron post, 30 ins. long, 2 in. diam., 24 ins. in the ground, with brass cap mkd.

WC
SC
¼ S 31

1945

from which

A yellow pine, 9 ins. diam., bears North, 16 lks. dist., mkd. WC ¼ S31 SC BT.

A yellow pine, 10 isn. diam., bears N. 57½° W., 92 lks. dist., mkd. WC ¼ S31 SC BT.

40.00 True point for standard ¼ sec. cor. falls in a stream, 60 lks. wide, course N. 70° E.; asc. gradually.

54.96 Intersect the W. bdy. of the Las Animas Land Grant, N. 1.2 lks. from the secant.

Point for the closing cor. of sec. 31, T. 13 N., R. 22 E.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

T13N
R22E
S31
LA
CC
LG
PL
1945

from which

A yellow pine, 11 ins. diam., bears N. 22¾° W., 57 lks. dist., mkd. T13N R22E S31 CC BT.

A yellow pine, 7 ins. diam., bears N. 74¼° W., 135 lks. dist., mkd. T13N R22E S31 CC BT.

From this point the 14th Mi. Cor. of the grant boundary bears N. 33° 38′ E., 27.84 chs. dist., and is monumented with a sandstone, 16 x 12 ins., standing firmly 6 ins. above the top of a mound of stone, 5 ft. base, 3 ft. high, marked and witnessed as described in the official record.

From the same point the 15th Mi. Cor. of the grant boundary bears S. 33° 38′ W., 51.96 chs. dist., and is monumented by a pine tree, 34 ins. in diameter; the surface scars on the tree, and on the bearing trees, and the kind and position of the latter, agree with the official record; I do not uncover the marks.

Land, gently rolling and broken.
Soil, sandy loam.
Timber, yellow pine.

---

Continue the secant on a blank line across the grant.

392.78 Intersect the E. bdy. of the grant, N. 2.4 lks. from the secant.

Point for the closing cor. of sec. 36, T. 13 N., R. 22 E.

Set a sandstone, 32 x 10 x 8 ins., 22 ins. in the ground, mkd.

13N on N.,
CC 22E and 1 groove on E., and
LA LG on W. face; and raise a mound of stone, 2 ft. base, 1½ ft. high, E. of cor.

*Chains*

From this point the 7th Mi. Cor. of the grant boundary bears S. 0°42′ E., 19.12 chs. dist. and is monumented by a sandstone boulder, 8 x 5 x 3 ft. above ground, marked and witnessed as described in the official record.

From the same point the 8th Mi. Cor. of the grant boundary bears N. 0°42′ W., 60.62 chs. dist. and is monumented with a sandstone, 12 x 8 x 6 ins. above ground, firmly set, marked and witnessed as described in the official record.

---

Thence East, along 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 standard corner of secs. 35 and 36.

Over nearly level land.

80.00 Point for the standard cor. of Ts. 13 N., Rs. 22 and 23 E., N. 4 lks. from the secant.

Set a sandstone, 36 x 10 x 8 ins., 24 ins. in the ground, mkd.

SC 13N on N.,
23E on E., and
22E on W. face; and raise a mound of stone, 5 ft. base, 3 ft. high, N. of cor.

Land, nearly level.
Soil, sandy loam and stony.
No timber.

---

Aug. 24: At this point, in order to verify the alinement of the secant, I make a series of six altitude observations upon 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 back-sight flag on the secant.

| | |
|---|---|
| Mean time of observation, 105th meridian standard time | $=9^h15^m42^s$ a. m. |
| Declination of sun at mean time of observation | =11°06.7′ N. |
| Mean observed vertical angle to sun's center | =44°32′35″. |
| Mean horizontal angle from flag to sun's center | =156°14′ W-S-E. |
| True bearing to flag | =N. 89°58′14″ W. |
| Theoretical bearing of the secant | =N. 89°58′00″ W. |

---

NOTE.—The field notes of the survey of the Third Standard Parallel North, along the S. bdy. of Ts. 13 N., Rs. 23 and 24 E., continue on the same form, and are omitted here. An entry indicates that at the standard cor. of Ts. 13 N., Rs. 24 and 25 E., an angle was turned from the secant to the meridian and that the verification of the alinement of the secant would be found in the observation for meridian made for the survey of the Sixth Guide Meridian East.

## MEMORANDUM

The alinement of the secant is to be verified always by an azimuth observation at the end of the run; if the line is to be continued more than 12 miles a new meridian will ordinarily be employed for control at intervals of not to exceed 12 miles.

The form of the record of the survey of a standard parallel by the tangent method will be similar to that of the specimen field notes by the secant method, and does not need to be extended here. The tangent method may as well be employed if the parallel runs over a country that is comparatively free from heavy timber and dense undergrowth.

If the solar transit method is employed the resulting line will conform to the parallel without making offsets. There is no other essential difference in the form of the record. This method will be given preference in regions that are heavily timbered or covered by very dense undergrowth, where the work incident to opening a transit line would add unnecessarily to the cost of the survey.

Ordinarily only one set of measurements will be required on the standard parallel if the special instructions provide that the township is to be subdivided.

A summary description of the region crossed by a standard parallel will be supplied at the close of the field notes, or the information may be carried in the general description of the subdivisional survey.

AUGUST 23, 1945.

*Sixth guide meridian east, through T. 13 N., between Rs. 24 and 25 E.*

Chains

Aug. 29, 1945, at the standard cor. of Ts. 13 N., Rs. 24 and 25 E., in latitude 36°59.6′ N., and longitude 104°38.3′ W., as computed by reference to the values given for the standard cor. of Ts. 13 N., Rs. 20 and 21 E., I make a noon observation of the sun for time, and an observation upon Polaris at eastern elongation for meridian, as follows:

| | |
|---|---|
| Watch time of transit of sun's west limb | $11^{h}54^{m}48^{s}$ |
| Watch time of transit of sun's east limb | 11 56 56 |
| Mean | $11^{h}55^{m}52^{s}$ |
| Reduced watch slow of l. m. t. | $4^{m}59^{s}$ |

At $9^{h}17.7^{m}$ p. m., l. m. t., or $9^{h}12.7^{m}$ watch time, I observe Polaris at eastern elongation, making 6 settings, 3 each with the telescope in direct and reversed positions, accumulating the horizontal angle, measured by the method of repetitions, counting from a signal light at my flag point 16.40 chs. N. of station.

| | |
|---|---|
| Horizontal angle, 6 repetitions | 7°32′00″ |
| Reduced angle | 1°15′20″ |
| Azimuth of Polaris at e. e. | 1°15′02″ |
| True bearing of point on peg | N. 0°00′18″ W. |

In order to mark the true meridian, I mark a second point, 0.16 lks. (0.11 ft.) to the east of the original point; then, to verify the angle at the standard Tp. cor., subtended by the 2 points on the peg, I make 10 repetitions and find that the multiple angle reads 0°03′00″.

The observed magnetic declination is 18°20′ E.

---

From the standard cor. of Ts. 13 N., Rs. 24 and 25 E.,

North, with the establishment of the Sixth Guide Meridian East, through T. 13 N., bet. Rs. 24 and 25 E., bet. secs. 31 and 36.

Over nearly level land.

40.00 Point for the ¼ sec. cor. of secs. 31 and 36.

Set an iron post, 30 ins. long, 2 in. diam., 24 ins. in the ground, with brass cap mkd.

1/4

S 36 | S 31

1945

dig pits,
18 x 18 x 12 ins., N. and S. of post, 3 ft. dist.

43.50 Begin gradual ascent.

67.00 Top of ascent; enter heavy timber, edge bears NE. and SW.; descend over gradual NW. slope.

80.00 Point for the cor. of secs. 25, 30, 31, and 36.

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; from which

A juniper, 10 ins. diam., bears N. 64¾° E., 70 lks. dist., mkd. T13N R25E S30 BT.

A juniper, 12 ins. diam., bears S. 69¾° E., 44 lks. dist., mkd. T13N R25E S31 BT.

A juniper, 10 ins. diam., bears S. 79½° W., 59 lks. dist., mkd. T13N R24E S36 BT.

A juniper, 20 ins. diam., bears N. 74¾° W., 220 lks. dist., mkd. T13N R24E S25 BT.

Land, level and gently rolling.
Soil, sandy loam, and stony.
Timber, juniper and pinon.

---

North, bet. secs. 25 and 30.

Descend gradually through heavy timber.

21.50 An ungraded road, bears NW. and SE., from Fort Myer to Valley City.

*Chains*

23.20 An arroyo, drains SW.; asc. 100 ft. over SE. slope.

40.00 Point for the ¼ sec. cor. of secs. 25 and 30.

Set a sandstone, 21 x 8 x 6 ins., 14 ins. in the ground, mkd. ¼ on W. face; from which

A juniper, 8 ins. diam., bears N. 60¼° E., 28 lks. dist., mkd. ¼ S30 BT.

A juniper, 11 ins. diam., bears West, 89 lks. dist., mkd. ¼ S25 BT.

64.20 Top of ascent; leave timber, edge bears N. 60° E. and S. 60° W.; desc. gradually.

76.00 An arroyo, drains S. 65° W.; asc. 50 ft. to sec. cor.

80.00 Point for the cor. of secs. 19, 24, 25, and 30.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

T 13 N

| R 24 E | R 25 E |
|---|---|
| S 24 | S 19 |
| S 25 | S 30 |

1945

raise a mound of stone, 4 ft. base, 2 ft. high, W. of cor.

Land, rolling and broken.
Soil, sandy loam, and stony.
Timber, juniper and pinon.

---

North, bet. secs. 19 and 24.

Asc. over broken land.

2.10 Top of ascent; enter scattering timber and dense undergrowth.

40.00 Point for the ¼ sec. cor. of secs. 19 and 24.

Set an iron post, 30 ins. long, 2 in. diam., 24 ins. in the ground, with brass cap mkd.

1/4

| S 24 | S 19 |
|---|---|

1945

raise a mound of stone, 4 ft. base, 2 ft. high, W. of cor.

56.00 Leave scattering timber.

64.20 An arroyo, drains N. 60° W.; asc. 85 ft. to sec. cor.

80.00 Point for the cor. of secs. 13, 18, 19, and 24.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

T 13 N

| R 24 E | R 25 E |
|---|---|
| S 13 | S 18 |
| S 24 | S 19 |

1945

*Chains*

raise a mound of stone, 4 ft. base, 2 ft. high, W. of cor.

Land, broken.
Soil, sandy loam and stony.
Timber, scattering pinon; undergrowth, sagebrush.

---

NOTE: The field notes of the survey of the line bet. secs. 13 and 18, and bet. secs. 7 and 12, continue on the same form, and are omitted here.

---

North, bet. secs. 1 and 6.

Desc. 40 ft. over broken NE. slope, through dense undergrowth.

7.90 A graded road, bears N. 80° W. and S. 80° E., from Ft. Myer to Douglass P. O.
9.10 Right bank of the South Fork of Trapper River, course S. 80° E.; banks 2 to 6 ft. high; water at present low stage from 1 to 3 ft. deep.

Point for the meander cor. of secs. 1 and 6.

Set an iron post, 30 ins. long, 2 in. diam., 24 ins. in the ground, with brass cap mkd.

MC
S 1 | S 6
R 24 E | R 25 E
T 13 N
1945

raise a mound of stone, 4 ft. base, 2 ft. high, S. of cor.

Distance across river by steel tape measurement, 4.60 chs.

13.70 Left bank of river.

Point for the meander cor. of secs. 1 and 6.

Set a washed flint boulder, 32 x 14 x 8 ins., 24 ins. in the ground, mkd.

1 groove on N.,
6 grooves on E.,
MC on S., and
6 grooves on W. face; and raise a mound of stone, 5 ft. base, 3 ft. high, N. of cor.

Asc. 160 ft. over broken S. slope.

29.80 Ridge, bears E. and W.; desc. 60 ft.; enter scattering timber.

40.00 Point for ¼ sec. cor. of secs. 1 and 6 falls on a sandstone boulder, 8 x 5 x 2 ft. above ground,

Seat a brass tablet 3¼ ins. diam., 3½ ins. stem, with top mkd.

¼
S 1 | S 6
1945

from which

A pinon, 8 ins. diam., bears S. 54¾° E., 297 lks. dist., mkd. ¼ S6 BT.

A juniper, 9 ins. diam., bears S. 65° W., 84 lks. dist., mkd. ¼ S1 BT.

46.60 An arroyo, drains N. 75° E.; continue over nearly level land.

67.50 Leave scattering timber.

*Chains*

80.00 Point for the cor. of Ts. 13 and 14 N., Rs. 24 and 25 E.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

T 14 N
R 24 E | R 25 E
S 36 | S 31
S 1 | S 6
T 13 N
1945

raise a mound of stone, 5 ft. base, 3 ft. high, S. of cor.

Land, southern portion broken, balance level.
Soil, sandy loam, and stony.
Timber, juniper and pinon; undergrowth, sagebrush.

SEPTEMBER 2, 1945.

---

*Sixth guide meridian east, through T. 14 N., between Rs. 24 and 25 E.*

NOTE: The field notes of the survey of the Sixth Guide Meridian East, through Ts. 14, 15, and 16 N., between Rs. 24 and 25 E. continue on the same form, and all but the last mile are omitted here. An entry shows an observation for meridian at the cor. of Ts. 14 and 15 N., Rs. 24 and 25 E., for the verification of the alinement to that point, and for the control of the balance of the survey.

---

*Sixth guide meridian east, through T. 16 N., between Rs. 24 and 25 E.*

North, bet. secs. 1 and 6.

Over broken W. slope, through heavy juniper and pinon timber and dense undergrowth; asc. 25 ft. to top of spur.

3.00 Spur from ridge, slopes W.; desc. gradually over steep W. slope.

12.70 Gulch, course S. 30° W.; asc. 350 ft. to spur; timber changes to mostly pine.

29.80 Spur from ridge, slopes SW.; continue ascent of 125 ft. over steep W. slope.

40.00 Point for the ¼ sec. cor. of secs. 1 and 6.

Set an iron post, 30 ins. long, 2 in. diam., 15 ins. in the ground to bed rock and in a mound of stone, 8 ft. base, 1½ ft. high, with brass cap mkd.

1/4
S 1 | S 6
1945

from which

A yellow pine, 14 ins., diam., bears S. 36¾° E., 54 lks. dist., mkd. ¼ S6 BT.

A yellow pine, 12 ins. diam., bears S. 72¼° W., 96 lks. dist., mkd. ¼ S1 BT.

This corner falls in a wash which drains SW.

41.00 Spur from ridge, slopes W.; desc. 125 ft.

44.20 Deep draw, drains W.; ascend 300 ft. over steep slope.

57.00 Top of steep ascent; ascend gradually.

*Chains*

67.00 Divide bet. South Fork and North Fork of Trapper River, bears East and S. 75° W.; desc. 225 ft. to cor.

81.44 Intersect the Fourth Standard Parallel North.

Point for the closing cor. of Ts. 16N., Rs. 24 and 25 E.

Set an iron post, 30 ins. long, 2 ins. diam., 12 ins. in the ground to bedrock, and in a mound of stone to top with brass cap mkd.

T 17 N R 24 E
S 36

S 1 | S 6
R 24 E | R 25 E
T 16 N
CC
1945

from which

A juniper, 12 ins. diam., bears S. 33¼° E., 58 lks. dist., mkd. T16N R25E S6 CC BT.

A yellow pine, 9 ins. diam., bears S. 72¾° W., 129 lks. dist., mkd. T16N R24E S1 CC BT.

From point of intersection the standard ¼ sec. cor., S. bdy, sec. 36, T. 17 N., R. 24 E., bears S. 89°56′ E., 12.76 chs. dist., and is monumented with a sandstone 12 x 8 x 6 ins. above ground, mkd. and witnessed as described in the record of the 1906 resurvey of the Fourth Stan. Par. N. through R. 24 E.

From the same point the standard cor. of secs. 35 and 36. T. 17 N., R. 24 E., bears N. 89°56′ W., 27.18 chs. dist., and is monumented with a sandstone, 14 x 8 ins., standing firmly 8 ins. above the top of a mound of stone, 4 ft. base, 2 ft. high, marked and witnessed as described in the record of 1906 resurvey of the Fourth Stan. Par. N. through R. 24 E.

Land, mountainous.
Soil, sandy and stony.
Timber, yellow pine, juniper, and pinon; undergrowth, service and oak brush.

---

Sept. 11: At the closing Tp. cor., in order to verify the alinement of the Sixth Guide Meridian East, I bisect Polaris, follow the motion of the star to eastern elongation, at 8h 26.8 m p. m., l. m. t., and mark the direction upon a peg driven firmly in the ground 8 chs. N.; I then reverse the instrument, again bisect Polaris, and mark the direction upon the peg. Without changing the instrument in horizontal motion, I sight to Polaris to make certain that the settings were made at elongation; there appeared to be no deviation in azimuth for some 15 or 20 minutes.

Sept. 12: I lay off the azimuth of Polaris 1°14′57″, to the west of the mean direction determined by the observation and set a point for the test meridian; then, by direct and reversed sights, I ascertain that the angle subtended by the last back sight flag, near the top of the divide on the guide meridian as established, is less than 0°01′00″ from this line.

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MEMORANDUM

Ordinarily only one set of measurements will be required on the guide meridian where the special instructions provide that the township is to be subdivided.

A summary description of the region crossed by a guide meridian will be supplied at the end of the field notes, or it may be included in the general description of the subdivisional survey.

SEPTEMBER 12, 1945.

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## *West boundary of T. 13 N., R. 24 E.*

MEMORANDUM

The field notes of the survey of a meridional township boundary will ordinarily take the form of the specimen field notes of the Sixth Guide Meridian East, with only one set of measurements.

NOTE.—Specimen field notes omitted.

Chains

## *North boundary of T. 13 N., R. 24 E.*

NOTE.—Latitudinal township boundaries will generally be run by the random and true method but the random line will be given in the field notes only where needed to show the detail of a triangulation, offset, or some technical operation. Detail of the random is given here to show the form.

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Sept. 19, 1945, at the cor. of Ts. 13 and 14 N., Rs. 24 and 25 E., in latitude 37°04.8′ N., and longitude 104°38.3′ W., as computed by reference to the values given for the standard cor. of Ts. 13 N., Rs. 20 and 21 E., I turn 90° from a flag point previously located on the Sixth Guide Meridian East, and run

West, on a random line, making proper offsets to the north from the tangent to the parallel at intervals of 40.00 chs., setting temp. ¼ sec. and sec. cors. along the line bet. Ts. 13 and 14 N., R. 24 E. At 479.25 chs., the parallel falls 25 lks. to the left of the cor. of Ts. 13 and 14 N., Rs. 23 and 24 E. The correction is 4.2 lks. N. per mile, counting from the point of beginning.

Thence

S. 89°58′ E., bet. secs. 6 and 31, marking and blazing the true line.

Asc. over SW. slope, through dense undergrowth.

30.25 Ridge, bears N. 15° 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, 30 ins. long, 2 in. diam., 24 ins. in the ground, with brass cap mkd.

1/4 S 31
S 6
1945

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, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

T 14 N R 24 E
S 31 | S 32
S 6 | S 5
T 13 N
1945

raise a mound of stone, 4 ft. base, 2 ft. high, W. of cor.

Land, rolling mountainous.
Soil, sandy.
No timber; undergrowth, sagebrush.

---

S. 89°58′ E., bet. secs. 5 and 32.

Over rolling N. slope, changing to E. slope; through dense undergrowth.

29.50 Gulch, course SE.; asc. to spur.

35.50 Point of spur from ridge, slopes S.; leave undergrowth and enter scattering timber; desc. gradually.

40.00 Point for the ¼ sec. cor. of sec. 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.

700004°—47——35

*Chains*

53.00 Top of slope; desc. 50 ft. to creek.

60.00 Crooked Wash Creek, 30 lks. wide, dry, course S. 20° W.; asc. 150 ft.

77.00 Ridge, bears N. and S.; desc. gradually to cor.

80.00 Point for the cor. of secs. 4, 5, 32, and 33.

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; from which

A juniper, 20 ins. diam., bears N. 36°35′ W., 423 lks. dist., mkd. T14N R24E S32 BT.

Raise a mound of stone, 4 ft. base, 2 ft. high, W. of cor.

Land, rolling mountainous.
Soil, sandy and stony.
Timber, scattering juniper; undergrowth, greasewood and sagebrush.

---

NOTE.—The field notes of the survey of the line bet. secs. 4 and 33, 3 and 34, and bet. secs. 2 and 35, continue on the same form, and are omitted here.

---

S. 89°58′ E., bet. secs. 1 and 36.

Descend gradually through heavy pinon timber and dense undergrowth.

11.40 A graded road, bears N. 55° W. and S. 55° E., from Ft. Myer to Douglass P. O.

16.20 Right bank of the South Fork of Trapper River, course S. 50° E.; banks 2 to 5 ft. high, water at present low stage from 1 to 3 ft. deep.

Point for the meander cor. of secs. 1 and 36.

Set an iron post, 30 ins. long, 2 in. diam., 24 ins. in the ground, with brass cap mkd.

T 14 N
S 36
R 24 E MC
S 1
T 13 N
1945

from which

A juniper, 14 ins. diam., bears N. 76¼° W., 142 lks. dist., mkd. T14N R24E S36 MC BT.

A juniper, 10 ins. diam., bears S. 21¾° W., 98 lks. dist., mkd. T13N R24E S1 MC BT.

Width of river about 4.50 chs.; distance across on line by steel tape measurement, 7.15 chs.

23.35 Left bank of river.

Point for meander cor. of secs. 1 and 36.

Set a washed flint boulder, 28x16x8 ins., 21 ins. in the ground, mkd.
6 grooves on N.,
1 groove on E.,
6 grooves on S., and
MC on W. face; and raise a mound of stone, 5 ft. base, 3 ft. high, E. of cor.

Asc. 150 ft. over broken SW. slope, through scattering pinon timber.

40.00 Point for the ¼ sec. cor. of secs. 1 and 36.

Set an iron post, 30 ins. long, 2 in. diam., 24 ins. in the ground, with brass cap mkd.

$\frac{1}{4}$ S 36
S 1
1945

from which

A pinon, 9 ins. diam., bears S. 29°40′ W., 387 lks. dist., mkd. ¼ S1 BT.

Raise a mound of stone, 4 ft. base, 2 ft. high, N. of cor.

| *Chains* | |
|---|---|
| 45.70 | Ridge and edge of heavy timber, bear NW. and SE.; desc. 35 ft.; timber changes to pine, spruce, and fir. |
| 65.20 | Base of slope and edge of timber, bear NW. and SE.; leave timber; continue over nearly level land. |
| 80.00 | The cor. of Ts. 13 and 14 N., Rs. 24 and 25 E. |

Land, mostly broken; eastern part nearly level.
Soil, sandy loam, and stony.
Timber, juniper, pinon, yellow pine, blue spruce, and Douglas fir; undergrowth, sagebrush.

MEMORANDUM

A summary description of the region crossed by the township exteriors will be supplied at the close of the field notes, excepting where it may be included in the general description of the subdivisional survey.

A table of latitudes and departures of the boundaries of the townships whose exteriors have been duly completed, showing proper allowances for convergency, and the reduced closing errors, will be filed with the public survey office with the field tablets, computation sheets and other data that pertain to the survey.

The following is an example:

*Boundaries of T. 13 N., R. 24 E.*

| | True bearing | Distance | N. | S. | E. | W. |
|---|---|---|---|---|---|---|
| | | *Chains* | *Chains* | *Chains* | *Chains* | *Chains* |
| 3d Stan. Par. N | East | 480.00 | | | 480.00 | |
| 6th Guide Mer. E | North | 480.00 | 480.00 | | | |
| North boundary | N. 89°58′ W. | 479.25 | .25 | | | 479.25 |
| West boundary | South | 480.00 | | 480.00 | | |
| Convergency | | | | | | .55 |
| Totals | | | 480.25 | 480.00 | 480.00 | 479.80 |
| | | | 480.00 | | 479.80 | |
| Error in latitude | | | .25 | | | |
| Error in departure | | | | | .20 | |

The table will not be carried to the field notes.

NOTE.—This completes the field work directed in the special instructions.
Names of assistants omitted.
Certificates omitted.

SEPTEMBER 21, 1945.

SPECIMEN

# FIELD NOTES

OF THE SURVEY OF THE

# SUBDIVISIONAL AND MEANDER LINES OF TOWNSHIP 15 NORTH, RANGE 20 EAST

## OF THE PRINCIPAL MERIDIAN IN THE STATE OF MONTANA

Executed by

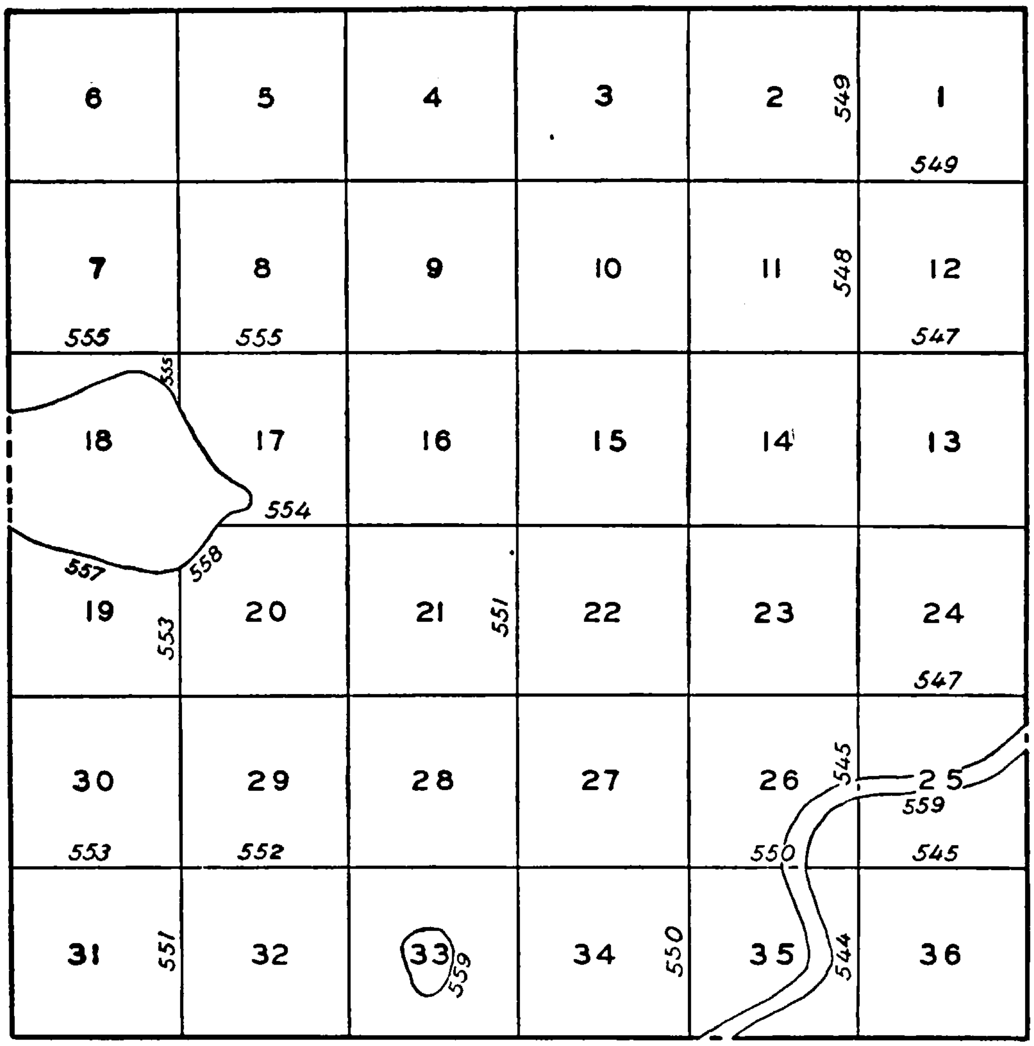
ROBERT ACRES, Cadastral Engineer

Under special instructions dated April 1, 1945, which provided for the surveys included under Group No. 123, approved April 10, 1945, and assignment instructions dated May 20, 1945.

Survey commenced June 1, 1945
Survey completed June 30, 1945

## INDEX TO SPECIMEN FIELD NOTES

T. 15 N., R. 20 E.






NOTE.—When the survey is executed by more than one engineer, the lines surveyed by each engineer will be indicated by distinctive color and a statement made below the diagram of the color which applies to the work of each engineer.

*Chains*

The subdivisional survey of T. 15 N., R. 20 E., is executed with a light-mountain solar transit made by ............, Serial No. ......, constructed in accordance with the standard specifications of the General Land Office. The horizontal circle has two double opposite verniers reading to single minutes, and the vertical circle has one double vernier reading to single minutes; the telescope has fixed stadia wires, ratio 1:132, with a focal constant of 1.2 lks. The instrument is equipped with the General Land Office solar attachment; radius of latitude arc 2¼ ins., and of declination arc 3¼ ins., each with verniers reading to single minutes. The instrument is in good condition, and having been placed in satisfactory adjustment prior to beginning the survey, is tested and found free from appreciable error.

The directions of the subdivisional lines are determined by solar transit method. The measurements are made with narrow steel tapes, 5 chs. and 8 chs. in length, graduated every link for the first 100 lks., and the balance at intervals of 10 lks. The tapes are tested by comparison with a 1-chain standard steel tape and found correct. The measurements are made on the slope, and the vertical angle of each interval is ascertained by a clinometer in good adjustment; the horizontal equivalents are entered in the field note record. Some of the distances are determined by stadia method as shown in the record. Lines connecting previously established corners are run by the random and true method but the random lines are omitted from the field notes except where needed to show the detail of a triangulation, offset, or other technical operation.

The data furnished with the special instructions give the geographic position for the SE. cor. of the Tp., as latitude 45°45.0′ N., and longitude 107°54.0′ W.

June 1, 1945, in camp on the Yellowstone River near the center of the NE¼ of sec. 35, at $3^h10.8^m$ a. m., l. m. t., or $3^h22.4^m$ a. m. by my watch, I observe Polaris at eastern elongation, making two sights each with the telescope in direct and reversed positions, and place a tack at the mean point, on a peg driven firmly in the ground 8 chs. N. After sunrise, I lay off the azimuth of Polaris, 1°26′00″, and make a meridian mark on a second peg, 20.10 lks. (13.33 ft.) to the west of the mean point in the line determined by the observation; I verify the angle by a vernier reading of the instrument.

In order to verify the latitude of this station and the reading of my watch, I make a meridian observation of the sun, first setting on the lower limb and noting the transit of the west limb, then, after reversal of the instrument, setting on the upper limb and noting the transit of the east limb,

| | |
|---|---|
| Mean observed altitude | 66°19′15″ |
| Reduced latitude | 45°45′45″ |
| Mean watch time of observation | $12^h09^m26^s$ |
| Watch fast of l. m. t. | $11^m46^s$ |
| Same, by reference to radio time signals and calculated difference in longitude | $11^m36^s$ |
| Sun's apparent declination at Greenwich apparent noon | 22°02′34.6″ |

Every 30 m. from 6 to 10.30 a. m. and from 1.30 to 6 p. m., I make proper settings on the arcs of the solar attachment and ascertain that the resulting orientation of the instrument, when compared with the meridian established by Polaris observation, has a maximum error of less than 1′30″.

I repeat the tests of the arcs daily by noon observation, and verify the meridional indications at frequent intervals throughout the survey.

The observed magnetic declination is 18°10′ E.

I make the following test of the stadia wire interval:

| | |
|---|---|
| Horizontal length of base by steel tape measurement | 17.180 chs. |
| Mean of 10 rod readings at different hours during the day, vertical rod | 8.703 ft. |
| Vertical angle of test | +5°41′ |
| | K=131.487 |
| Reduced error in 10 chs., correction to be subtracted | 4.0 lks. |

---

| Chains | |
|---|---|
| | Beginning the subdivisional survey at the cor. of secs. 1, 2, 35, and 36, on the S. bdy. of the Tp., which is monumented with a sandstone, 8 x 6 x 5 ins. above ground, firmly set, marked and witnessed as described in the official record. |
| | N. 0°01′ W., bet. secs. 35 and 36. |
| | Over level bottom land. |
| 20.00 | Enter scattering timber. |
| 29.30 | SE. cor. of field; leave scattering timber. |
| 31.50 | A cabin bears West, 6.00 chs. dist. |
| 39.50 | Enter State Highway No. 25, bears N. along section line, and E. |
| 40.00 | Point for the ¼ sec. cor. of secs. 35 and 36. |
| | Bury a granite stone, 12 x 12 x 12 ins., mkd. X, 2 ft. underground, from which |
| | An iron post, 30 ins. long, 2 ins. diam., set 24 ins. in the ground, for a reference monument, with brass cap mkd. with an arrow pointing to the cor. and ¼ S36 RM, bears East, 46 lks. dist. |

*Chains*

An iron post 30 ins. long, 2 ins. diam., set 24 ins. in the ground, for a reference monument, with brass cap mkd. with an arrow pointing to the cor. and ¼ S35 RM, bears West, 46 lks. dist.

50.50 NE. cor. of field.

51.50 Highway turns to N. 70° W.

57.50 Enter heavy timber and dense undergrowth, edge bears N. 54° E. and S. 54° W.

72.00 Leave undergrowth.

80.00 Point for the cor. of secs. 25, 26, 35, and 36.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

| T 15 N | R 20 E |
|---|---|
| S 26 | S 25 |
| S 35 | S 36 |

1945

from which

A green ash, 13 ins. diam., bears N. 22° E., 26 lks. dist., mkd. T15N R20E S25 BT.

A green ash, 23 ins. diam., bears S. 71¼° E., 37 lks. dist., mkd. T15N R20E S36 BT.

A green ash, 17 ins. diam., bears S. 64° W., 41 lks. dist., mkd. T15N R20E S35 BT.

A cottonwood, 13 ins. diam., bears N. 21¼° W., 36 lks. dist., mkd. T15N R20E S26 BT.

Land, level bottom; northern 20 chs. subject to overflow.
Soil, alluvial, silt and loam.
Timber, green ash and cottonwood; undergrowth, willow.

---

From the cor. of secs. 25, 30, 31, and 36 on the E. bdy. of the Tp., which is monumented with a sandstone, 8 x 5 x 5 ins. above ground, marked and witnessed as described in the official record.

N. 89° 56′ W., bet. secs. 25 and 36.

Over level bottom land, through scattering timber.

16.20 Cherry Creek, 12 lks. wide, course NW.

39.98 Point for the ¼ sec. cor. of secs. 25 and 36.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

$\frac{1}{4}$ S 25 / S 36
1945

from which

A green ash, 8 ins. diam., bears N. 64¾° W., 124 lks. dist., mkd. ¼ S25 BT.

A green ash, 7 ins. diam., bears S. 65¼° W., 189 lks. dist., mkd. ¼ S36 BT.

79.96 The cor. of secs. 25, 26, 35, and 36.

Land, level bottom; mostly subject to overflow.
Soil, alluvial, silt and loam.
Timber, green ash and cottonwood.

---

N. 0°01′ W., bet. secs. 25 and 26.

Over level bottom land, through heavy timber.

25.36 Right bank of Yellowstone River, course N. 81° E.; banks 2 to 12 ft. high; water is high at present stage and from 1 to 8 ft. deep.

*Chains*

Point for the meander cor. of secs. 25 and 26.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

| MC | |
|---|---|
| S 26 | S 25 |
| T 15 N | R 20 E |
| 1945 | |

from which

A cottonwood, 12 ins. diam., bears S. 18¼° E., 16 lks. dist., mkd. T15N R20E S25 MC BT.

A green ash, 11 ins. diam., bears S. 74½° W., 25 lks. dist., mkd. T15N R20E S26 MC BT.

Stadia to left bank of river: 12.096 and 12.088 ft., —0°10′.

49.46 Left bank of river.

Point for the meander cor. of secs. 25 and 26.

Set a washed granite boulder, 34 x 9 x 7 ins. 24 ins. in the ground, mkd.

5 grooves on N.,
1 groove on E.,
MC on S., and
5 grooves on W. face; from which

A green ash, 10 ins. diam., bears N. 34¼° 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.

52.60 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, 30 ins. long, 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 |
| 1945 | |

dig pits, 18 x 18 x 12 ins., in each sec., 3 ft. dist.

Land, nearly level; 52 chs. bottom land subject to overflow.
Soil, alluvial, silt and loam, and sandy.
Timber, green ash and cottonwood.

---

The cor. of secs. 19, 24, 25, and 30 on the E. bdy. of the Tp. is monumented with a sandstone, 12 x 9 x 5 ins., poorly mkd. with 4 notches on one edge and 2 notches on opposite edge, loosely set on the east side of a small mound of stone.

At the corner point,

Set an iron post, 30 ins. long, 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 |
| 1945 | |

raise a mound of stone, 3 ft. base, 2 ft. high, W. of cor. and bury the original corner stone alongside the iron post.

| *Chains* | |
|---|---|
| | Thence |
| | N. 89° 55′ W., bet. secs. 24 and 25. |
| | Over level land. |
| 38.00 | Fletcher's service station bears South, 8 chs. dist. |
| 39.99 | Point for the ¼ sec. cor. of secs. 24 and 25. |
| | Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd. |
| | $\frac{1}{4}$ $\frac{\text{S 24}}{\text{S 25}}$ 1945 |
| | dig pits, 18 x 18 x 12 ins., E. and W. of post, 3 ft. dist. |
| 70.00 | U. S. Highway No. 87, bears N. 73° W. and S. 73° E. |
| 79.98 | The cor. of secs. 23, 24, 25, and 26. |
| | Land, level.<br>Soil, sandy.<br>No timber. |

NOTE.—The field notes continue in the regular order and on the same form; the record of 3 miles omitted.

| | |
|---|---|
| | From the cor. of secs. 7, 12, 13, and 18 on the E. bdy. of the Tp., which is monumented with a sandstone, 8 x 5 x 8 ins. above ground, firmly set, marked and witnessed as described in the official record. |
| | N. 89° 52′ W., bet. secs. 12 and 13. |
| | Over nearly level land. |
| 31.49 | Intersect the NE. bdy. of the Rancho San Blas. |
| | Point for the closing cor. of secs. 12 and 13. |
| | Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd. |
| | T 15 N<br>RSB S 12<br>CC<br>LG S 13<br>R 20 E<br>1945 |
| | raise a mound of stone, 3 ft. base, 2 ft. high, E. of cor. |
| | From this point the 5th Mi. Cor. of the grant boundary bears S. 33° 00′ E., 7.00 chs. dist., and is monumented with a limestone, 15 x 8 x 5 ins. above ground, firmly set, marked and witnessed as described in the official record. |
| | Thence on a blank line across the grant. |
| 40.015 | Point for ¼ sec. cor. of secs. 12 and 13, not monumented. |
| 67.07 | Intersect the SW. bdy. of the grant. |
| | Point for the closing cor. of secs. 12 and 13. |
| | Set a granite stone, 25 x 7 x 6 ins., 16 ins. in the ground, mkd. |
| | 2 grooves on N.,<br>RSB LG on E.,<br>4 grooves on S., and<br>CC and 6 grooves on W. face; and raise a mound of stone, 2 ft. base, 1½ ft. high, W. of cor. |

*Chains*

From this point the 3½ Mi. Cor. of the grant boundary bears N. 19°30′ W., 12.00 chs. dist., and is monumented with a flint stone, 12 x 6 x 8 ins. above ground, firmly set, marked and witnessed as described in the official record.

The closing corner is located on the top of a ridge bearing N. 15° W. and S. 15° E.; thence over rough stony ground.

76.00 Begin descent over broken SW. slope.

80.03 The cor. of secs. 11, 12, 13, and 14.

Land, eastern part, level; western part, mountainous.
Soil, sandy loam and stony.
No timber.

---

N. 0°01′ W., bet. secs. 11 and 12.

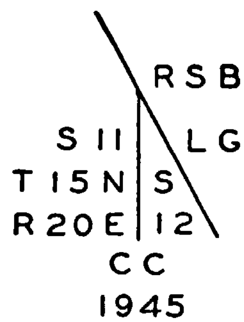
Ascend over broken SW. slope.

11.00 Top of ascent, bears N. 50° W. and S. 50° E.; thence over nearly level land.

36.60 Intersect the SW. bdy. of the Rancho San Blas.

Point for the closing cor. of secs. 11 and 12.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.




from which

A lone juniper, 20 ins. diam., bears S. 34°25′ W., 484 lks. dist., mkd. T15N R20E S11 CO BT.

Raise a mound of stone, 2 ft. base, 1½ ft. high, S. of cor.

From this point Cor. No. 7 of the grant boundary bears N. 19°30′ W., 7.40 chs. dist., and is monumented by a granite boulder, 6 x 4 x 1½ ft. above ground, marked and witnessed as described in the official record.

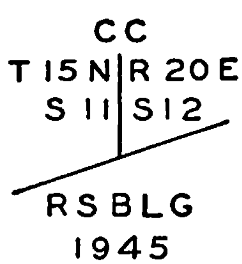
Thence on a blank line across the grant.

40.00 Point for ¼ sec. cor. of secs. 11 and 12, not monumented.

44.32 Intersect the NW. bdy. of the grant.

Point for the closing cor. of secs. 11 and 12.

Set an iron post, 30 ins. long, 2 ins. diam., 15 ins. in the ground to bedrock, and in a mound of stone to top, with brass cap mkd.




Bury a granite stone 10 x 7 x 6 ins., mkd. X alongside the iron post.

From this point Cor. No. 7 of the grant boundary bears S. 73°00′ W., 2.58 chs. dist., previously described.

| *Chains* | |
|---|---|
| | Thence over rolling ground. |
| 60.80 | A creek, 6 lks. wide, course SE. |
| 80.00 | Point for cor. of secs. 1, 2, 11, and 12. |
| | 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; and raise a mound of stone, 2 ft. base, 1½ ft. high, W. of cor. |
| | Land, mountainous.<br>Soil, sandy clay and stony.<br>Timber, a few scattering juniper. |
| | From the cor. of secs. 1, 6, 7, and 12 on the E. bdy. of the Tp., which is monumented with an oak post, 4 ins. sq., 12 ins. above ground, firmly set, marked and witnessed as described in the official record. |
| | N. 89°49′ W., bet. secs. 1 and 12. |
| | Over rolling land. |
| 3.50 | Enter a grove of heavy timber, edge bears North and S. 20° W. |
| 18.07 | A burr oak, 12 ins. diam., on line, mkd. with two hacks each on E. and W. sides. |
| 40.02 | Point for the ¼ sec. cor. of secs. 1 and 12. |
| | Set a granite stone, 28 x 11 x 9 ins., 18 ins. in the ground, mkd. ¼ on N. face; from which |
| | A burr oak, 9 ins. diam., bears N. 19½° W., 22 lks. dist., mkd. ¼ S1 BT. |
| | A burr oak, 11 ins. diam., bears S. 65¾° W., 129 lks. dist., mkd. ¼ S12 BT. |
| 41.10 | A ravine, course S. 20° W. |
| 49.60 | A ravine, course S. 30° W. |
| 69.00 | Leave grove, edge bears NE. and SE. |
| 80.04 | The cor. of secs. 1, 2, 11, and 12. |
| | Land, rolling mountainous.<br>Soil, sandy clay and stony.<br>Timber, burr oak. |
| | N. 0°02′ E., bet. secs. 1 and 2. |
| 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; and raise a mound of stone, 2 ft. base, 1½ ft. high, W. of cor. |
| 49.30 | An arroyo, course N. 70° E. |
| 79.77 | Intersect N. bdy. of the Tp. at the cor. of secs. 1, 2, 35, and 36, which is monumented with a limestone, 16 x 6 x 5 ins., mkd. with 1 notch on E. and 5 notches on W. edge, loosely set, with small mound of stone on the W. |
| | At the corner point, |
| | Set an iron post, 30 ins. long, 2 ins. diam., 10 ins. in the ground to bedrock, and in a mound of stone to top, with brass cap mkd. |
| | T 16 N R 20 E<br>S 35 \| S 36<br>S 2 \| S 1<br>T 15 N<br>1945 |
| | Bury the original corner stone alongside the iron post. |
| | Land, rolling mountainous.<br>Soil, sandy clay.<br>No timber. |

*Chains*

From the cor. of secs. 2, 3, 34, and 35, on the S. bdy. of the Tp., which is monumented with a sandstone, 14 x 8 x 8 ins. above ground, firmly set, marked and witnessed as described in the official record.

N. 0°02′ W., bet. secs. 34 and 35.

Over level bottom land.

40.00 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; and raise a mound of stone, 4 ft. base, 3 ft. high, W. of cor.

42.00 Leave bottom land, bears N. 70° E. and S. 70° W.; ascend sandy ridge.

46.00 Top of wind-blown sandy ridge, bears N. 70° E. and S. 70° W.

50.00 Foot of sandy ridge; thence over nearly level land.

80.00 Point for the cor. of secs. 26, 27, 34, and 35.

Set an iron post, 30 ins. long, 2 ins. diam., in a concrete form, 8 ins. upper diam., 14 ins. lower diam., and 30 ins. long, 24 ins. in the ground, with brass cap mkd.

T 15 N R 20 E
S 27 | S 26
S 34 | S 35
1945

Land, south-half, level bottom subject to overflow; north-half, level sandy plain.
Soil, alluvial, silt and loam.
No timber.

---

S. 89°57′ E., on a random line bet. secs. 26 and 35.

40.00 Set temp. ¼ sec. cor.

48.13 Left bank of river; set temp. meander cor.

Stadia to right bank; 9.131 and 9.119 ft., level.

66.32 Right bank of river; set temp. meander cor.

80.06 Fall 3 lks. to the right of cor. of secs. 25, 26, 35, and 36.

Thence

N. 89°58′ W., on true line bet. secs. 26 and 35.

Over level bottom land, through heavy timber.

13.74 Right bank of Yellowstone River, course N. 20° W.; banks 2 to 10 ft. high; water is high at present stage and from 1 to 8 ft. deep.

Point for the meander cor. of secs. 26 and 35.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

T 15 N
S 26
M C
S 35
R 20 E
1945

from which

A green ash, 9 ins. diam., bears N. 49¼° E., 26 lks. dist., mkd. T15N R20E S26 MC BT.

A cottonwood, 13 ins. diam., bears S. 38½° E., 21 lks. dist., mkd. T15N R20E S35 MC BT.

31.93 Left bank of river.

*Chains*

Point for meander cor. of secs. 26 and 35.

Set a washed granite boulder, 40 x 12 x 8 ins., 30 ins. in the ground, mkd.

5 grooves on N.,
MC on E.,
1 groove on S., and
5 grooves on W. face; and raise a mound of stone, 5 ft. base, 3 ft. high, W. of cor.

Ascend gradually through scattering timber.

37.50 Leave timber.

40.03 Point for the ¼ sec. cor. of secs. 26 and 35.

Set a granite stone, 24 x 12 x 8 ins., 16 ins. in the ground, mkd. ¼ on N. face; from which

A green ash, 14 ins. diam., bears N. 28°50′ E., 328 lks. dist., mkd. ¼ S26 BT.

A green ash, 9 ins. diam., bears S. 78°05′ E., 278 lks. dist., mkd. ¼ S35 BT.

70.50 State Highway No. 25, bears N. 68° W. and S. 68° E.

80.06 The cor. of secs. 26, 27, 34, and 35.

Land, east of river, level bottom subject to overflow; west of river, level upland.
Soil, alluvial, silt and loam.
Timber, green ash and cottonwood.

---

NOTE.—The field notes continue in the regular order, and on the same form; the record of 13 miles omitted.

---

N. 0°03′ W., bet. secs. 21 and 22.

Over level land.

13.90 Enter marsh, bears N. 60° E. and N. 80° W.

40.00 Point for the ¼ sec. cor. of secs. 21 and 22.

Set a brass tablet, 3¼ ins. diam., 3½-inch stem, in a cylindrical concrete form, 30 ins. long, 6 ins. diam., 24 ins. in the ground, with top mkd.

$\frac{1}{4}$

S 21 | S 22

1945

53.60 Leave marsh, bears N. 30° W. and S. 60° E.

80.00 Point for the cor. of secs. 15, 16, 21, and 22.

Set a brass tablet, 3¼ ins. diam., 3½-inch stem, in a concrete form, 8 ins. upper diam., 14 ins. lower diam., 30 ins. long, 24 ins. in the ground, with top mkd.

T 15 N R 20 E

S 16 | S 15

S 21 | S 22

1945

Land, level; 39.70 chs., swamp and overflowed.
Soil, rich loam.
No timber.

---

NOTE.—The field notes continue in the regular order, and on the same form; the record of 17 miles omitted.

---

The cor. of secs. 5, 6, 31, and 32, on the S. bdy. of the Tp. is monumented with a limestone

*Chains*

15 x 8 x 6 ins., poorly mkd. with 5 notches on one edge and 1 notch on opposite edge, lying on the ground on the east side of a small mound of stone.

At the corner point,

Set an iron post, 30 ins. long, 2 ins. diam., 24 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
1945

raise a mound of stone, 4 ft. base, 2 ft. high, W. of cor. and bury the original corner stone alongside the iron post.

N. 0°05′ W., bet. secs. 31 and 32.

Over level land.

40.00 Point for the ¼ sec. cor. of secs. 31 and 32.

Set a brass tablet, 3¼ ins. diam., 3½-inch stem, in a cylindrical concrete form, 36 ins. long, 6 ins. diam., 24 ins. in the ground, with top mkd.

$\frac{1}{4}$
S 31 | S 32
1945

80.00 Point for the cor. of secs. 29, 30, 31, and 32.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

T 15 N R 20 E
S 30 | S 29
S 31 | S 32
1945

raise a mound of stone, 3 ft. base, 2 ft. high, W. of cor.

Land, level.
Soil, sandy.
No timber.

From the cor. of secs. 28, 29, 32, and 33.

N. 89°54′ W., bet. secs. 29 and 32.

Over level land.

14.50 Base of slope, bears N. 30° E. and S. 30° W.

16.50 Top of slope.

28.50 A spring bears South, 2.50 chs. dist.

39.98 Point for the ¼ sec. cor. of secs. 29 and 32

*Chains*

Set a brass tablet, 3¼ ins. diam., 3½-inch stem, in a cylindrical concrete form, 30 ins. long, 6 ins. diam., 24 ins. in the ground, with top mkd.

$\frac{1}{4}$ S 29 / S 32
1945

79.96 The cor. of secs. 29, 30, 31, and 32.

Land, level.
Soil, sandy.
No timber.

---

N. 89°57′ W., bet. secs. 30 and 31.

40.00 Point for the ¼ sec. cor. of secs. 30 and 31.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd

$\frac{1}{4}$ S 30 / S 31
1945

dig pits, 18 x 18 x 12 ins., E. and W. of post, 3 ft. dist.

78.35 Intersect W. bdy. of Tp. at the cor. of secs. 25, 30, 31, and 36, identified by traces of four pits, one in each section, NE., SE., SW., and NW., with a part of an old stake bearing incomplete scribe marks lying in the SE. pit.

At the corner point

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

| T 15 N | |
|---|---|
| R 19 E | R 20 E |
| S 25 | S 30 |
| S 36 | S 31 |
| 1945 | |

Bury a sandstone 6 x 6 x 6 ins., mkd. X alongside the iron post.

Land, level.
Soil, sandy clay.
No timber.

---

NOTE.—The field notes continue in the regular order and on the same form; the record of 3 miles omitted.

---

N. 0°05′ W., bet. secs. 19 and 20.

Descend over stony N. slope.

2.00 Base of slope, bears N. 80° E. and S. 80° W

| Chains | |
|---|---|
| 40.00 | Point for the ¼ sec. cor. of secs. 19 and 20. |
| | Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.. |
| | $\frac{1}{4}$ <br> S19 \| S20 <br> 1945 |
| | raise a mound of stone, 4 ft. base, 2 ft. high, W. of cor. |
| 44.50 | South bank of Lins Lake, bears N. 74° W. and East. |
| | Point for the meander cor. of secs. 19 and 20. |
| | Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd. |
| | MC <br> S19 \| S20 <br> T15N \| R20E <br> 1945 |
| | from which |
| | A box elder, 8 ins. diam., bears S. 77½° E., 221 lks. dist., mkd. T15N R20E S20 MC BT. |
| | A green ash, 10 ins. diam., bears West, 327 lks. dist., mkd. T15N R20E S19 MC BT. |
| | Land, gently rolling. <br> Soil, rich loam. <br> Timber, scattering green ash and box elder along lake shore. |
| | From the cor. of secs. 16, 17, 20, and 21. |
| | N. 89°54′ W., bet. secs. 17 and 20. |
| | Descend gradually over gently rolling land. |
| 20.50 | An ungraded road, bears N. and S. |
| 28.70 | Ditch, course S. 30° W.; enter cultivated field. |
| 36.50 | Leave field; enter heavy timber, edge bears N. 30° E. and S. 30° W. |
| 40.00 | Point for the ¼ sec. cor. of secs. 17 and 20. |
| | Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd. |
| | S17 <br> $\frac{1}{4}$ ——— <br> S20 <br> 1945 |
| | from which |
| | A box elder, 12 ins. diam., bears N. 22¼° W., 119 lks. dist., mkd. ¼ S17 BT. |
| | A green ash, 13 ins. diam., bears S. 70½° W., 28 lks. dist., mkd. ¼ S20 BT. |
| 43.20 | East bank of Lins Lake, bears N. 19° E. and S. 39¾° W. |
| | Point for the meander cor. of secs. 17 and 20, monumented by. |
| | A green ash, 8 ins. diam., mkd. |
| | S17 on N., <br> T15N R20E on E., <br> S20 on S., and <br> MC on W. side; |

*Chains*

from which

A green ash, 10 ins. diam., bears N. 40¾° E., 20 lks. dist., mkd. T15N R20E S17 MC BT.

A box elder, 6 ins. diam., bears S. 62¼° E., 114 lks. dist., mkd. T15N R20E S20 MC BT.

Land, gently rolling.
Soil, loam.
Timber, mostly green ash and box elder, with some cottonwood.

NOTE.—The line bet. secs. 8 and 17 is established next by running from the cor. of secs. 8, 9, 16, and 17, N. 89°54′ W., parallel to the S. bdy. of sec. 17, 80.00 chs., with ¼ sec. cor. at 40.00 chs.

The line bet. secs. 17 and 18 is then established by running from the cor. of secs. 7, 8, 17, and 18, S. 0°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 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. a 40.00 chs. from the east.

The remaining 4 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 bearings and distance to the U. S. Location Monument, located at the SW¼SE¼, sec. 5, is determined and recorded.

IVY ISLAND

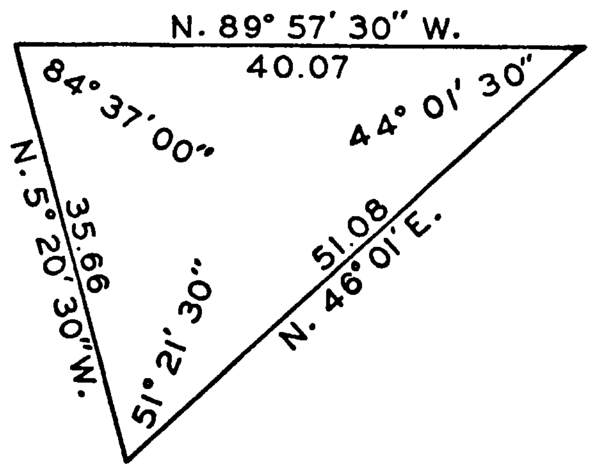
In order to establish the line bet. secs. 18 and 19, which crosses Ivy Island in Lins Lake, I sight from the meander cor. of secs. 17 and 20, N. 89°54′ W., on an extension of the section line, to a temp. point on the SE. bank of the island.

At the point on the island I observe the bearing to the meander cor. of secs. 19 and 20, on the south bank of the lake, and by calculation determine that this position is 80.04 chs. N. of the S. bdy. of sec. 19. I then move the temp. point 4 lks. south.

From the adjusted point the meander cor. of 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.

As a base for the triangulation I employ the meanders of the lake in sec. 20, hereinafter described, which reduce to an equivalent direct line between the meander corners with a bearing of N. 46°01′ E., and a length of 51.08 chs.

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 distance reduce to a northing of 35.50 chs., and a westing of 3.32 chs.; the allowance for the bearing of the E. bdy. of sec. 19, continued to the theoretical point for the cor. of secs. 17, 18, 19, and 20, in the lake, is 5 lks., making the net westing 3.27 chs.

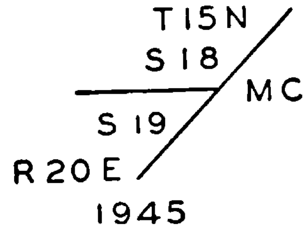
N. 89°58′ W., bet. secs. 18 and 19.

Over water.

*Chains*

8.27 The adjusted point for the meander cor. of secs. 18 and 19 on the SE. bank of Ivy Island; the bank bears N. 47¼° E., and S. 47¼° W.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.




from which

A burr oak, 9 ins. diam., bears N. 16¾° W., 29 lks. dist., mkd. T15N R20E S18 MC BT.

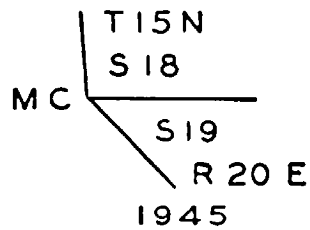
A green ash, 8 ins. diam., bears S. 78¾° W., 127 lks. dist., mkd. T15N R20E S19 MC BT.

Thence over level land, across Ivy Island.

7.38 The SW. bank of the island, bears N. 5½° W. and S. 52° E.

Point for the meander cor. of secs. 18 and 19.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.




raise a mound of stone, 6 ft. base, 3 ft. high, E. of cor.

Land nearly level; being higher to the north side of the island.
Soil, rich loam, and stony.
Timber, scattering burr oak and green ash.

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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°30′ W., 2.90 chs.

N. 35°00′ W., 1.60 chs.

S. 45°15′ W., 1.40 chs.

S. 56°00′ W., 2.30 chs.

N. 73°30′ W., 4.50 chs.

N. 38°00′ W., 6.40 chs. On this course the bank increases in height from 3 to 15 ft., and the beach becomes narrow and rocky.

N. 12°00′ E., 4.20 chs.

N. 59°15′ E., 5.30 chs. On this course the bank becomes a nearly vertical cliff, 35 ft. above mean high water.

East, 2.60 chs.

S. 36°00′ E., 3.80 chs.

S. 56° 15′ E., 6.40 chs. On this course leave cliff; bank gradually becomes lower, down to a height of about 4 ft.

S. 29°00′ E., 7.00 chs.

| Chains | |
|---|---|
| | S. 47°15′ W., 3.40 chs. The meander cor. of secs. 18 and 19. |
| | Land, rolling.<br>Soil, loam; and stony.<br>Timber, scattering burr oak and green ash; undergrowth, ivy. |
| | Thence in sec. 19. |
| | Along the top of a low bank, from 1 to 4 ft. in height, on the upper side of a gravelly beach. |
| | S. 47°15′ W., 2.50 chs. |
| | N. 53°10′ W., 2.84 chs. The meander cor. of secs. 18 and 19, and place of beginning. |
| | Land, level.<br>Soil, loam; and gravelly.<br>Timber, scattering burr oak and green ash; no undergrowth. |
| | The detail of the improvements on the island is carried to the general description at the close of the field notes, and to the plat of the survey. |
| | DIAMOND ROCK |
| | In order to survey a small island called Diamond Rock, in Lins Lake, in sec. 18, I begin at the meander cor. of secs. 19 and 24 on the W. bdy. of the Tp. and on the south bank of the lake, which is monumented with limestone, 14 x 8 x 8 ins. above ground, firmly set, marked and witnessed as described in the official record. |
| | N. 71°30′ E., on a connecting line. |
| | Over water. |
| | Distance by stadia: 10.752 and 10.761 ft., level. |
| 21.44 | The SW. bank of Diamond Rock at ordinary high water elevation. |
| | Point for auxiliary meander cor. in sec. 18. |
| | Set a brass tablet, 3¼ ins. diam., 3½-in. stem, in solid rock, with top mkd.<br>AMC<br>T 15 N R 20 E<br>S 18<br>1945<br>raise a mound of stone, 2 ft. base, 1½ ft. high, NE. of cor. |
| | 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 distance, by triangulation, with the crossing distance on the W. bdy. of the Tp. as the base, is 48.06 chs.; the cor. is monumented with a juniper post, 4 ins. sq., 1 ft. above ground, firmly set, marked and witnessed as described in the official record. |
| | Thence with the meanders of the island. |
| | Along the top of a low, but well-defined bank, on the upper side of a gravelly beach. |
| | N. 16°30′ W., 2.70 chs. |
| | N. 61°15′ E., 2.90 chs. |
| | S. 48°30′ E., 3.50 chs. |
| | S. 33°00′ W., 2.20 chs. |
| | N. 86°46′ W., 3.19 chs. The auxiliary meander cor. |
| | Land, level.<br>Soil, gravelly loam.<br>No timber. |
| | MEANDERS OF LINS LAKE |
| | From the meander cor. of secs. 19 and 24, on the W bdy. of the Tp., and on the south bank of the lake. |
| | With the meanders of Lins Lake in sec. 19. |

*Chains*

Along the edge of a well-defined bank from 2 to 4 ft. in height on the upper side of a gravelly beach.

S. 56°00′ E., 7.20 chs.

S. 46°30′ E., 3.40 chs.

S. 44°00′ E., 2.40 chs.

S. 43°15′ E., 5.70 chs.

S. 45°15′ E., 4.40 chs.

S. 44°45′ E., 5.80 chs.

S. 45°30′ E., 2.00 chs.

S. 49°30′ E., 4.00 chs.

S. 54°15′ E., 5.00 chs.

S. 67°45′ E., 2.00 chs.

S. 78°00′ E., 6.67 chs. At end of course,

Point for the special meander cor. on the meridional center line of sec. 19, 40.00 chs. in westing from the east bdy. of the section.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

SMC
C
S | 19
C
1945

raise a mound of stone, 6 ft. base, 2 ft. high, S. of cor.

N. 85°30′ E., 1.93 chs.

N. 77°45′ E., 11.00 chs.

S. 77°45′ E., 7.20 chs.

S. 74°00′ E., 21.11 chs. The meander cor. of secs. 19 and 20.

Land, level.
Soil, gravelly loam.
Timber, scattering green ash and burr oak.

---

Thence in sec. 20.

Along the top of a well-defined bank, from 2 to 4 ft. in height, on the upper side of a gravelly beach; through scattering ash and oak.

S. 89°45′ E., 6.10 chs.

N. 57°00′ E., 12.00 chs.

N. 37°30′ E., 10.50 chs.

N. 46°00′ E., 5.00 chs.

N. 23°15′ E., 9.90 chs. On this course enter a belt of heavy timer, parallel to the bank.

N. 89°45′ E., 10.48 chs. The meander cor. of secs. 17 and 20.

Land, level.
Soil, gravelly loam.
Timber, green ash and burr oak.

---

NOTE.—The meanders continue around the north bank of the lake through secs. 17 and 18, on the same form; the record omitted.

*Chains*

**CLEAR LAKE**

From the ¼ sec. cor. bet. secs. 28 and 33.

S. 0°03′ E., on the theoretical bearing of the N. and S. center line of sec. 33.

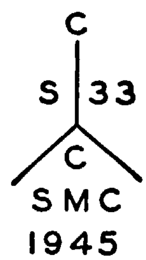
Over level land.

3.50 Spring branch, 8 lks. wide, course S. 80° E.

24.00 North bank of Clear Lake, bears S. 53° E. and S. 52° W.

Point for the special meander cor. on the meridional center line of sec. 33.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.




raise a mound of stone, 2 ft. base, 1½ ft. high, N. of cor.

---

Thence with the meanders of the lake.

Along the top of a well-defined bank, from 6 to 10 ft. in height.

S. 53°00′ E., 13.00 chs. At 7.00 chs. leave scattering timber.

S. 0°30′ W., 7.20 chs. At end of course, the outlet of the lake, 20 lks. wide, course SE.

S. 70°00′ W., 16.10 chs. Along a belt of heavy timber, parallel to the bank.

N. 63°45′ W., 10.00 chs. At 7.00 chs. leave timber.

N. 13°00′ W., 21.00 chs. At end of course, the outlet of a spring branch, 8 lks. wide.

N. 52°00′ E., 17.34 chs. Along scattering timber for 8 chs. At end of course, the special meander cor.

Land, level and gently rolling.
Soil, loam.
Timber, green ash and burr oak.

---

**MEANDERS OF THE YELLOWSTONE RIVER**

From the meander cor. of secs. 25 and 30, on the E. bdy. of the Tp. and on the right bank of the Yellowstone River, which is monumented with a sandstone, 16 x 9 x 7 ins. above ground, firmly set, marked and witnessed as described in the official record.

Thence upstream with the meanders of the right bank of the river, in sec. 25.

Over bottom land, along a well-defined cut-bank, from 2 to 12 ft. high, through heavy timber.

S. 85°00′ W., 13.00 chs.

S. 72°00′ W., 7.10 chs.

S. 64°30′ W., 13.00 chs.

S. 40°30′ W., 5.40 chs. At end of course, mouth of Cherry Creek, 14 lks. wide.

S. 77°45′ W., 7.00 chs.

N. 76°00′ W., 7.40 chs.

S. 80°00′ W., 12.00 chs.

S. 81°08′ W., 19.43 chs. The meander cor. of secs. 25 and 26.

Land, level bottom; subject to overflow.
Soil, alluvial, silt and loam.
Timber, green ash and cottonwood.

*Chains*

Thence in sec. 26.

NOTE.—The meanders of the right bank are continued upstream in secs. 26 and 35, to the S. bdy. of the Tp.; the field notes then show the meanders of the left bank running downstream in secs. 35, 26, and 25, all on the same form; the record is omitted.

---

LAKE CITY TOWN SITE

By an examination on the ground and in consultation with the surveyor who was employed by the applicants for the subdivision of the Lake City town site, I ascertain that a preliminary survey was initiated at the 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 town site 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 town site, and the temp. NE. cor. was placed at a point where a line running south would include all contemplated improvements; the temporary E. and W. bdrs. were run south to Lins Lake. I find that this general plan can be adhered to.

Transit 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 town site, the azimuths being referred to a meridian established by Polaris observation, as follows:

(NOTE.—Record of observation upon Polaris at eastern elongation, at the cor. of secs. 7, 8, 17, and 18, omitted.)

I proceed with the subdivision of secs. 7 and 18, and with the establishment of the town site boundaries, with the following true-line results.

---

From the ¼ sec. cor. of secs. 7 and 18,

N. 0°05′ W., on the N. and S. center line of sec. 7.

40.00 Intersect the E. and W. center line.

80.04 The ¼ sec. cor. of secs. 6 and 7.

From the ¼ sec. cor. of secs. 7 and 8.

N. 89°56′ W., on the E. and W. center line of sec. 7.

25.80 Point for the NE. cor. of the town site.

Set an iron post, 30 ins. long, 2 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.

S 7
C C
LC S7
TS
1945

From this point the temp. NE. cor. monument bears North, 7 lks. dist.; a limestone, 21 x 14 x 9 ins., mkd. NE COR LC; I remove the stone and bury it as a memorial alongside the iron post.

Continue on the E. and W. center line, along the N. bdy. of the town site.

40.00 Point for the center ¼ sec. cor. of sec. 7, at intersection with the N. and S. center line.

Set an iron post, 30 ins. long, 2 in. 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.

C $\frac{1}{4}$ S 7
LCTS
1945

*Chains*

60.00 Point for the CW 1/16 sec. cor. of sec. 7 and NW. cor. of the town site.

Set an iron post, 30 ins. long, 2 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.

CW 1/16
S 7
S 7 | L C
| T S
1945

From this point the temp. NW. cor. monument bears N. 81° 45′ E., 14 lks. dist.; an oak post 4 ins. sq., 4 ft. long, mkd. NW COR LC; I remove the post.

Continue on the E. and W. center line of sec. 7.

77.885 The 1/4 sec. cor. of secs. 7 and 12. on the W. bdy. of the Tp., which is monumented with a limestone, 12 x 8 x 10 ins. above ground, firmly set, marked and witnessed as described in the official record.

---

From the NE. cor. of the town site.

S. 0°05′ E., on the E. bdy. of the town site.

40.00 The closing cor. of secs. 7 and 18.

---

Thence in sec. 18.

7.53 The north bank of Lins Lake.

Point for auxiliary meander cor. in sec. 18, and SE. cor. of the town site.

Set an iron post, 30 ins. long, 2 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.

L C | T 15 N
T S | R 20 E
| S 18
AMC
1945

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; I remove the stone.

---

From the CW. 1/16 sec. cor. of sec. 7, and NW. cor. of townsite, S. 0°05′ E., on the N. and S. center line of the SW1/4 of sec. 7, and W. bdy. of the townsite.

40.00 The closing cor. of secs. 7 and 18 at the point for the W. 1/16 sec. cor.

---

Thence in sec. 18, on the N. and S. center line of the NW1/4 and W. bdy. of the townsite.

29.50 The north bank of Lins Lake.

Point for the special meander cor. on the meridional center line of the NW1/4 of sec. 18, and SW. cor. of the townsite.

*Chains*

Set an iron post, 30 ins. long, 2 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.

W

LC

S 18 | TS

W

SMC

1945

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; I remove the stone.

MEMORANDUM

The segregation of the mineral claims in secs. 4 and 5 and the computation of the areas of the surrounding fractional lots that are subject to entry as agricultural land are derived by aid of the field notes and plats of the mineral patent surveys, which show the connecting courses and distances to the U. S. Location Monument located in the SW¼ SE¼, sec. 5. The position of the latter monument, with reference to the quarter-section corner on the south boundary of the section, is shown in the record of the subdivisional survey. Ordinarily, the courses and distances along the boundaries of the mineral claims can not be shown at the scale of the township plat, in addition to the more essential information.

The survey of the boundaries of the Rancho San Blas was made under the provisions of the public land laws (R. S. sec. 2223; Mar. 3, 1925, 43 Stat. 1144; 43 U. S. C. sec. 52), prior to the subdivision of the township.

The location of the right of way of the Montana & Manitoba R. R. with reference to the subdivisional survey is ascertained by notation of the intersections on the section boundaries, and by aid of the map filed with the application for a right of way across public land. The land occupied by the railroad is not segregated from the public lands excepting within a town site.

TEST OF SOLAR ORIENTATION

June 30: At the cor. of secs. 7, 8, 17, and 18, at $6^h45^m$ a. m., app. t., I set off 45°48′30″ N., on the lat. arc; 23°12′ N., on the decl. arc; and orient the instrument with the solar; the line of sight agrees with the meridian established by Polaris observation.

At $4^h30^m$ p. m., app. t., I set off 45°48′30″ N., on the lat. arc; 23°10′ N., on the decl. arc; and repeat the test of the solar; the line of sight agrees with the meridian established by Polaris observation.

JUNE 30, 1945.

GENERAL DESCRIPTION

A considerable variety of land and soil are found in Township 15 North, Range 20 East. The general elevation of the township ranges from about 4,500 to 4,800 ft. above sea level; the summit of the Little Snowy Mountains, which extends into secs. 2 and 3, is about 1,200 ft. higher. Most of the northern and northeastern portion of the township is rough and stony, the central part gently rolling, and the southern part nearly level. The soil of the bottom land along the Yellowstone River is an alluvial silt and loam; much of the soil in the central part of the township is a black loam, but the southwestern part is very sandy. There is one small alkali flat which is located along the line between secs. 23 and 24. There is a heavy stand of cottonwood and green ash along the right bank of the river in sec. 25, a grove of heavy burr oak along the line between secs. 1 and 12, and a good growth of yellow pine, burr oak and fir timber over most of the mountain region.

The Yellowstone River crosses the southeastern 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; there is a ferry operating in sec. 35. There is some actual navigation on Lins Lake, which is a deep and permanent body of water; only the upper end of the lake extends into this township. Clear Lake is a permanent body of water, and meanderable under the Manual regulations. There is an extensive marsh in secs. 16, 21, and 22, which evidently was the bed of a former shallow lake; the marsh, and a group springs which are situated along the line between secs. 9 and 16, drain into Lins Lake. There are three good springs in secs. 28 and 32, all of considerable flow, which are tributary to Clear Lake.

The most important developments at the present time are the gold-bearing quartz mineral claims in secs. 4 and 5, and the Montana & Manitoba R. R., which crosses the northwestern part of the township. There is a limestone quarry in the NW¼ SW¼ sec. 9, which may be considerably expanded if there should be a demand for building stone in this vicinity. The proposed Lake City town site is well chosen and offers many advantages. The applicants for the town site subdivision are making a bona fide effort to encourage an interest in the situation.

There are three settlers in secs. 17 and 20 who have small fields in cultivation, under irrigation; three additional settlers, one in sec. 19, one in sec. 25, and one in sec. 35 have made their first improvements, and one of them has about 40 acres in cultivation. The settlement will

| *Chains* | |
|---|---|
| | doubtless be considerably increased whenever there is a demand for the land, but at the present time the predominating interest is in stock grazing, as there is an excellent growth of native grass over most of the township, which flourishes excepting during periods of drouth, and the township affords an unusual water supply. There are several small cottages on Ivy Island, in Lins Lake, which are occupied at intervals during the summer months, but apparently no one has made a permanent settlement on the island. |
| | At several corner points in the subdivision of the township the site conditions are such that a superior monumentation was desirable. In most of these places this was secured by the employment of an iron post, or a tablet, set in a concrete form shaped as a frustrum of a cone, 8 ins. upper diam., 14 ins. lower diam., 36 ins. long, which were constructed at the points where required. In a few places a tablet was used, set in a cylindrical form of concrete, 36 ins. long, 6 ins. in diam.; a number of these were constructed in camp, allowed to thoroughly set, then transported to the points where needed. There were no trees or stone in those situations where no accessories are recorded, and the soil was not sufficiently firm for pits. |
| | The average of a considerable number of readings over all parts of the township gives a value of 18° 10′ E. for the mean magnetic declination. There is a range of 20′ in local attraction. |

FIELD ASSISTANTS

| *Names* | *Capacity* |
|---|---|
| ---------------------------------------- | Principal Assistant |
| ---------------------------------------- | Chainman |
| ---------------------------------------- | Flagman |
| ---------------------------------------- | Axeman |
| ---------------------------------------- | Cornerman |
| ---------------------------------------- | |
| ---------------------------------------- | |

## CERTIFICATE OF CADASTRAL ENGINEER

I, Robert Acres, hereby certify upon honor, that in pursuance of special instructions bearing date of the 1st day of April, 1945, I 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 and under my direction; and that said survey has been made in strict conformity with said instructions, the Manual of Instructions foı the Survey of the Public Lands of the United States, and in the specific manner described in the foregoing field notes.

(Signed) ROBERT ACRES,
*Cadastral Engineer.*

HELENA, MONTANA, *July 31, 1945.*

## CERTIFICATE OF APPROVAL

BUREAU OF LAND MANAGEMENT,
*Washington, D. C., September 15, 1946.*

The foregoing field notes of the survey of the subdivisional and meander lines of Township 15 North, Range 20 East, of the Principal Meridian, Montana, executed by Robert Acres, having been critically examined and found correct, are hereby approved.

(Signed) ----------------------------------------
*Chief, Branch of Engineering and Construction.*

## CERTIFICATE OF TRANSCRIPT

I certify that the foregoing transcript of the field notes of the above-described surveys in T. 15 N., R. 20 E., is a true copy of the original field notes.

(Signed) ----------------------------------------
*Chief, Branch of Engineering and Construction.*

## SPECIMEN FIELD NOTES, DEPENDENT RESURVEY

**427.** The example taken from a *dependent resurvey*, is to illustrate certain explanatory, introductory statements, that are regarded as appropriate and necessary, in order that the resurvey record may be fully coordinated with the original. This is a bona fide township in which the resurvey is strictly a restoration according to the best available evidence, with proportionate distribution of all differences in measurement. Several miles of the field notes are included to show forms of record, and the manner in which the style agrees with, or differs from, the specimen field notes of an original survey; some modification of corner descriptions has been made in order to furnish a variety of examples.

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*Dependent Resurvey of T. 1 S., R. 26 W., Fifth Prin. Mer., Arkansas*

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Township 1 South, Range 26 West, of the Fifth Principal Meridian, Arkansas, is located within the Ouachita National Forest. The south boundary of the township was surveyed by Rudolph N. Rowland, Deputy Surveyor, in 1837; the east and west boundaries were surveyed by John E. Graham, Deputy Surveyor, in 1838; and the township was subdivided by B. F. Owen, Deputy Surveyor, in 1845. These surveys are represented upon the township plat approved July 28, 1845, on file in the General Land Office. The north boundary of the township, being the base line of the 5th Prin. Mer., was resurveyed under the direction of the General Land Office, in 1929, as represented on the plats of the resurvey of Tps. 1 N., Rs. 26 and 27 W., approved May 22, 1931 and April 8, 1931, respectively. The following field notes are those of the dependent resurvey, or reestablishment, of the east, west, and south boundaries, and subdivisional lines of the township.

The resurvey was initiated on the official request of the U. S. Forest Service because of the advanced obliteration of the original marks, and the need for a plain marking of the lines. The identified evidence consisted of marks and remains of original bearing trees; in some cases merely the stumps remained. The direct evidence was mostly deteriorated, badly decayed and bordering on disappearance, though dependable for fixing about one-third of the corner positions. Two locations were restored from the testimony of persons who had known the bearing trees before their disappearance. About one-fourth of the positions could be accepted as perpetuations of the original corner locations, or acceptable determinations by local survey; these had been preserved and recognized, but there was no testimony or definite record as to their origin; the locations could be adopted after being verified by the direct evidence. The remainder of the corner positions were lost. The original survey was faithfully and carefully executed. These facts were reported in justification of the need for a resurvey.

Before restoring the corners, the lines of the original survey were retraced, and diligent search made for any evidence of the original corners, bearing trees, and other calls of the original field note record. When duly identified the corner positions were remonumented and new bearing trees marked.

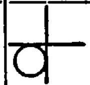
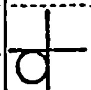
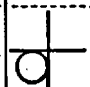
The rules of proportionate measurement were applied in order to ascertain the position of lost corners, after completing the necessary retracements to connect with the identified corner locations, but not until exhausting every reasonable possibility of finding direct evidence for the control of each particular corner. The true lines, thus adjusted to the identified original evidence, were then duly run and marked through the timber.

The retracement data were submitted for office examination and verification prior to the conclusion of the field work. In order to simplify the record, the true line notes only are supplied herewith, which refer to the completed resurvey.

The survey was executed with light mountain solar transits made by Buff and Buff, serial numbers 9937, 14187, and 17993, all constructed in accordance with the standard instrumental specifications of the General Land Office. The horizontal circles have diameters of 4½ inches, with two double opposite verniers reading to single minutes; the vertical circles have diameters of 4 inches, with one double vernier reading to single minutes. The instruments are equipped with improved telescopic solar attachments, radii of latitude arcs 3 inches, and of declination arcs 3½ inches, each with verniers reading to single minutes. The instruments were in good condition and were placed in satisfactory adjustment prior to the beginning of the survey.

The directions of all lines were determined with the solar transit, and the measurements made with Lallie steel tapes, 5 chains in length, graduated every link for the first 100 links, and thereafter at intervals of 10 links. The tapes were tested by comparison with a standard tape and found correct. The measurement were made on the slope, and the vertical angle of each interval was ascertained by a clinometer in good adjustment; the horizontal equivalents only are entered in this field note record.

April 13, 1943, at camp located in the SE. ¼ SW. ¼, sec. 36, T. 1 N., R. 27 W., in approximate latitude 34°41'30'' N., longitude 93°49' W., at 7h 52m a. m., app. t., I make a series of three altitude observations of the sun for azimuth, each with the telescope in direct and reversed positions, observing opposite limbs of the sun, and reading the horizontal angle from the line of sight to a nail in a pump house, SE. to the sun:

| Observation | Telescope | Sun | Apparent time | Vertical angle | Horizontal angle |
|---|---|---|---|---|---|
| 1st | Direct |  | | 27° 33' 00'' | 61° 32' 00'' |
| | Reversed |  | | 27 55 00 | 60 12 00 |
| | Mean | | | 27° 44' 00'' | 60° 52' 00'' |
| 2d | Direct |  | 7h 52m | 27° 45' 00'' | 61° 23' 00'' |
| | Reversed |  | | 27 44 00 | 60 21 00 |
| | Mean | | | 27° 44' 30'' | 60° 52' 00'' |
| 3d | Direct |  | | 27° 52' 00'' | 61° 17' 00'' |
| | Reversed |  | | 27 38 00 | 60 27 00 |
| | Mean | | | 27° 45' 00'' | 60° 52' 00'' |
| | Mean of all | | | 27° 44' 30'' | 60° 52' 00'' |

By reduction of observation, the line of sight of the nail bears S./N. 20°23'33'' E./W.

| | |
|---|---|
| Mean observed vertical angle | 27°44'30'' |
| Refraction in zenith distance | −1'49'' |
| Parallax | +8'' |
| True vertical angle | h=27°42'49'' |
| Declination of the sun | 8°51'34''N. |
| Reduced azimuth of the sun at the mean period of the observation | S.81°15'33''E. |
| Observed horizontal angle from the sun to the line of sight of the nail | 60°52'00'' |
| True bearing, line of sight of the nail | S./N. 20°23'33'' W./E. |

I turn an angle of 20°23'33'' to the right of the nail and mark the true meridian.

Every hour from 7 to 10:30 a. m. and from 1:30 to 5 p. m., I make proper settings on the arcs of the solar attachments and ascertain that the resulting orientations of the instruments, when compared with the meridian established by observation of the sun, have a maximum error of less than 1'30''.

I repeat the tests of the arcs daily, when conditions are favorable, by noon observation, and verify the meridional indications at frequent intervals throughout the survey.

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*Dependent Resurvey of the East Boundary, T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas.*

| Chains | |
|---|---|
| | Reestablishment of the Survey Executed by John E. Graham, Deputy Surveyor, in 1838. |
| | The cor. of Tps. 1 and 2 S., Rs. 25 and 26 W., is determined from the remains of the original bearing trees; point for cor. falls by a fence bearing N. and S. |
| | from which 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. |
| | At the corner point |
| | Set an iron post, 30 ins. long, 2 ins. diam., in a concrete form, 9 ins. diam., and 30 ins. long, 24 ins. long, in the ground, with brass cap mkd. |
| | T1S<br>R26W \| R25W<br>S36 \| S31<br>S1 \| S6<br>T2S<br>1943 |
| | from which |
| | A granite boulder 3 x 2 x 1 ft. above ground, bears N. 20¼° W., 40 lks. dist., mkd. XBO on SE. face. |
| | A pine, 10 ins. diam., bears N. 16° E., 125 lks. dist., mkd. T1S R25W S31 BT. |
| | A white oak, 7 ins. diam., bears S. 40½° E., 75 lks. dist., mkd. T2S R25W S6 BT. |
| | A white oak, 18 ins. diam., bears S. 53½° W., 94 lks. dist., mkd. T2S R26W S1 BT. |
| | A pine, 9 ins. diam., bears N. 44¼° W., 35 lks. dist., mkd. T1S R26W S36 BT. |
| | N. 0°28′ E., along the E. bdy. of sec. 36, marking and blazing the true line. |
| | Ascend 25 ft. over S. slope, along a fence, through timber and undergrowth. |
| 5.00 | Top of ascent; descent 70 ft. over N. slope. |
| 12.20 | Draw, course W.; ascend 87 ft. over broken S. slope. |
| 26.90 | Point of spur, slopes N. 70° E.; descend 70 ft. over broken N. slope. |
| 39.29 | Road, bears E. and W.; leave fence S. of road, fence turns to E. |
| 39.79 | Point for the ¼ sec. cor. of sec. 36, at proportionate distance; there is no remaining evidence of the original corner. |
| | Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd. |
| | ¼ S36 \|<br>1943 |
| | from which |
| | A white oak, 5 ins. diam., bears N. 2¾° W., 22 lks. dist., mkd. ¼ S36 BT. |
| | A pine, 14 ins. diam., bears S. 14¾° W., 130½ lks. dist., mkd. ¼ S36 BT. |
| | Raise a mound of stone, 4 ft. base, 2 ft. high, W. of cor. |
| 40.60 | Spring branch, course SE.; ascend 45 ft. over S. slope. |
| 47.00 | Top of ascent; thence along E. slope. |

*Chains*

51.40 Vacant farm house, bears S., 1.62 chs. dist.

59.86 Highway No. 270, bears N. 47½° W. and S. 47½° E.

63.00 Descend 62 ft. over N. slope to cor.

79.58 The cor. of secs. 25 and 36, monumented by a white oak, 12 ins. diam., mkd. T 1 R26 S25 on NW. and dim scribe marks on the SW. face, from which the remains of the original bearing trees:

An elm stump, 18 ins. diam., bears S. 28° W., 53 lks. dist., with fallen log having old blaze. (Record bearing S. 26° W.)

A post oak stump, 24 ins. diam., bears N. 78° W., 65 lks. dist.

And new bearing trees,

A white oak, 20 ins. diam., bears S. 22½° W., 340 lks. dist., mkd. T1S R26W S36 BT.

An elm, 15 ins. diam., bears N. 7¼° W., 103 lks. dist., mkd. T1S R26W S25 BT.

Land, rolling hills.
Soil, stony clay.
Timber, pine, oak, hickory, and elm; undergrowth, young timber.

---

N. 1°22′ E., along the E. bdy. of sec. 25.

Over gently rolling land, in creek bottom, through timber and undergrowth.

0.25 Hackberry Creek, 30 lks. wide, course N. 80° E.; ascend 40 ft. over S. slope.

19.20 Top of ascent.

27.70 Descend 20 ft. over NW. slope.

29.50 Branch, 10 lks. wide, course SW.; ascend 20 ft. over S. slope.

40.09 The ¼ sec. cor. of sec. 25 as determined from the remains of the original bearing trees:

A stump hole, bears N. 62° W., 63 lks. dist. (Record bearing N. 58° W.).

A stump hole, bears S. 45° W., 27 lks. dist. (Record bearing S. 35° W.).

At the corner point.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground with brass cap mkd.

$\frac{1}{4}$ S 25 |
1943

from which

A pine, 10 ins. diam., bears N. 48° W., 49 lks. dist., mkd. ¼ S25 BT.

A pine, 5 ins. diam., bears S. 21¼° W., 39 lks. dist., mkd. ¼ S25 BT.

A pine knot, 4 ins. diam., 12 ins. above ground, and mound of stone, b[illegible] S. 78¾° E., 28 lks. dist.

Raise a mound of stone, 4 ft. base, 2 ft. high, W. of cor.

---

N. 1°00′ E., beginning new measurement.

Ascend 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, course NW.

25.40 Branch, 5 lks. wide, course SW.

40.68 Point for the corner of secs. 24 and 25, at proportionate distance; there is no remaining evidence of the original corner.

*Chains*

Set a brass tablet, 3¼ ins. diam., 3½ ins. stem, in a concrete form, 6 ins. diam., 30 ins. long, and set 24 ins. in the ground, with top mkd.

| | |
|---|---|
| T1S | T1S |
| S24 | |
| S25 | |
| R26W | R25W |

1943

from which

A pine, 8 ins. diam., bears S. 49¾° W., 44½ lks. dist., mkd. T1S R26W S25 BT.

A pine, 12 ins. diam., bears N. 60¾° 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, stony clay.
Timber, pine, oak, elm, hickory and gum; undergrowth, young timber, and dogwood.

Remainder of east boundary of township omitted here.

*Dependent Resurvey of the South Boundary, T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas.*

*Chains*

Reestablishment of the Survey Executed by
Rudolph N. Rowland, Deputy Surveyor, in 1837.

From the cor. of Tps. 1 and 2 S., Rs. 25 and 26 W.

S. 88°51′ W., along the S. bdy. of sec. 36, marking and blazing the true line.

Over rolling land, through scattering timber and undergrowth.

1.40 Thence descend 70 ft. over W. slope.

7.50 Enter river bottom, 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.

40.32 Point for the ¼ sec. cor. of sec. 36, at proportionate distance; there is no remaining evidence of the original corner.

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

$\frac{1}{4}$ S36

1943

from which

A post oak, 10 ins. diam., bears N. 60¼° E., 75 lks. dist., mkd. ¼ S36 BT.

A pine, 7 ins. diam., bears N. 73½° W., 16 lks. dist., mkd. ¼ S36 BT.

73.00 Thence down lane.

74.55 Creek, 2 lks. wide, course NW.

79.60 Lane turns south; thence along fence.

80.65 The cor. of secs. 35 and 36, determined longitudinally by proportionate measurement, and latitudinally by an old fence bearing E. and W.

At the corner point

| *Chains* | |
|---|---|
| | Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd. |
| | T I S \| R 26 W<br>S 35 \| S 36<br>1943 |
| | from which |
| | A cedar, 4 ins. diam., bears N. 85½° 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. |
| | Land, gently rolling.<br>Soil, stony and sandy clay.<br>Timber, pine, oak, hickory and gum; undergrowth, young timber. |
| | S. 89°55′ W., along the S. bdy. of sec. 35. |
| | Over gently rolling land, between fields. |
| 4.70 | Enter timber and undergrowth, bears NE. and S. 80° W.; descend 30 ft. |
| 14.00 | Creek, 15 lks. wide, course NE. |
| 17.00 | Thence ascend 110 ft. over SE. slope. |
| 31.10 | Crest of ridge, bears NE. and SW.; descend 65 ft. to ¼ sec. cor. |
| 40.32 | The ¼ sec. cor. of sec. 35 which is marked by a pine stake and mound of stone at cor. of fences, bearing E. and N., and substantiated by a large pine stump hole which bears N. 33½° W., 15 lks. dist. (Record). |
| | At the corner point. |
| | Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd. |
| | ¼ S 35<br>1943 |
| | from which |
| | A red oak, 13 ins. diam., bears N. 69° E., 25 lks. dist., mkd. ¼ S35 BT. |
| | A post oak, 13 ins. diam., bears N. 7¼° W., 31 lks. dist., mkd. ¼ S35 BT. |
| | Raise a mound of stone, 3 ft. base, 2 ft. high, N. of cor. |
| | Reset the pine stake, inverted and alongside the iron post. |
| | S. 89°37′ W., beginning new measurement. |
| | Over gently rolling land. |
| 18.50 | Fence, bears N. and S.; thence along old fence row. |
| 38.45 | Creek, 3 lks. wide, course N. 30° E.; enter timber, bears N. 30° E. and S. |
| 40.16 | The cor. of secs. 34 and 35, which is marked by a wooden stake at cor. of fences which bear N., E. and W. This position is harmoniously related to existing original corners, has long been recognized as the cor. by adjacent land owners, and is accepted as the best existing evidence of the position of the original cor. |
| | At the corner point |
| | Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd. |
| | T I S \| R 26 W<br>S 34 \| S 35<br>1943 |
| | from which |

*Chains*

A water oak, 6 ins. diam., bears N. 53½° E., 79½ lks. dist., mkd. T1S R26W S35 BT.

A water oak, 7 ins. diam., bears N. 75½° W., 22½ lks. dist., mkd. T1S R26W S34 BT.

Reset the wooden stake, inverted and alongside the iron post and raise a flat mound of stone, 5 ft. diam., around the cor.

Land, gently rolling.
Soil, stony clay.
Timber, pine, oak, hickory and gum; undergrowth, young timber, vines and briers.

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Remainder of south boundary, and all of west boundary of township omitted here.

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*Dependent Resurvey of the Subdivisional Lines, T. 1 S., R. 26 W., 5th Prin. Mer., Arkansas.*

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*Chains*

Reestablishment of the Survey Executed by
B. F. Owen, Deputy Surveyor, in 1845.

From the cor. of secs. 35 and 36, on the S. bdy. of the Tp.

N. 0°26′ E., bet. secs. 35 and 36, marking and blazing the true line.

Descend 45 ft. over N. slope, through field.

11.15 Right bank 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; acsend 85 ft. over S. slope to cor.

33.45 Farm road, bears E. and W.

40.08 The ¼ sec. cor. of secs. 35 and 36, determined from the remains of the original bearing trees:

A dim stump hole bears N. 64° W., 9 lks. dist.

A dim stump hole bears S. 73° E., 19 lks. dist.

At the corner point

Set an iron post, 30 ins. long, 2 ins. diam., 26 ins. in the ground, with brass cap mkd.

$\frac{1}{4}$
S35 | S36
1943

from which

A white oak, 9 ins. diam., bears N. 72½° E., 50 lks. dist., mkd. ¼ S36 BT.

A white oak, 15 ins. diam., bears N. 59° W., 36 lks. dist., mkd. ¼ S35 BT.

A set stone, 12 x 12 x 12 ins. above ground, bears N. 64° W., 2 lks. dist.

---

N. 0°44′ E., beginning new measurement.

Over gently rolling upland.

17.00 Descend 62 ft. over N. slope.

28.10 Branch, course NE.; thence over level land.

29.09 Fence, bears E. and W.; ascend 30 ft. over S. slope.

39.00 Top of ascent; descend 5 ft. over N. slope to cor.

40.26 The cor. of secs. 25, 26, 35, and 36, which is marked by an iron peg, 12 x 1 x ½ ins., set 10 ins. in ground. This peg was shown me by interested property owners and is accepted as the best available evidence of the position of the original cor.

At the corner point

*Chains*

Set an iron post, 30 ins. long, 2 ins. diam., 25 ins. in the ground, with brass cap mkd.

T1S R26W
S26 | S25
S35 | S36
1943

from which

A cedar, 14 ins. diam., bears N. 80° E., 134¼ lks. dist., mkd. T1S R26W S25 BT.

A red oak, 17 ins. diam., bears S. 44½° E., 71 lks. dist., mkd. T1S R26W S36 BT.

A white oak, 14 ins. diam., bears S. 61° W., 37 lks. dist., mkd. T1S R26W S35 BT.

A white oak, 14 ins. diam., bears N. 3¼° W., 67 lks. dist., mkd. T1S R26W S26 BT.

NW. cor. of pasture fence, bears S. 46° E., 11 lks. dist.

Reset iron peg S. and alongside the iron post.

Raise a mound of stone, 3 ft. base, 2 ft. high, W. of cor.

Land, rolling hills.
Soil, stony clay.
Timber, pine, oak, hickory, maple, elm, gum, sycamore, and cedar; undergrowth, young timber.

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From the cor. of secs. 25 and 36, on the E. bdy. of the Tp.

S. 89°12′ W., bet. secs. 25 and 36.

Ascend 65 ft. over rolling NW. slope, through field.

16.95 Highway No. 270, bears N. 48½° W. and S. 48½° E.; leave field and enter timber and undergrowth, edge bears NE. and SW.

37.50 Crest of spur, slopes SW.; descend 20 ft. over W. slope to cor.

40.23 The ¼ sec. cor. of secs. 25 and 36 which is monumented with an unmarked stone, 7 x 8 x 18 ins. set alongside the NE cor. of a fence. This cor. was shown me by interested property owners and is accepted as the best available evidence of the position of the original cor.

At the corner point

Set an iron post, 30 ins. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd.

S25
¼
S36
1943

from which

A post oak, 8 ins. diam., bears N. 3° E., 40½ lks. dist., mkd. ¼ S25 BT.

An elm, 6 ins. diam., bears S. 53½° E., 32 lks. dist., mkd. ¼ S36 BT.

---

S. 89° 26′ W., beginning new measurement.

Ascend 20 ft. over E. slope, through scattering timber and undergrowth.

1.93 House, bears S. 28 lks. dist.

5.20 Top of ascent; thence over rolling land descending 40 ft.; line follows near secondary road, winding westward.

29.70 Creek, 15 lks. wide, course S. 10° E.; ascend 30 ft. over E. slope.

38.00 Top of ascent; descend 8 ft. over NW. slope to cor.

*Chains*

40.09 The cor. of secs. 25, 26, 35, and 36.

Land, rolling hills.
Soil, stony clay.
Timber, pine, oak, hickory, and elm; undergrowth, young timber and dogwood.

---

N. 0°46′ E., bet. secs. 25 and 26.

Over gently rolling land, crossing road.

0.24 Secondary road, winding E. and W.

0.88 Thence along a fence line, with hedgerow; old clearings E. and W.

27.50 Creek, course winding S. 20° E.; enter cleared land.

40.57 The point for ¼ sec. cor. of secs. 25 and 26 on the center line of Highway No. 88 and in line with a property line fence to the S. This is the position for the ¼ sec. cor. according to residents, who stated the road was constructed through the corner position; road bears N. 89° E and S. 89° W.; it is accepted as the best available evidence of the position of the original corner.

At the corner point

Bury a washed sandstone, 9 x 8 x 6 ins., 14 ins. in the ground, mkd. X.

from which

An iron post, 30 ins. long, 2 ins. diam., set 28 ins. in the ground, for a reference monument, bears N. 48° W., 73 lks. dist., with brass cap mkd. ¼ S26 RM 1945 and an arrow pointing to the true corner.

An iron post, 30 ins. long, 2 ins. diam., set 26 ins. in the ground, for a reference monument, bears S. 48° E., 73 lks. dist., with brass cap mkd. ¼ S25 RM 1945 and an arrow pointing to the true corner.

---

N. 0°58′ E., beginning new measurement.

Ascend 35 ft. over SW. slope.

6.00 Top of ascent; thence over gently rolling land.

19.05 Intersection of roads bearing N. 74° E., S. 62° W., and N. along line.

34.37 Highway No. 270, bears N. 33°22′ W. and S. 33°22′ E.

40.10 The point for cor. of secs. 23, 24, 25, and 26, on the center line of a road, bearing N. and S., and in line with property line fences to the E. and W. This is the position for the cor. according to statement of Charley Ballentine, a resident in the vicinity for many years; it is accepted as the best evidence of the position of the original corner.

At the corner point

Bury a granite stone, 10 x 9 x 6 ins., 19 ins. in the ground, mkd. X.

from which

A granite boulder, 6 x 4 x 9 ft. above ground, bears N. 34°26′ E., 63½ lks. dist., mkd. B+0, 6 ins. above the ground and near the SW. cor.

An elm, 7 ins. diam., bears S. 56¾° E., 62 lks. dist., mkd. T1S R26W S25 BT.

A pine, 4 ins. diam., bears S. 51°36′ W., 404 lks. dist., mkd. T1S R26W S26 BT.

A mulberry, 4 ins. diam., bears N. 61°50′ W., 203 lks. dist., mkd. S23 BT.

Land, gently rolling hills.
Soil, stony clay.
Timber, scattering pine, oak, hickory and elm; undergrowth, young timber.

---

From the cor. of secs. 24 and 25, on the E. bdy. of the Tp.

S. 89°33′ W., bet. secs. 24 and 25.

Over gently rolling upland, through timber and undergrowth.

| Chains | |
|---|---|
| 23.20 | Draw, course S. |
| 25.30 | Crest of minor ridge, bears N. and S. 20° E.; descend 72 ft. over W. slope. |
| 40.27 | The ¼ sec. cor. of secs. 24 and 25, marked by a large X chiseled on the SW. face of rough surfaced conglomerate boulder, 4 x 4 x 2 ft. above ground. |
| | from which the remains of an original bearing tree: |
| | A post oak stump, 20 ins. diam., bears N. 52° E., 16 lks. dist.; this tree was cut recently but was pointed out to me as the old bearing tree. |
| | Chisel ¼ on the W. side of the X. |
| | from the X |
| | A pine, 6 ins. diam., bears N. 40½° E., 130 lks. dist., mkd. ¼ S24 BT. |
| | A post oak, 6 ins. diam., bears S. 70½° E., 139½ lks. dist., mkd. ¼ S25 BT. |
| | Raise a mound of stone, 4 ft. base, 2 ft. high, N. of cor. |
| | S. 88°44′ W., beginning new measurement. |
| | Over gently rolling land, through scattering timber and undergrowth. |
| 2.10 | House, bears N., 1.00 ch. dist. |
| 4.70 | Enter road right of way curving from N. to W. |
| 11.12 | Bridge over Hackberry Creek, 48 lks. wide, course S. |
| 13.70 | Leave road, curving SW. from E. |
| 15.17 | Leave road right of way; enter field, bears N. and S. |
| 40.47 | The cor. of secs. 23, 24, 25, and 26. |
| | Land, rolling and gently rolling hills.<br>Soil, stony clay.<br>Timber, pine, oak, and hickory; under growth, young timber and dogwood. |

Remainder of the subdivisional notes omitted.

NOTE.—On each mile along the north boundary of the township, which is the base line of the Fifth Prin. Mer., 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 upon the representations of the original plat. The descriptive statements are given for two cors.

The point for the ¼ sec. cor. of sec. 4 on the N. bdy. of the Tp. is at proportionate distance as based upon the original plat and falls in a graded road which bears N. 89° 08′ W., and S 89°08′ E.

At the corner point

Bury a sandstone 14 x 10 x 6 ins., 12 ins. under the ground.

from which

An iron post, 30 ins. long, 2 ins. diam., set 24 ins. in the ground, for a reference monument, bears NORTH, 40 lks. dist., with brass cap mkd. RM 1943 and an arrow pointing to the true cor.

An iron post, 30 ins. long, 2 ins. diam., set 24 ins. in the ground, for a reference monument, bears SOUTH, 40 lks. dist., with brass cap mkd. ¼ S4 RM 1943 and an arrow pointing to the cor.

From this corner the standard corner of secs. 32 and 33, T. 1 N., R. 26 W., which is an iron post, 2 ins. diam., firmly set in ground and mound of stone, with brass cap marked and witnessed as described in the official record, bears S. 89°08′ E., 1.29 chs. dist.

The point for the W. ¼ sec. cor. of sec. 31 is at midpoint and on the W. bdy. of the Tp.

| *Chains* | |
|---|---|
| | At the corner point |
| | Set an iron post, 30 ins. long, 2 ins. diam., 26 ins. in the ground, with brass cap mkd. |
| | \| $\frac{1}{4}$ S 31 <br> 1943 |
| | from which |
| | A pine, 5 ins. diam., bears N. 37½° E., 41 lks. dist., mkd. ¼ S31 BT. |
| | A post oak, 9 ins. diam., bears S. 31¼° E., 7½ lks. dist., mkd. ¼ S31 BT. |
| | From this corner the ¼ sec. cor. of sec. 36, T. 1 S., R. 27 W., bears S. 0°35′ W., 0.36 chs. dist. |

SPECIMEN

FIELD NOTES

# MINERAL SURVEY NO. 20220 A AND B

# COLORADO

FIELD NOTES

OF THE SURVEY OF THE MINING CLAIM OF

## THE GOLD MINING COMPANY

## KNOWN AS THE JIM DANDY, PRINCE, AND PROTECTOR LODES AND DUMP MILL SITE

Cottonwood Mining District, Chaffee County

Pueblo Land District

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, 1945

Survey commenced May 10, 1945; completed May 14, 1945.

Address of claimant's agent, John Jones, 561 Foster Building, Denver, Colo.

Dates of amended locations: Protector lode, June 16, 1944; Prince lode, August 10, 1944.

Dates of locations: Jim Dandy lode, July 26, 1932; Dump Mill Site, August 10, 1944.

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 upon the sun. The instrument was in good condition at the time of the survey and all adjustments were in good order.

All azimuths in this record were determined by the method of deflection angles referred to the meridian determined by the following observation:

May 10, 1945, at cor. No. 1 of the Jim Dandy lode, in latitude 38°45′ N., and longitude 106°20′ W., I make a series of six altitude observations upon 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.

| | |
|---|---|
| Mean time of observation, 105th meridian standard time | $=8^h15^m$ a. m. |
| Declination of sun at mean time of observation | =17°38′ N. |
| Mean observed vertical angle to sun's center | =37°47′ |
| Mean horizontal angle from reference point to sun's center | =74°10′ S-E. |
| True bearing to reference point | =S. 8°20′ E. |

The lines were measured with a ............ steel tape 300 feet in length, graduated every foot for 100 ft., and the remainder at intervals of 10 ft.; and a ........... steel tape 10 feet in length, graduated to feet, tenths and hundredths; both tapes were compared with a .......... standard at the time of beginning the survey, and found correct.

All lines and connections of this survey were run by direct methods where the lines are accessible; the inaccessible lines were run by traverse methods, as shown by the calculation sheets herewith submitted.

The magnetic declination observed at each corner of the survey gave a uniform value of 15°30′ E.

## *Survey No. 20220 A*

*Feet*

### JIM DANDY LODE

At cor. No. 1 of the Jim Dandy lode, identical with cor. No. 1 of the Prince lode of this survey.

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. J D—1—PRI—1—20220 A; from which

The cor. of secs. 7, 8, 17, and 18, T. 16 S., R. 80 W., 6th Prin. Mer., bears S. 55°40′ W., 212.5 ft. dist.; an iron post, 2 ins. diam., 12 ins. above ground, firmly set, marked and witnessed as described in the official record.

Cor. No. 1 Sur. No. 19557 Alley lode bears N. 55°19′ W., 360 ft. dist.

Cor. No. 1 Sur. No. 19142 I. X. L. lode, claimant herein, bears S. 49°48′ W., 642.7 ft. dist.

Cor. No. 3 Sur. No. 18837 C. C. D. lode bears N. 58°45′ E., 208.47 ft. dist.

A yellow pine, 14 ins. diam., bears N. 10°00′ E., 38.3 ft. dist., mkd. J D 1-20220 A B T.

A distant peak, known as Barren Mt., bears N. 55°57′ W.

Thence N. 28°50′ W.

170.28 Intersect line 3–4 Sur. No. 19142 I. X. L. lode at a point from which cor. No. 3 bears N. 61°27′ E., 871.43 ft. dist.

301.3 Lode line; discovery point bears N. 50°23′ E., 496 ft. dist.

370.28 Intersect line 4–1 Sur. No. 19557 Alley lode at a point from which Cor. No. 4 bears N. 44°30′ E., 1,332.42 ft. dist.

456.67 Intersect line 4–1 Protector lode of this survey.

| Feet | |
|---|---|
| 535.9 | Cor. No. 2, identical with Cor. No. 2 of the Prince lode of this survey. |
| | Set a white oak post, 36 ins. long, 5 ins. sq., 24 ins. in the ground, and in a mound of stone, mkd. J D-2-PRI-2-20220 A; from which |
| | A granite rock in place, 34 x 46 ins., 26 ins. above the ground, bears S. 24°00′ E., 10.5 ft. dist., mkd. X B O-J D-2-20220 A. |
| | Thence N. 50°23′ E. |
| 679.32 | Intersect line 3-4 Protector lode of this survey. |
| 1,150.19 | Intersect line 4-1 Sur. No. 20062 Copper lode at a point from which Cor. No. 4 bears S. 59°25′ E., 94.5 ft. dist. |
| 1,230.73 | Intersect line 1-2 Sur. No. 12071 Major lode at a point from which Cor. No. 2 bears S. 11°00′ E., 101.3 ft. dist. |
| 1,291.67 | Intersect line 3-4 Sur. No. 19557 Alley lode at a point from which Cor. No. 4 bears S. 45°30′ L., 26.31 ft. dist. |
| 1,500.0 | Cor. No. 3. |
| | On line 3-4 Sur. No. 20062 Copper lode. |
| | On granite bedrock outcrop, even with the general surface, point for Cor. No. 3, mkd. X-J D-3-20220 A; from which |
| | Cor. No. 4 Sur. No. 20062 Copper lode bears S. 34°45′ W., 330.0 ft. dist.; identical with Cor. No. 2 Sur. No. 12071 Major lode. |
| | A silver spruce, 16 ins. diam., bears N. 40°00′ E., 47.0 ft. dist., mkd. J D 3-20220 A B T. |
| | Thence S. 28°50′ E. |
| 234.6 | Lode line; discovery point bears S. 50°23′ W., 1,004 ft. dist. |
| 241.9 | Intersect line 2-3 Sur. No. 12071 Major lode at a point from which Cor. No. 2 bears S. 79°00′ W., 310.46 ft. dist. |
| 404.5 | Intersect line 1-2 Sur. No. 10910 Golden lode, claimant herein, at a point from which Cor. No. 1 bears S. 47°12′ W., 620.0 ft. dist. |
| 535.9 | Cor. No. 4. |
| | This corner falls on a rock slide where a permanent monument can not be established; from this point Cor. No. 1 Sur. 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 bowlder, 26 x 48 ins., 36 ins. above ground, for witness Cor. No. 4, mkd. X-W C-J D-4-20220 A. |
| 612.92 | Intersect Cor. No. 3 Sur. No. 19142 I. X. L. lode established on line 6-1 Sur. No. 19910 Golden lode at a point from which Cor. No. 1 bears N. 28°33′ W., 96.46 ft. dist. |
| 1,500.0 | Cor. No. 1, and place of beginning. |

## PRINCE 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 Sur. 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 ft. dist. |
| 370.28 | Intersect line 4-1 Sur. No. 19557 Alley lode at a point from which Cor. No. 1 bears S. 44°30′ W., 167.58 ft. dist. |
| 456.67 | Intersect line 4-1 Protector lode of this survey. |
| 535.9 | Cor. No. 2, identical with Cor. No. 2 of the Jim Dandy lode of this survey. |
| | Thence S. 41°58′ W. |
| 215.3 | Intersect line 1-2 Sur. No. 19557 Alley lode at a point from which Cor. No. 1 bears S. 45°30′ E., 149.14 ft. dist. |
| 356 | Center of road, bears N. 15° W. and S. 15° E. |

| Feet | |
|---|---|
| 598.76 | Intersect line 1-2 Sur. No. 4923 Idella lode at a point from which Cor. No. 1 bears N. 24°48′ E., 399.35 ft. dist. |
| 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 | Road, bears N. 40° W. and S. 40° E. |
| 1,504.0 | Cor. No. 3. |
| | Set a schist rock, 28 x 10 x 6 ins., 18 ins. in the ground, mkd. PRI-3-20220 A; from which |
| | A silver spruce, 14 ins. diam., bears N. 10°00′ E., 15.0 ft. dist., mkd. PRI-3-20220 A B T. |
| | A yellow pine, 26 ins. diam., bears S. 45°00′ E., 22.0 ft. dist., mkd. PRI-3-20220 A B T. |
| | A corner of the location bears N. 28°50′ W., 12.5 ft. dist. |
| | Thence S. 28°50′ E. |
| 255.45 | Lode line; discovery point bears N. 42°25′ E., 651 ft. dist. |
| 331.8 | Intersect line 1-2 Sur. No. 4923 Idella lode at a point from which Cor. No. 1 bears N. 24°48′ E., 1,461.0 ft. dist. |
| 507.3 | Cor. No. 4. |
| | 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-4-20220 A; from which |
| | Cor. No. 2 Sur. No. 4923 Idella lode bears N. 38°50′ W., 157.72 ft. dist. |
| | A point on granite bedrock outcrop, even with the general surface, bears S. 26°00′ E., 20.0 ft. dist., mkd. XBO-PRI-4-20220 A. |
| | A corner of the location bears S. 28°50′ E., 16.1 ft. dist. |
| | Thence N. 43°00′ E. |
| 220.0 | Cor. No. 2 Dump Mill Site of this survey. |
| 480 | Creek, 2 ft. wide, course North. |
| 665 | Road, bears N. 55° W. and S. 55° E. |
| 772 | Right bank of Chalk Creek, 16 ft. wide, course S. 47° E. |
| 880.0 | Cor. No. 1 Dump Mill Site of this survey. |
| 1,084.8 | Intersect line 1-2 Sur. No. 19142 L. X. L. lode at a point from which Cor. No. 1 bears S. 61° 27′ W., 240.5 ft. dist. |
| 1,108 | Road, bears N. 42° W. and S. 42° E. |
| 1,237.6 | Intersect the line bet. secs. 17 and 18, at a point from which the cor. of secs. 7, 8, 17, and 18, bears North, 68.3 ft. dist., previously described. |
| | Enter T. & S. Entry No. 2614. |
| 1,331.0 | Intersect the line bet. 8 and 17, at a point from which the cor. of secs. 7, 8, 17, and 18, bears N. 89°59′ W., 63.7 ft. dist. |
| | Leave T. & S. Entry No. 2614. |
| 1,494.9 | Cor. No. 1, and place of beginning. |

## PROTECTOR LODE

| | |
|---|---|
| | Beginning at Cor. No. 1 of the Protector Lode— |
| | A point on top of a granite rock in place, 14 x 56 ins., 18 ins. above ground, mkd. X-PRO-1-20220 A; from which |
| | The cor. of secs. 7, 8, 17, and 18, bears N. 88°16′E., 640.1 ft. dist.; previously described. |
| | Cor. Nos. 1 of the Jim Dandy and the Prince lodes of this survey bears N. 80°19′ E., 827.1 ft. dist. |
| | Thence N. 42°11′ W. |
| 245.44 | Intersect line 3-4 Sur. No. 4923 Idella lode at a point from which Cor. No. 4 bears N. 24°48′ E., 518.26 ft. dist. |

| Feet | |
|---|---|
| 300 | Lode line; discovery point bears N. 47°49′ E., 73 ft. dist. |
| 310 | Left bank of Chalk Creek, 20 ft. wide, course S. 2° E. |
| 600.0 | Cor. No. 2. |
| | Set a galvanized iron post, 3 ft. long, 2 ins. diam., 24 ins. in the ground, with brass cap mkd. PRO-2-20220 A; from which |
| | Cor. No. 4 Sur. No. 4923 Idella lode bears N. 65°29′ E., 500.6 ft. dist. |
| | Cor. No. 2 Sur. No. 20100 Silver lode, claimant herein, bears N. 39°44′ E., 381.6 ft. dist. |
| | A yellow pine, 12 ins. diam., bears N. 20°00′ W., 35.0 ft. dist., mkd. PRO-2-20220 ABT. |
| | A yellow pine, 14 ins. diam., bears S. 51°00′ W., 22.0 ft. dist., mkd. PRO-2-20220 ABT. |
| | Thence N. 47°49′ E. |
| 70 | Right bank of Chalk Creek, 19 ft. wide, course S. 30° E. |
| 557.88 | Intersect line 1-2 Sur. No. 20100 Silver lode at a point from which Cor. No. 2 bears S. 64°25′ W., 187.91 ft. dist. |
| 625 | Road, bears N. 22° W. and S. 22° E. |
| 1390.0 | 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-3-20220 A. |
| 1,500.0 | Cor. No. 3. |
| | This corner falls at an inaccessible point on the cliff, described above, where a monument can not be established. |
| | Thence S. 42°11′ E. |
| 40 | Base of cliff, bears N. 82° E. and S. 80° W. |
| 280.77 | Intersect line 1-2 Sur. No. 20100 Silver lode at a point from which Cor. No. 2 bears S. 64°25′ W., 1,170.98 ft. dist. |
| 300.0 | Lode line; discovery point bears S. 47°49′W., 1,427 ft. dist. |
| 342.02 | Intersect line 2-3 Sur. No. No. 19557 Alley lode at a point from which Cor. No. 2 bears S. 44°30 W., 903.05 ft. dist. |
| 553.3 | Intersect line 2-3 Jim Dandy lode of this survey. |
| 600.0 | Cor. No. 4. |
| | Set a granite stone, 25 x 10 x 9 ins., 16 ins. in the ground, mkd. PRO-4-20220 A; from which |
| | Cor. No. 4 Sur. No. 19557 Alley lode bears N. 48°28′ E., 613.35 ft. dist. |
| | No local bearing objects or bearing trees available. |
| | Thence S. 47°49′ W. |
| 696.94 | Intersect the common line 1-2 Jim Dandy and Prince lodes of this survey. |
| 889.61 | Intersect line 1-2 Sur. No. 19557 Alley lode at a point from which Cor. No. 2 bears N. 45°30′ W., 206.06 ft. dist. |
| 1,054 | Road, bears N. 15° W. and S. 15° E. |
| 1,312.10 | Intersect line 1-2 Sur. No. 4923 Idella lode at a point from which Cor. No. 1 bears N. 24°48′ E., 440.63 ft. dist. |
| 1,431.05 | Intersect line 2-3 Prince lode of this survey. |
| 1,500.0 | Cor. No. 1, and place of beginning. |

*Survey No. 20220 B*

| Feet | DUMP MILL SITE |
|---|---|
| | At Cor. No. 1 of the Dump Mill Site, on line 4–1 Prince lode of this survey. |
| | Set a brass tablet, 3¼ ins. diam., 3½ ins. stem, in a concrete post, 24 ins. long, 6 ins. sq., 16 ins. in the ground, and surrounded by a mound of stone, with top mkd. DMS–1–20220 B; from which |
| | The cor. of secs. 7, 8, 17, and 18, bears N. 36°28′ E., 410.3 ft. dist.; previously described. |
| | Thence S. 43°00′ W. |
| 92 | Left bank of Chalk Creek. |
| 215 | Road. |
| 400 | Creek. |
| 660.0 | Cor. No. 2, on line 4–1 Prince lode of this survey. |
| | A yellow pine stump, 18 ins. diam., 3 ft. high, squared to 10x10 ins., mkd. DMS–2–20220 B; from which |
| | A yellow pine stump, 18 ins. diam., 26 ins. high, bears S. 80°00′ E., 17.5 ft. dist., mkd. DMS–2–20220 B B T. |
| | Thence S. 47°00′ E. |
| 220 | Creek, 2 ft. wide, course N. 50° E. |
| 330.0 | Cor. No. 3. |
| | Set a granite stone, 24x14x8 ins., 12 ins. in the ground to bed rock, surrounded by a mound of stone to top, mkd. DMS–3–20220 B. |
| | No local bearing objects or bearing trees available. |
| | Thence N. 43°00′ E. |
| 390 | Road, bears N. 40° W. and S. 40° E. |
| 425 | Right bank of Chalk Creek, 23 ft. wide, course S. 35° E. |
| 660.0 | Cor. No. 4. |
| | Set a granite stone, 26x10x8 ins., 14 ins. in the ground to bedrock, surrounded by a mound of stone to top, mkd. DMS–4–20220 B; from which |
| | A yellow pine, 16 ins. diam., bears N. 15°00′ E., 20.0 ft. dist., mkd. DMS–4–20220 B B T. |
| | Thence N. 47°00′ W. |
| 330.0 | Cor. No. 1, and place of beginning. |
| | The Dump Mill Site contains 5.00 acres. |

*Survey No. 20220 A and B*

AREAS

| | Acres |
|---|---|
| Total area, Jim Dandy lode | 18.129 |
| Area in conflict with— | |
| Tract A, hereinafter described | 0.450 |
| Sur. No. 12071 Major lode | 1.095 |
| Sur. No. 19142 I. X. L. lode | 1.708 |
| Sur. No. 19557 Alley lode | 2.815 |
| Sur. No. 19557 Alley lode, exclusive of its conflict with Sur. No. 12071 Major lode | 2.767 |
| Sur. No. 19910 Golden lode | 1.572 |
| Sur. No. 19910 Golden lode, exclusive of its conflict with Tract A | 1.122 |
| Sur. No. 20062 Copper lode | 0.357 |
| Sur. No. 20062 Copper lode, exclusive of its conflict with: | |
| (1) Sur. No. 12071 Major lode | 0.082 |
| (2) Sur. No. 19557 Alley lode | 0.246 |
| (3) Surs. Nos. 12071 and 19557 Major and Alley lodes | 0.030 |
| Total area, Prince lode | 17.008 |
| Area in conflict with— | |
| T. & S. Entry No. 2614 | 0.050 |
| Sur. No. 4923 Idella lode | 3.258 |
| Sur. No. 19142 I. X. L. lode | 3.744 |
| Sur. No. 19142 I. X. L. lode, exclusive of its conflict with T. & S. Entry No. 2614 | 3.694 |

| | |
|---|---|
| Sur. No. 19557 Alley lode | 0.675 |
| Total area, Protector lode | 20.661 |
| Area in conflict with— | |
| Sur. No. 4923 Idella lode | 3.826 |
| Sur. No. 19557 Alley lode | 4.776 |
| Sur. No. 20100 Silver lode | 3.036 |
| Jim Dandy lode of this survey | 0.981 |
| Jim Dandy lode of this survey, exclusive of its conflict with Sur. No. 19557 Alley lode | 0.000 |
| Prince lode of this survey | 0.650 |
| Prince lode of this survey, exclusive of its conflict with: | |
| (1) Sur. No. 4923 Idella lode | 0.628 |
| (2) Sur. No. 19557 Alley lode | 0.342 |
| (3) Surs. Nos. 4923 and 19557 Idella and Alley lodes | 0.320 |
| Total area, Dump Mill Site | 5.000 |

### TRACT A

That portion of Sur. No. 19910 Golden lode in conflict with Jim Dandy lode of this survey, excluded by said Golden lode in favor of a location now abandoned, is bounded and described as follows:

Beginning at Cor. No. 4 Jim Dandy lode—
Thence N. 28°50′ W., 131.4 ft., to line 1-2 Golden lode;
Thence S. 47°12′ W., 275.6 ft., to a point on same line;
Thence N. 79°00′ E., 237.6 ft., to line 4-1 Jim Dandy lode;
Thence N. 50°23′ E., 42.0 ft., to place of beginning.

Tract A contains 0.450 acres.

### LOCATION

This survey is located in the SE ¼ sec. 7, SW ¼ sec. 8, NW ¼ sec. 17, and NE ¼ sec. 18, of T. 16 S., R. 80 W., of the sixth principal meridian.

The survey of the Jim Dandy and Protector lodes and the Dump Mill Site is identical with the respective location or amended location as marked on the ground. 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.

### EXPENDITURES

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:

No. 1. The discovery cut of the Jim Dandy lode, the face of which being the discovery point, is on the lode line 496 ft. from a point on line 1-2, 301.2 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.
Value of cut, tunnel and winze, $380.

No. 2. 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.
Value, $2,300.

No. 3. A trench, the west end of which bears N. 38°12′ E., 395 ft., from Cor. No. 1 Jim Dandy lode; 4 ft. wide, 8 ft. deep, running N. 48° E., 40 ft.
Value, $125

No. 1. The discovery cut of the Prince lode, the face of which being the discovery point, is on the lode line 849 ft., S. 42°25′ W., from the center of line 1-2; 6 ft. wide, 13 ft. face; running N. 42°25′ E., 20 ft. to face.
Value, $100.

No. 2. A shaft, the center of which bears N. 20°42′ E., 450 ft., from Cor. No. 4 Prince lode; 4 x 7 ft., 3 ft deep.
Value, $130.

No. 1. The discovery shaft of the Protector lode, the center of which being the discovery point, is on the center line 73 ft. from the center of line 1-2; 6 x 8 ft., 18 ft. deep, partly timbered.
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 Sur. No. 19142 I. X. L. lode, Sur. No. 19910 Golden lode, Sur. No. 20100 Silver lode, and the Lead King and Daisy lodes, unsurveyed, which are all the contiguous lode claims owned in common within the range of benefit of said tunnel.

The surface rises rapidly to the north and east from the portal of the tunnel and the extension in its present course, with necessary laterals, affords the most practical and economical means of developing each of the stated lodes at depth.

Five hundred dollars or over has been expended in this improvement in such a manner as tends to the development of each lode of this survey subsequent to its location and to the time since which common ownership and contiguity have prevailed; therefore an undivided one-eighth interest in its value is hereby credited to each of said lodes and a like interest apportioned to each of the other stated lodes of the common group.

The first 165 ft. of this tunnel, valued at $2,400 was credited to Sur. No. 19142 I. X. L. lode.

An undivided one-half interest in the first 290 ft., valued at $2,200, was credited to Sur. No. 19910 Golden lode.

An undivided one-fifth interest in the first 510 ft., valued at $1,520, was credited to Sur. No. 20100 Silver lode.

Except as above stated, no portion of or interest in this improvement has been credited heretofore as patent expenditure to any lode claim.

## OTHER IMPROVEMENTS

A cut 6 ft. wide, the face of which bears S. 17°42′ W., 402 ft., from Cor. No. 2 Prince lode; runs East 20 ft., to 12 ft. face.

A shaft, 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 corner of which bears S. 3°00′ W., 210 ft., from Cor. No. 1 Dump Mill Site; the long sides bear N. 20° W.

Claimant herein.

A frame compressor house and shop, the NE. corner of which bears S. 25°00′ E., 80 ft., from Cor. No. 1 Dump Mill Site; 16 x 30 ft. in size; the long sides bear N. 85° W.

Claimant herein.

A frame bunk house, the NE. corner of which bears S. 50°00′ W., 690 ft. from Cor. No. 1 Prince lode; 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 Mill Site; of logs and planks, 10 ft. wide and 30 ft. long, bearing N. 50° E.

Claimant herein.

## OTHER CORNER DESCRIPTIONS AND SUPPLEMENTAL DATA

Sur. No. 4923 Idella Lode: Cors. Nos. 1, 3, and 4 are granite stones, firmly set and properly marked; Cor. No. 2 has been destroyed. Line 3–4 was found to be approximately correct as approved; line 4–1 was found to be S. 65°05′ E., 299.4 ft., instead of S. 65°12′ E., 300 ft., as approved; line 1–2 is shown as approved. From Cor. No. 1 the cor. of secs. 7, 8, 17, and 18, bears S. 31°56′ E., 596.9 ft., instead of S. 33°47′ E., 605.0 ft., as approved.

Sur. No. 12071 Major lode: Cor. No. 2 is a pine post, firmly set and properly marked; no other corners could be found. All lines shown as approved. Owing to the absence of Cor. No. 1, the apparent error in the connecting line to the cor. of secs. 7, 8, 17, and 18, could not be verified.

Sur. No. 18837 C. O. D. lode: Cor. No. 3 is a granite stone, firmly set and properly marked.

Sur. No. 19142 I. X. L. lode: Cors. Nos. 2, 3, and 4 are pine posts, firmly set and properly marked; Cor. No. 1 could not be found. Lines 2–3 and 3–4 are correct as approved; lines 1–2 and 4–1 are shown as approved.

Sur. No. 19557 Alley lode: Cor. No. 1 is a pine post, and Cor. No. 4 is a granite stone, both firmly set and properly marked; Cors. Nos. 2 and 3, including all accessories, have become obliterated, leaving no evidences of their original positions. Line 4–1 was found to be S. 44°30′ W., 1,500.0 ft., instead of S. 44°20′ W., 1,500.0 ft., as approved; lines 1–2 and 3–4 are shown at right angles to line 4–1, and each 300 ft. long as approved; this makes line 2–3 N. 44°30′ E., instead of N. 44°20′ E. as approved, and lines 1–2 and 4–3 each N. 45°30′ W., instead of N. 45°40′ W., as approved. From Cor. No. 4 of the Alley lode, Cor. No. 2 Sur. No. 12071 Major lode bears S. 21°10′ W., 128.7 ft., instead of S. 20°35′ W., 136 ft., as approved.

Sur. No. 19910 Golden lode: Cors. Nos. 1, 2, and 6 are granite stones, firmly set and properly marked. Lines 1–2 and 6–1 are correct as approved.

Sur. No. 20062 Copper lode: Cors. Nos. 1, 2, and 3 are pine posts, firmly set and properly marked. Cor. No. 4 is identical with Cor. No. 2 Sur. No. 12071 Major lode, described above. All lines are correct as approved.

Sur. No. 20100 Silver lode: Cors. Nos. 1 and 2 are granite stones, firmly set and properly marked. Line 1–2 is correct as approved.

(Memo.—Here explain any allowable disagreement with the location certificate, and show the cause.)

## FIELD ASSISTANTS

| *Name* | *Capacity* |
|---|---|
| ---------------------------------------- | ---------------------------------------- |
| ---------------------------------------- | ---------------------------------------- |
| ---------------------------------------- | ---------------------------------------- |

## CERTIFICATE OF SURVEYOR

I, ......................................., Mineral Surveyor, hereby certify upon honor that in pursuance of an order received from the ............................ at ..............................
dated ......................., I have faithfully and correctly executed the survey of the mining claim of
.................................................................................................,
known as the ...................................................................................,
(lode, placer, or millsite)
situate in ...................................................., T. ..............., R. ...............
.............................. Meridian, ............................., and designated as Survey No.
(State)
......................., which is represented in the foregoing field notes as having been executed by me and under my direction, and that said survey has been made in strict conformity with said order, the Manual of Instructions for the Survey of the Public Lands of the United States, and in the specific manner described in the foregoing field notes, and I do further certify that the labor expended and improvements made upon or for the benefit of the ............................. location.. embraced in the said mining
(lode or placer)
claim by claimant.. or ....... grantors are fully stated in my report therein, and that the character, extent, location, and itemized value thereof are specified therein with particularity and full detail, and that no portion of, or interest in, said labor and improvements so credited to this claim has been included in the estimate of expenditures upon any other claim.

.................................................. ..............................................
(Place) *Mineral Surveyor.*

..................................................
(Date)

## CERTIFICATE OF APPROVAL

......................................
(Office)

.................... ...............
(Place) (Date)

The foregoing field notes of mineral survey No. ............, in ............................, T. ......,
R. ......., .......... Mer., ............... executed by ............................, Mineral Sur
(State)
veyor, under order dated ......................., having been critically examined and the necessary corrections made prior to their certification by the surveyor, the said field notes and the survey therein described are hereby approved.

......................................
......................................
(Title)

## CERTIFICATE OF TRANSCRIPT

I certify that the foregoing transcript of field notes of the above described mineral survey No. ............ is a true copy of the original field notes on file in the public survey office.

......................................
......................................
(Title)

(NOTE.—To be attached to the claimant's copy of the field notes only in case the record shows expenditures equal or exceed $500.)

## CERTIFICATE FOR PATENT APPLICATION ON MINERAL SURVEY NO. ...., ...........
(State)

.................... ...................
(Place) (Date)

I hereby certify that the record of mineral survey No. ............, on file in this office, furnishes such an accurate description of said mining claim as will, if incorporated into a patent, serve fully to identify the premises, and that such references are made therein to natural objects or permanent monuments as would perpetuate or fix the locus thereof, and I further certify that the record shows $500 worth of labor has been expended for improvements upon, or for the benefit of, each of the lode locations embraced in said mining claim by the claimant.. or .......... grantors, and that no portion of, or interest in, said labor or improvements has been included in the estimate of expenditures upon any other claim.

......................................
......................................
(Title)

(NOTE.—The copies of the location certificates will be attached to the returns following this page.)

# INDEX

MEMORANDUM.—*Subdivisions* of a subject are indented on the left margin and the principal subject is repeated when the subdivision extends to a new page. *Explanatory notes* are shown in *italics*.





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